वार्षिक प्रतिवेदन
Annual Report
2022-23

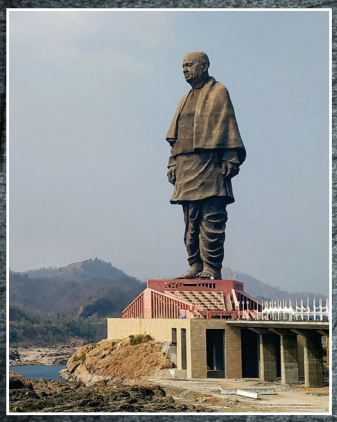
सीएसआईआर
CSIR
भारत का नवाचार इंजन
The Innovation Engine of India

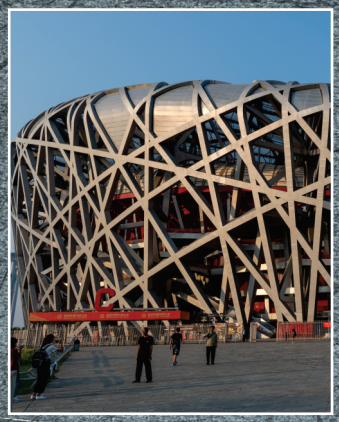
CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, India

Famous Metal Wonders *of the World*

Several splendid constructions in the world have been built from metals such as steel, iron and copper in entirety or a crucial part of it. These have became famous tourist attractions as well. This book treasures some of the most iconic bridges, buildings, statues, and monuments across the globe.





Sources: wikipedia

President-CSIR
Mr. Narendra Modi
(Hon'ble Prime Minister)

VP-CSIR
Mr. Jitendra Singh
(Hon'ble S&T Minister)

DG-CSIR
Dr. N. Kalaiselvi
(Secretary DSIR)

Management Council

Director CSIR-NML, CMERI
Dr. Naresh Chandra Murmu

Research Council

R&D Division/Centers

MTE
Dr. Sandip Ghosh Chowdhury
Chief Scientist & Head

MER
Dr. Sanjay Kumar
Chief Scientist & Head

MNP
Dr. Shobhana Dey
Chief Scientist & Head

AMP
Dr. Shashi Kant Tiwari
Chief Scientist & Head

AAC
Dr. (Mrs.) S Chakravarty
Chief Scientist & Head

NML-MC
Mr. T.V. Vijaya Kumar
Chief Scientist & Head

Support Divisions/ Units

RPBD
Dr. Sital Kumar Pal
Chief Scientist & Head

ENG
Mr. Uday Bhaskara Rao Modavalasa
Principal Scientist & Head

KRIT
Mr. Byomkesh Dash
Chief Scientist & Head

Functionaries

Administration
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Administrative Officer

F&A
Mr. Pankaj Kumar
F&A Officer

Administration
Mr. Aditya Mainak
Administrative Officer

F&A
Mr. Dayakant Kumar
F&A Officer

HRG
Dr. S. Sivaprasad
Chief Scientist & Head

S&P
Mr. Anil Kr. Choudhury
S&P Officer

AMP: Advanced Materials & Processes; MTE: Materials Engineering; AAC: Analytical & Applied Chemistry; MER: Metal Extraction & Recycling; MNP: Minerals Processing; NML-MC-: NML-Madras Center; S&P: Stores & Purchase; HRG: Human Resource Group; F&A : Finance & Accounts; RPBD: Research Planning & Business Development; KRIT : Knowledge Resources & Information Technology Unit; ENG: Engineering

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"I was very impressed in my visit to NML which was my first visit to Jamshedpur itself. On a very short interaction, I got a glimpse of the very active activities of NML. I have planned for the next visit along with my colleagues to set up collaboration".

Tanusri Saha-Dasgupta

28/09/2022

CSIR-National Metallurgical Laboratory

The Inception

The foundation stone for National Metallurgical Laboratory was laid by Hon'ble Sri C. Rajagopalachari on 21st November, 1946. It was formally inaugurated and dedicated to the nation on 26th November, 1950 by Pandit Jawaharlal Nehru "in a spirit of hope and in a spirit of faith in the future'. The laboratory was an element of Sir Shanti Swaroop Bhatnagar's vision of providing India with a network of research institutions for taking the country ahead in science and technology. CSIR-NML played a significant role in the industrial revolution of India starting from 1950 especially in the areas of mineral processing, iron and steel making, ferroalloys and extraction of non-ferrous metals, notably magnesium. Asia's largest creep testing facility was also set up at CSIR-NML in the early 1970s and even today it ranks as the second largest creep testing lab in Asia.

".....But when I come to Jamshedpur it is not the past of India that comes up before me but some vision of the future comes before my eyes."

"I do not wish any worker to come to these laboratories merely with the aim of earning his living. What I wish is that our young men and women who come here should have a zeal for working out problems, which would have great consequence. That would give vitality to these Institutes. They should realize that service to science is real service to India - no, even to the whole world - science has no frontiers".

...Pandit Jawaharlal Nehru

Glorious Past

CSIR-National Metallurgical Laboratory (CSIR-NML) is a premier Indian research organisation dedicated to various facets of Minerals, Metals and Materials -science, technology, industrial services and human resource development. Since inception, CSIR-NML has diversified its research areas ranging from extractive metallurgy, alloy development and import substitution, refractory material, development, corrosion studies, mathematical and physical modeling of metallurgical processes, mineral research, advanced materials and materials tailoring, integrity evaluation of critical industrial components, surface engineering and cleaner and sustainable metals production. The Laboratory has made notable contributions in the areas of mineral beneficiation and agglomeration, ferrous and nonferrous metallurgy, alloy development and processing, materials science & engineering and, resource conservation & environment. A historical accounts of past achievements (1950-2010) of CSIR-NML is painted in the Diamond Jubilee commemorative volume 'la vintage metallurgie: 60 years of marriage of science to industry' (http://eprints.nmlindia.org/4360/).

Present Focus

Research & Development

CSIR-NML continues to play a vital role in the quest of the country towards scientific and technological leadership and providing scientific solutions to the industries in the areas of minerals, metals and materials. CSIR-NML is also carrying out major activities for creating awareness among the common masses on issues relating to health, environment, rural technology and sustainable development. With a strong and committed staff having a wide spectrum of expertise and modern facilities, CSIR-NML has completed 70 glorious years of existence and still endeavours to move ahead to meet the challenges of the global economy and reach greater heights. The Laboratory has kept pace with changing research scenarios and needs of the country. In the last few years, greater emphasis is given to industry-sponsored research and, alignment with government program; namely, Make in India, Innovate in India, Strategic sector needs, Swatch Bharat, Societal and skill India, etc. The activities of the Laboratory touch upon several major sectors relevant to the growth of India, including iron and steel, power and energy, oil and gas, automotive, railways, strategic, societal, and others.

CSIR-NML envisions becoming a self-reliant, self-sufficient R&D laboratory by providing feasible and sustainable solutions to the industries in the areas of metals, minerals and materials. The laboratory strives to recreate its niche in the areas relevant for empowering the evolving India via catering to the needs of modern India.

Our Vision Statement

"To become a global leader and an internationally benchmarked laboratory in mineral and metallurgical research and development. To become a self-sustained technology centre in minerals, metals and materials."

Research Council (RC)

Chairperson

Prof. Indranil Manna
Vice Chancellor,
Birla Institute of Technology, Mesra
Ranchi, Jharkhand

Members

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Department of Chemical
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Vice President
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Former Director
CSIR- National Metallurgical Laboratory,
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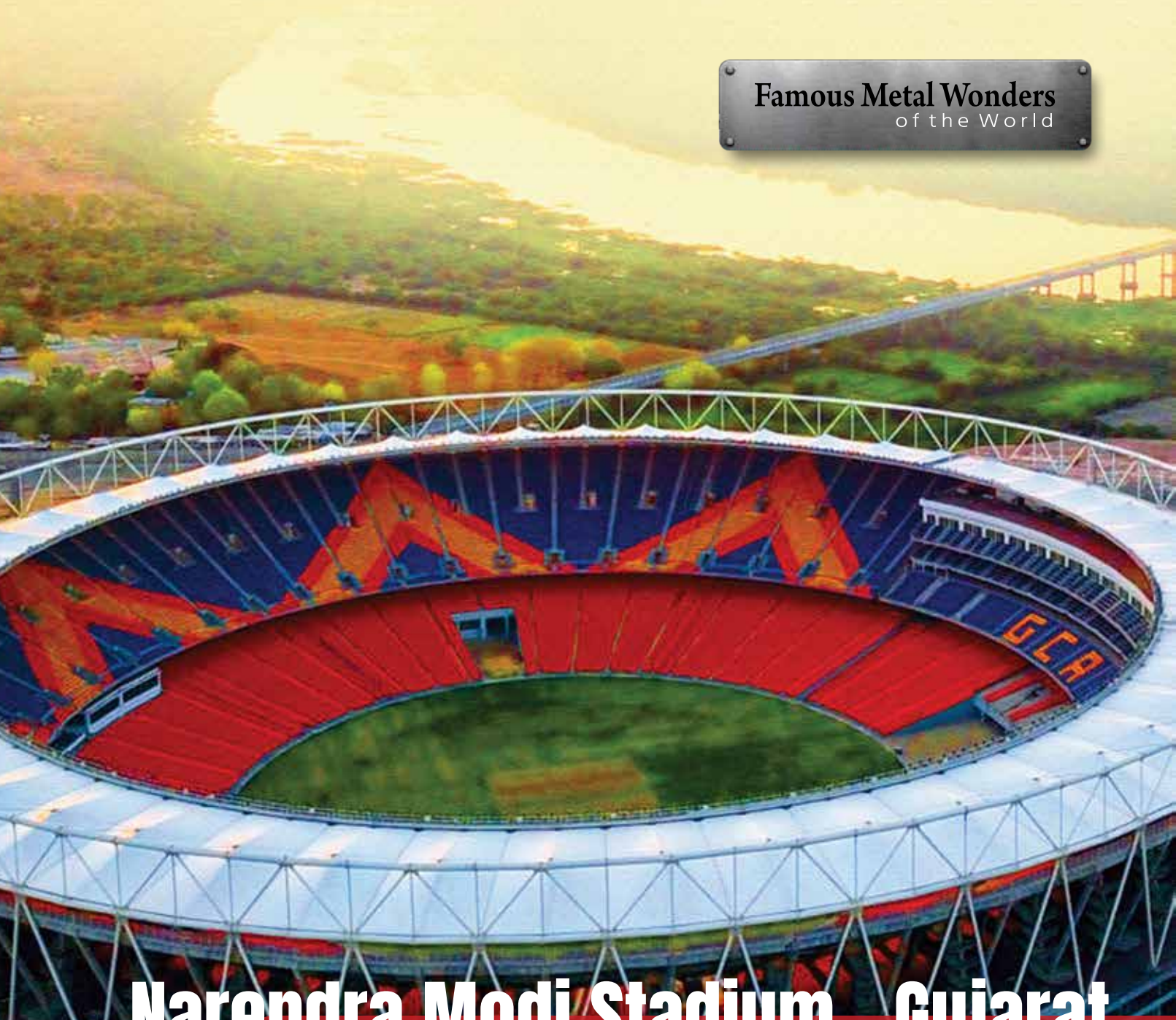
Principal Scientist,
TMD (SEMI)
CSIR, New Delhi

Dr. G. Padmanabham
Director
International Advance Research Center for
Powder Metallurgy & New Materials (ARCI),
New Delhi.

Prof. Prita Pant
Department of Metallurgical Engineering and
Materials Science,
IIT Bombay

Dr. G. Madhusudan Reddy
Director
Defence Metallurgical Research Laboratory
Hyderabad

Prof. Jyotsna Dutta Majumdar
Department of Metallurgical and Materials
Engineering,
IIT Kharagpur



Narendra Modi Stadium - Gujarat

- Largest International Cricket Stadium in the world.
- Seating capacity of 132,000 spectators.
- Constructed with 11,000 tons of steel rebars.
- The 13th edition Cricket World Cup 2023, final was played between host nation India and Australia recently at the stadium.

Sources: wikipedia

Foreword

CSIR-NML, a constituent of CSIR laboratories, focuses on excellence, relevance, and sustainability aspects of Research and Development. Thanks to the foresight and vision of its earlier directors and mentors, the laboratory has maintained a consistent momentum of research excellence and relevance. This trend continued in the past year, contributing significantly to the intents of CSIR-NML. The laboratory pursues R&D through various avenues such as contract & grant-in-aid research, technology development & transfer, consultancy and S&T services. The laboratory makes every effort for creating intellectual property (IP) and undertaking collaborative research.

The outputs and outcomes during the year were satisfying. The external cash flow (ECF) generated crossed a total of Rs. 26 Crores in the reporting year, which remained slightly short from our set target of Rs. 30 Crores. This shortfall happened due to non-realization of expected funds for a few major projects. We were able to generate Rs. 22. 74 Crores of industries funds which remained marginally lesser than the set target of 24.0 Crores. Still, it was very encouraging to see that around 76% of our ECF was generated from the industrial sources only. This reflected upon our excellence in delivering industrial solutions. Further, with respect to the generation of intellectual property, 12 Patents and 01 Copyright were filed by our researchers in the reporting period. On the technology front, due to stringent policies in place, none of the developed technologies could complete achieve the desired readiness level (TRL), to be declared as a fully developed and transferrable Technology. In the reporting year, one technology (Know-How for the Recovery of Li, Ni, Mn, Co from spent Lithium-ion Batteries) was transferred to M/s. ReCy Energy Pvt. Ltd., Pune. This success is attributed to the diligence, dedication, and industry expertise of our scientists in both the R&D Division and R&D support divisions. On the front of knowledge generation, the cumulative SCI publications (1986 onwards) from CSIR-NML has increased from 72017 to 77633 registering an increase of about 8%. During last fiscal year, 124 papers were published in SCI journals and 25 were published in Non-SCI journals. The institutional H-index also increased to higher than 120. Two of our technologies were commercialized during the reporting period: 1) Pilot scale flotation column of 200 tpd was installed at Bhelatand Coal Preparation Plant of M/s Tata Steel Limited and 2) Know-how for the recovery of Co, Li, Mn, Cu, Ni, Al, graphite and saleable plastics from waste LIBs was commercialized by M/s. Recyclib Pvt. Ltd., New Delhi. Few of our

flagship projects in the reporting period are: Effective Utilization of Middlings of Coking Coal Washery for Recovery of Carbon Values, Processing of high Ash & high Sulphur containing Lignite Coal from Gujarat, Corrosion behavior of different rail steels in varied environments, Extraction of critical metals form used Li-ion Batteries: A Mission Mode Project under CSIR Bulk Chemicals Mission. For the strategic sector, Space and Navy, we are working upon: Effect of Processing Parameters on Cryo Impact Properties of Cast Alloys, Electronic Packages for Ultrasonic Flow Meter for On-Board Propellant Gauging of Spacecraft, Metallurgical investigation to explore the damage mechanism of worn out quill shaft of aero engine, Destructive test/analysis for establishing life estimation matrix (LEM) boiler tubes.

We created an Intellectual Property Facilitation Centre in 2020 for facilitating the entrepreneurs and MSME for their IPR awareness and filling as well as to support commercialization of NML technologies. Till date, through the centre, 19 webinars, 02 seminars, IPR awareness and training of 1900 people have been organized. So far, 18 trademarks, 03 industrial designs, 05 patents, and 01 copyright have been registered and filed.

Connecting society at all levels and generating scientific awareness in society has always remained a priority for the organization. In this connection, the laboratory participated in a number of programs like: School-NML Interaction Program(SNIP) and Jigyasa. Under the GOI's mission "Skill India", the CSIR-Integrated Skill Initiative program has endeavored to train people in different areas. In the reporting period, more than 300 people were trained in metals, metallurgy, manufacturing, waste utilization, soft skills, and entrepreneurship. Under the DST project "Women Technology Park (WTP)". We have undertaken project on developing Detailed project report (DPR) on common facility centre for silver cluster of West Bengal. Based upon the inputs of Industrial Development Officer (IDO) of District Industry Centre (DIC), artisans, site survey, and discussion with vendors at their site, the intended Detailed Project Report (DPR) has been prepared which contains the basic details of the cluster, benchmark survey, proposed business model, machinery required, bill of quantity for civil estimation, commercial viability and demand and scope for diversification.

I on behalf of my colleagues, wish to express sincere thanks to our valued clients, members of the Research Council, and many other friends and mentors for their ongoing support and guidance.

Director, CSIR-NML

Performance Targets Achieved in 2022 - 2023

	Objectives	Planned	Achieved
1.	Total External Cash Flow (ECF)*	30.0 Crores	26.02 Crores
2.	Industrial ECF (a part of ECF)	24.0 Crores	22.74 Crores
3.	Customer Satisfaction Index	4.9 (Max 5)	4.7
4.	SCI Publications	125	124
5.	Patents	25	12
6.	Copyrights	5	01
7.	Technologies Developed	5	Nil
8.	Technologies Transferred#	5	01

*Cash flow generated from sponsored projects of industrial, PSU and government agencies.

Technology Transferred :

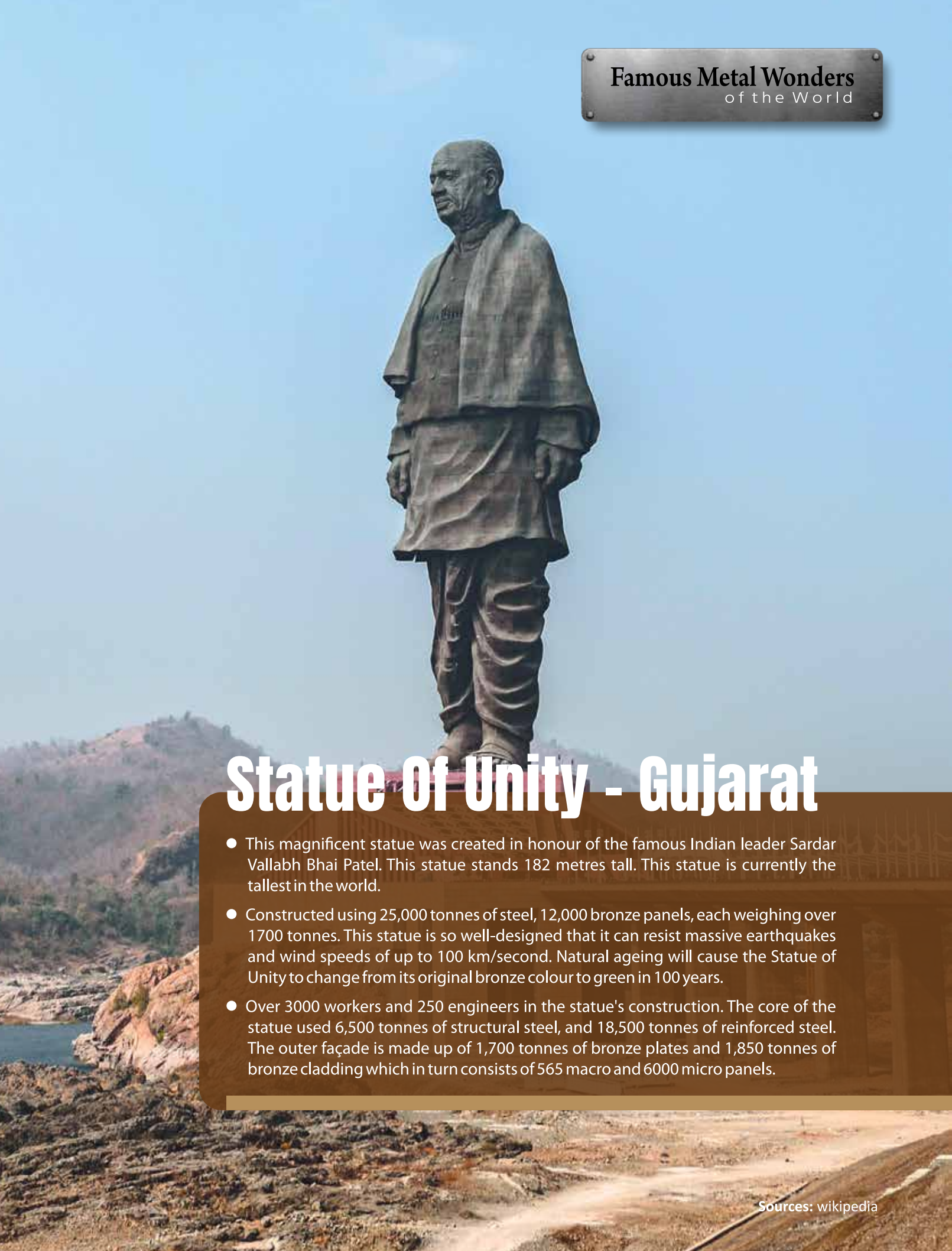
1. Know-How for the Recovery of Li, Ni, Mn, Co from spent Lithium-ion Batteries to M/s. ReCy Energy Pvt Ltd, Pune.

Major Technological & Scientific Targets Planned and Achieved in 2022-2023

Planned for 2022-2023	Achieved in 2022-2023
1. Benchmarking of zinc coated magnesium alloy as bio-implant	Desired corrosion rate (~0.25 mm/year) in simulated body fluid (SBF) achieved. Zn coated Mg alloy samples survived in SBF for 05 months.
2. Scale up of Ti_3AlC_2 (MAX) with purity ≥95% with our indigenous process to 100g scale	Process is scaled up to 200g scale and ready for transfer.
3. Magneto-Impedance Array sensor based device	Magneto-impedance (MI) Array Sensing Device using Nanostructured Material (MagRays)
4. Multi-channel coating weight measurement sensing device	Developed 5-channel system and performance evaluated at one of the renowned Wire mills
5. Scale-up of sol-pre-coating based universal HDPS process for AHSS	Universal Hot Dip Galvanizing Coating Process was successfully developed with optimized continuous process parameters compatible to CGL line using HDPS on Standard Size DP 980 Steel Sheet Specimen of size 12 cm width X 22 cm length X 0.8 mm Thickness

Planned for 2022-2023	Achieved in 2022-2023
6. Production of ferrochrome at pilot scale using 500 KVA submerged arc furnace	• Around 40 tons of ferrochrome has been produced using 500 KVA submerged arc furnace.
7. Technology transfers in the area of E-waste management	• MoU has been signed for the technology transfer in the area of E-waste.
8. Production of magnesium metal (kg scale) using Pidgeon process	• 2 Kg magnesium metal of >98% purity has been produced using modified Pidgeon process.
9. Benchmark data generation for HCF and LCF of Ni base alloys	• HCF data evaluation of Ni base alloys are in progress
10. Piloting Armour steel development, aiming for 2GPa strength and minimum fracture toughness of 50MPam$^{1/2}$ (Min)	• Armour steel with 2 GPa UTS and fracture toughness of 75MPa.m1/2 have developed at lab scale
11. Piloting coal with oily bubble flotation	• Oil-coated bubble flotation eliminate the addition of a collector to the aqueous phase. • Optimized results were obtained with an ash content of clean coal as 13.07 % with a yield of 44.99% from a feed ash of 27.4% for seam 7 coal. • Seam 5 coal study is under progress.
12. Processing of hydrocyclone underflow of grinding circuit towards recovery of silver through advance gravity separator	• Silver content in the sample was enriched from 200 ppm to 1000 ppm with a recovery of 36% using advanced gravity separation techniques.
13. Pelletization of iron ore concentrate using organic binder	• Performance of organic binder developed by NALCO Water Ltd for pelletization was evaluated through the laboratory scale experiments.
14. Effective utilization of middling and fines of coking coal washery for recovery of carbon values	• Process flowsheet has been developed for recovery of carbon values from middlings of the coking coal washeries by spiraling followed by column flotation. Project is in progress.

Planned for 2022-2023	Achieved in 2022-2023
15. Study on Performance Improvement of Coking coal washery through modelling and simulation	• Steady state model has been developed and validated for the Moonidih coal washery. Project is in progress.
16. Coal core analysis and beneficiation ▪ Coal beneficiation through oil agglomeration: Development of process to reduce mineral matter in coking and non-coking coal through oil agglomeration in 1 kg scale. ▪ Referee sample analysis of Coal challenged by different coal industries ▪ Preparation of coke from non-coking and semi-coking coal: Technology for preparation of coke from semi-coking and non-coking coals will be developed in 7 kg scale.	• Achieved and Completed
17. Certified reference materials (CRM) production and proliferation	• Achieved and Developed 5 nos. of new CRMs
18. Online chemical treatment of rebar to improve corrosion resistance	*Plant trail with TATA Steel and JSW Steel is ongoing*

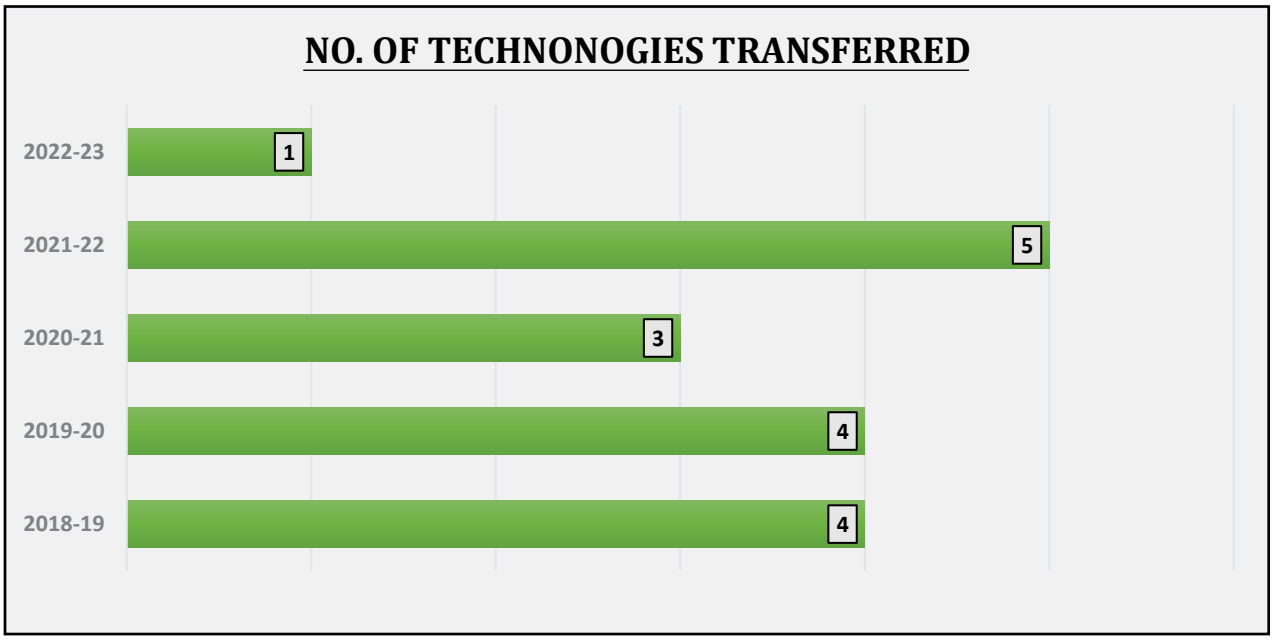


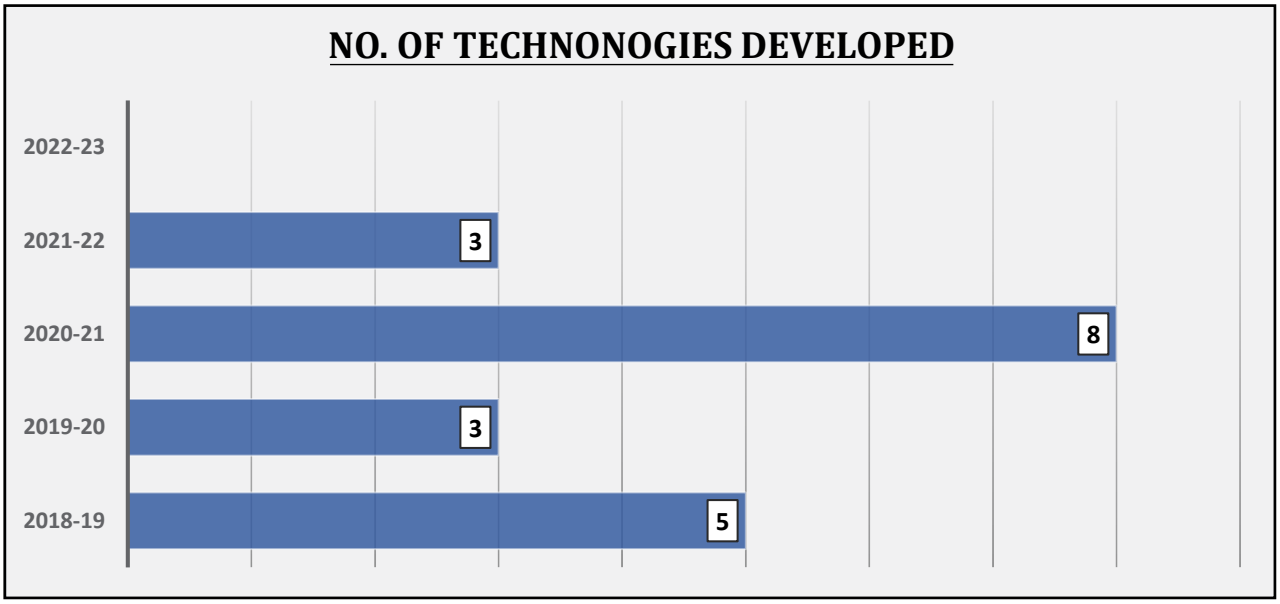
Statue Of Unity - Gujarat

- This magnificent statue was created in honour of the famous Indian leader Sardar Vallabh Bhai Patel. This statue stands 182 metres tall. This statue is currently the tallest in the world.
- Constructed using 25,000 tonnes of steel, 12,000 bronze panels, each weighing over 1700 tonnes. This statue is so well-designed that it can resist massive earthquakes and wind speeds of up to 100 km/second. Natural ageing will cause the Statue of Unity to change from its original bronze colour to green in 100 years.
- Over 3000 workers and 250 engineers in the statue's construction. The core of the statue used 6,500 tonnes of structural steel, and 18,500 tonnes of reinforced steel. The outer façade is made up of 1,700 tonnes of bronze plates and 1,850 tonnes of bronze cladding which in turn consists of 565 macro and 6000 micro panels.

Sources: wikipedia

R&D Output


NO. OF TECHNONOGIES TRANSFERRED
2022-23
1
2021-22
5
2020-21
3
2019-20
4
2018-19
4


NO. OF TECHNONOGIES DEVELOPED
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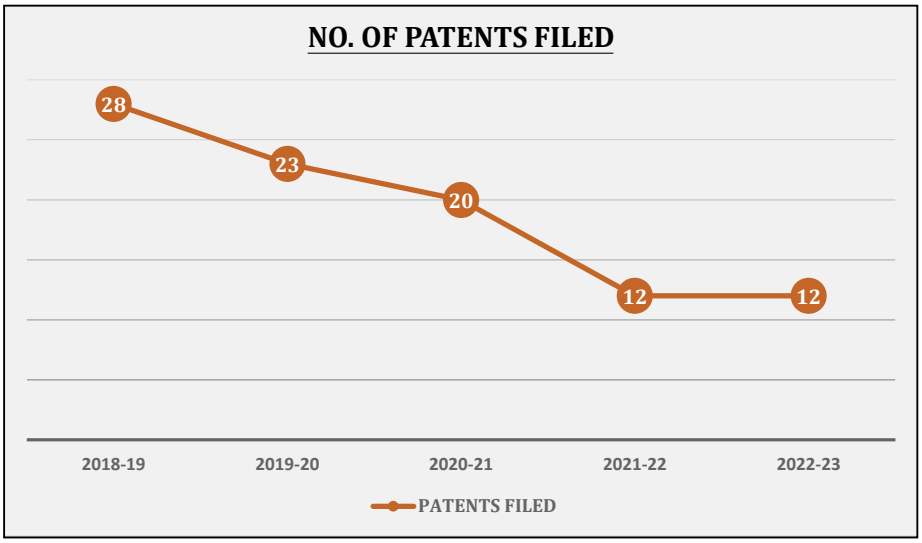
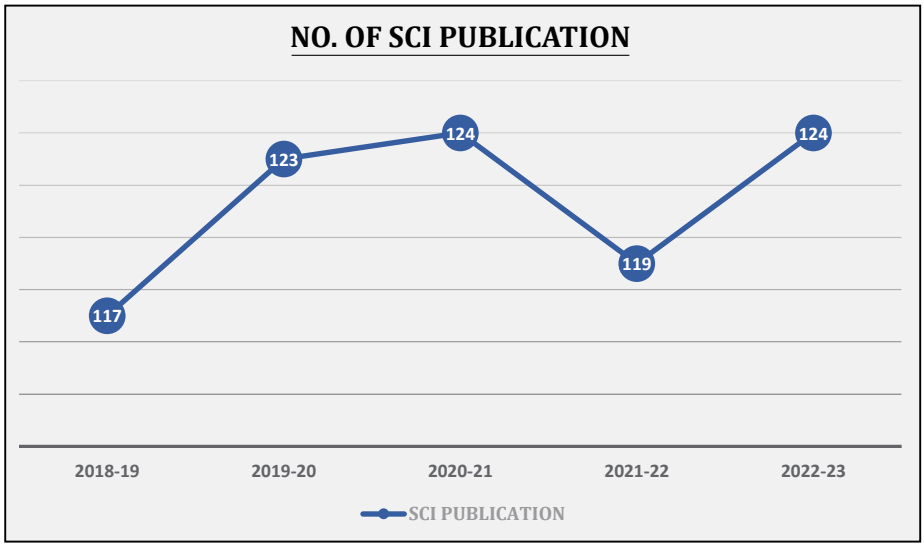
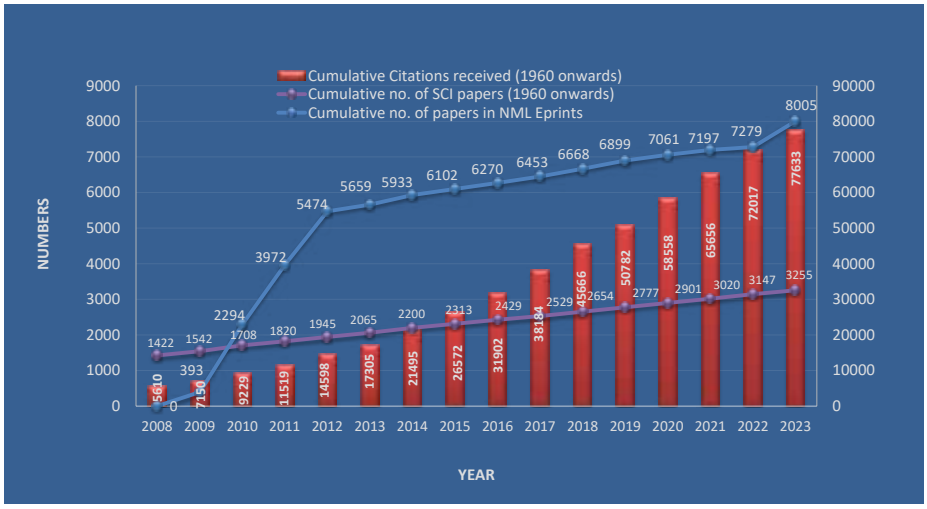
2021-22
3
2020-21
8
2019-20
3
2018-19
5







Source : Web of Science / Google Scholar as on 29.09.2023

Impact Making Technologies

Column Flotation Technology

CSIR - National Metallurgical Laboratory (CSIR-NML) has been in the forefront in indigenizing the **'Column Flotation Technology'** for processing lean grade and fine-grained ores for more than three decades. Laboratory scale (74mm diameter) and Pilot plant scale (500mm diameter) flotation columns were designed, fabricated and field tested at various private and public sector mineral processing industries located across the country. Development of column flotation technology achieved **Technology Readiness Level - 9**, implying that it is ready for successful deployment at commercial scale. The USP of CSIR - NML is providing a **'One-stop solution for installation and commissioning of commercial scale flotation columns'** by collaborating and partnering with an EPC company, M/s McNally Sayaji Engineering Co. Limited, Bengaluru and reagents manufacturers and suppliers, M/s Somu Organo-Chem Private Limited, Bengaluru. So far, **5 laboratory scale, 1 pilot plant scale and 8 commercial scale flotation columns were commissioned.**

The column flotation technology is a new mineral beneficiation method developed on strong scientific principles for processing of fine, low-grade ores and minerals. The merits of the technology includes improved metallurgical performance in terms of grade and recovery, effective cleaning of froths, small foot print, low capital investment, less operational and maintenance costs with user-friendly controls. Improved metallurgical performance is due to: (i) Less entrainment and entrapment of gangue in the froth, (ii) Independent control of operating variables, (iii) Froth washing provision and (iv) Control over bubble size – effective in fines collection. The Reduced operating & capital costs is due to: (a) No moving parts & Lower energy consumption, (b) Lower reagent consumption, (c) Substantial reduction in floor area – vertical configuration and (d) One stage of column flotation generally replaces multi-stage conventional flotation.

Column flotation is commercially used all over the world due to its salient features such as better hydrodynamic conditions and froth washing mechanisms that exist in the flotation column which enhances both recovery and grade, compared to conventional cells.

Extensive laboratory scale studies were carried out at CSIR-NML Madras Centre on feed to sillimanite flotation circuit to arrive at the required reagents' dosages, optimum grade, and recovery of sillimanite and design parameters of flotation column installed at M/s KMML.

M/s McNally Sayaji Engineering Limited, Bengaluru, CSIR-NML's engineering partner, executed the supply of all equipment and instruments, fabrication, erection, and integration of all sub-systems consisting of air compressor, air dehumidifier, column shells and conditioners etc.

Technology Package

(i) Flotation reagent development in collaboration with M/s Somu Organo Chem Pvt. Ltd., Bengaluru,

(ii) Flotation column design, engineering, erection, commissioning, stabilization and training in collaboration with M/s McNally Sayaji Engineering Limited., Bengaluru.

Figure 1: Flotation column

Impact on Society

Detailed Project Report (DPR) on Common Facility Centre for Silver Cluster

India is one of the world's largest silver markets, with a very traditional core in a diverse market. In the sculptures and the paintings can be seen the wide range of jewelry worn by king and commoner. It is the traditional cultural heritage of Indian society. The artisans are still following an age-old traditional process for making ornaments. Lack of innovation and modernization paves the way to a variety of problems ranging from raw material to the marketing of products. However, under the changing socio-economic environment, Government and non-government organizations are instrumental in assisting the sector. In order to this, Directorate of MSME, Government of West Bengal is coming forward to help the silver clusters. The artisans of this cluster form a co-operative society named "Jafarnagar Astha Silver Ornaments Artisan's Welfare Foundation".

Based on the inputs from General Manager (GM)/ Industrial Development Officer (IDO) of District Industry Centre (DIC), artisans, site survey, and discussion with vendors at their site as well as at CSIR-NML the intended Detailed Project Report (DPR) has been prepared which contains the basic details of the cluster, benchmark survey, proposed business model, machinery required, bill of quantity for civil estimation, commercial viability and demand and scope for diversification. Infra-facilities proposed for CFC to house the equipment and their accessories which also includes office building, operator's accommodation, boundary.

Figure: Silver thali and ornaments developed at cluster

Skill Development Program:

The Council of Scientific and Industrial Research (CSIR) aligning with the government of India on the "Skill India" mission launched the 'CSIR-Integrated Skill Initiative' program. Under the umbrella of skill India, all CSIR laboratories have taken up various skill training programs under different domains. The purpose of the CSIR-Integrated skill initiative is to generate quality human resources at various levels by providing and upgrading skills in all the possible fields at various levels beginning with school dropouts to Farmers to ITI diploma holders to graduates. From 2017 to 2022, CSIR-NML received fund around Rs. 150 Lakhs from CSIR under 'CSIR-Integrated Skill Training' to provide skill training ranging from basic training for rural youths, summer/winter internship for undergraduate students, M. Tech/Ph.D. dissertation guidance for post-graduate students, apprenticeship training for ITI/Diploma/Graduate engineers and specialized training

for professionals from industries. These training programs vary from a few days to a year in duration. The focus is to develop skills in the area of metals, metallurgy, manufacturing, waste utilization, soft skills, and entrepreneurship development. In FY 2022 – 2023, CSIR-NML trained 691 participants, through corporate training programmes, societal training program, and Others training program. CSIR-NML Conducted 3 corporate training program named Metallography Techniques, Minerals & Coal Characterization (MMC 2022) and Exposure Training on Metallic Pipes for CIPET Officials - (Phase-III)15 Societal training program has been conducted by CSIR-NML i.e. Innovative Product prototype making, Hands on experiment on water splitting for green hydrogen production, NML visit by NIT Jamshedpur, NML visit by Students of Goa Engineering College, Fitter – Mechanical Assembly, Industrial training on materials & metallurgical engineering, Internship Training on Innovative Product Prototype Making (Batch IV), Internship Training on Innovative Product Prototype Making (Batch III), Animation Making Training, Industrial R & D Training on Materials and Metallurgical Engineering, Internship Training on Innovative Product Prototype Making (Batch II), Internship training on innovation productivity prototype making (Batch I), NML Visit by Kazi Nazrul University students. CSIR-NML conducted 4 Others Training Program like M.Tech/ PhD guidance, National Apprenticeship Training, Winter and Summer Internship program. Some of the future plan by CSIR-NML is to conduct Women centric training programs, Entrepreneurship focused training programs, NSDC accreditation for conducting NSDC training program and Trainings to empower rural person.

Metallography Techniques Training

Women Technology Park

CSIR-National Metallurgical Laboratory (NML) in association with the National Institute of Advanced Manufacturing Technology (NIAMT), Ranchi is implementing a Women Technology Park (WTP) sponsored by the Department of Science & Technology (DST). The title of the project is Women Technology Park (WTP) for capacity building and entrepreneurship development at Ranchi and East Singhbhum. The project is approved under the Science for Equity, Empowerment & Development (SEED) program of DST. The project cost is 52.6 lakhs.

The objective of the project is to train rural women in the areas of Waste Management and Carpentry for capacity building and entrepreneurship development. In FY 22-23, CSIR-NML trained 117 women participants in the area of Institutional Waste Management and carpentry. CSIR-NML successfully conducted the following training: Handmade Paper Making, Carpentry and Woodcraft with 3D Design Software, Computer, 3d Printing & Product Development (C3PD).

In the Institutional Waste Management training program, the participants were trained to utilize paper waste & electronic waste. They learned to make handmade paper using waste paper and also learned to make various products from waste paper like earrings, planter covers, bookmarks and key hangers. In addition, participants learned basic computer skills, art & craft skills, professional soft skills and marketing skills.

Along with the above-mentioned training program, under the DST-Women Technology Park project, CSIR-NML organized training on Mental Health, Women Empowerment, COVID-19, Media Literacy, and Professional skills.

Certificate Distribution Program

Art & craft Training

Handmade Paper Products training at Jamtara

Carpentry Training at CSIR-NML

Paper Plate Making

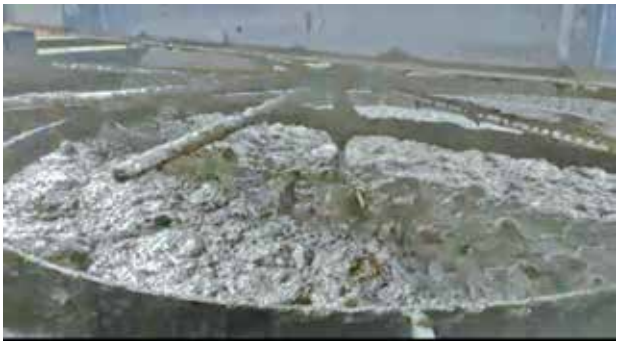
Technologies Commercialized

Column Flotation Technology

CSIR - National Metallurgical Laboratory (CSIR-NML) has been in the forefront in indigenizing the '**Column Flotation Technology**' for processing lean grade and fine-grained ores for more than three decades. Laboratory scale (74mm diameter) and Pilot plant scale (500mm diameter) flotation columns were designed, fabricated and field tested at various private and public sector mineral processing industries located across the country. Development of column flotation technology achieved **Technology Readiness Level - 9**, implying that it is ready for successful deployment at commercial scale. The USP of CSIR - NML is providing a '**One-stop solution for installation and commissioning of commercial scale flotation columns'** by collaborating and partnering with an EPC company, M/s McNally Sayaji Engineering Co. Limited, Bengaluru and reagents manufacturers and suppliers, M/s Somu Organo-Chem Private Limited, Bengaluru. So far, **5 laboratory scale, 1 pilot plant scale and 8 commercial scale flotation columns were commissioned**.

Recently, a commercial scale flotation column of 200 tpd was installed at Bhelatand Coal Preparation Plant of M/s Tata Steel Limited.

Commercial flotation column (200 tpd) at Bhelatand Coal Preparation Plant, M/s Tata Steel Limited



Recovery of fine coal in 200 tpd flotation column installed at M/s Tata Steel, Bhelatand Coal Processing Unit

Sillimanite concentrate recovery from 120 tpd flotation column at M/s Kerala Minerals & Metals Ltd. (KMML)

Recyclib Pvt. Ltd., New Delhi Commercialized the LIBs Recycling Plant Based on CSIR-NML Technology

A license was provided to M/s Recyclib Pvt. Ltd., New Delhi for the commercialization of CSIR-NML's Know-how for the recovery of Co, Li, Mn, Cu, Ni, Al, graphite and saleable plastics from waste LIBs. The recycling plant M/s Recyclib Pvt. Ltd. under the Directorship of Mr. Mohit Garg is ready for commercial production to recover Co, Li, Mn, Cu, Ni, Al and graphite as saleable product from waste LIBs. The plant has established good infrastructure and has latest equipments for the recycling of waste lithium-ion batteries (LIBs). All the equipments are properly installed and connected in a closed-loop for extraction and recovery of metals from waste LIBs. The newly commercialized recycling company is now operational for the production of saleable products of Cu, Ni, Co, Mn and Li from LIBs based on CSIR-NML technology.

Initially, the batteries are discharged in environmental friendly manner, further shredded using the scutter cutter and processed for the separation of black powder, plastics and metallic fractions using wet gravity separation techniques. The black powder obtained is processed for the leaching of metals using chemical processing in closed loop system. The obtained black powder is processed under the optimized condition in a leaching reactor as per the CSIR-NML know-how and optimized conditions. The leach liquor generated is filtered using filter press to separate the solution from the slurry whereas the leached residue (mainly graphite) is further treated and washed to make saleable graphite. The leach liquor is collected in a storage tank and further processed using advance separation techniques. From, the leach liquor the selective separation of Cu and Ni are made using solvent extraction techniques. The obtained purified solution is processed for the recovery of Co, Li and Mn using precipitation, evaporation and electrowinning technique. The recycling plant is successful in view of environmental concern and feasibility with physical processing, hydro- and electro-metallurgical set-up.

MoU signed between CSIR-NML and Recyclib Pvt. Ltd., Delhi for e-waste recycling technology

MoU Signed between CSIR-NML and M/s Recyclib Pvt. Ltd., New Delhi

Demonstration to M/s Recyclib Pvt. Ltd., New Delhi at CSIR-NML

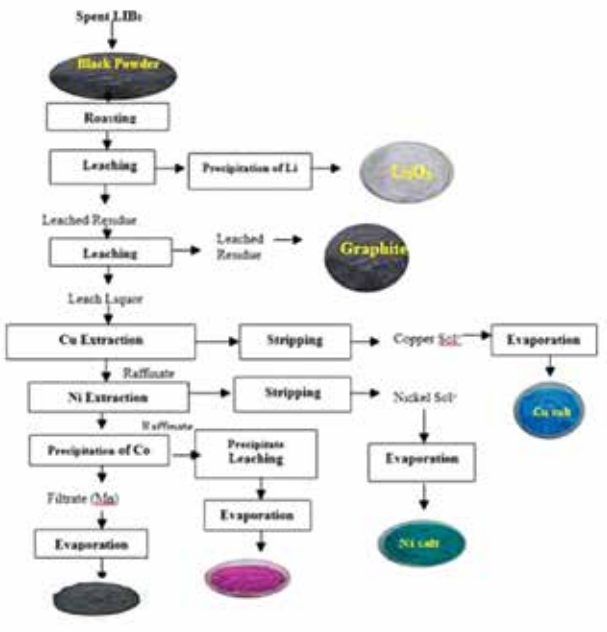
Closed-loop Know-How to recycle spent LitLihium-ion Batteries (LIBs) to produce value added products of Li, Co, Mn, Cu, Ni, saleable plastics and graphite (NILE Li-Cycle Pvt. Ltd., Hyderabad)

Front view of M/s Recyclib Pvt. Ltd., Kashipur, Uttrakhand

LitLihium-ion Batteries (LIBs) to Produce Value Added Products of Li, Co, Mn, Cu, Ni, Saleable Plastics and Graphite (NILE Li-Cycle Pvt. Ltd., Hyderabad)

CSIR-NML transferred Know-how for the recovery of Li, Co, Mn, Cu, Ni, saleable plastics and graphite from waste LIBs to M/s NILE Li-Cycle Pvt. Ltd., Hyderabad. The recycling plant M/s NILE Li-Cycle Pvt. Ltd., Hyderabad under the Directorship of Mr. Kaliprasad is now operational for the production of saleable products of Li, Co, Mn, Cu, Ni, saleable plastics and graphite from LIBs based on CSIR-NML technology.

Initially, the discharged batteries are shredded using scutter cutter machine and processed for the separation of black powder, plastics and metallic fractions using wet gravity separation techniques. Subsequently, leaching of metals from the black powder is carried out by chemical processing in closed loop system in a leaching reactor as per the CSIR-NML technological know-how and optimized conditions. Filtration of the leach liquor is carried out using filter press for the separation of solution from the slurry whereas the leached residue (mainly graphite) is further treated and washed to make saleable graphite. The leach liquor is collected in a storage tank and further processed using advance separation techniques. The obtained purified solution is processed for the recovery of Co, Li, Cu, Ni and Mn using precipitation, evaporation and electrowinning technique.



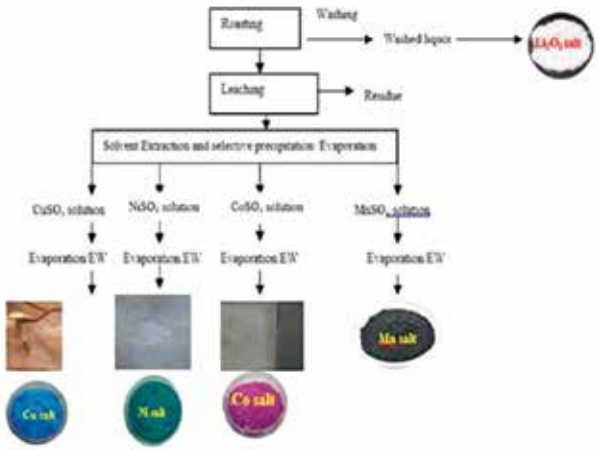
Complete process flow-sheet for the recovery of Li, Co, Mn, Cu, Ni, saleable plastics and Graphite from waste lithium batteries.

Know-How for the Recovery of Co, Li and Mn From Lithium-Ion Batteries (LIBs) with Fine Tuning (Metaore Recycler Pvt. Ltd., Kolkata)

CSIR-NML transferred Know-how to recover Co, Li and Mn from Lithium-Ion Batteries (LIBs) with fine tuning to M/s Metaore Recycler Pvt. Ltd., Kolkata. In this regard, demonstration, training & license were provided to M/s Metaore Recycler Pvt. Ltd., Kolkata.

The recycling plant M/s Metaore Recycler Pvt. Ltd. under the Directorship of Mr. Sourabh Rungta is now operational for the production of saleable products of Co, Li and Mn from Lithium-Ion Batteries based on CSIR-NML technology. The plant has established good infrastructure and has latest equipments for the recycling of waste LIBs. All the equipments are properly installed and connected in a closed-loop for extraction and recovery of metals from waste LIBs.

Initially, the batteries are discharged in environmental friendly manner, further shredded using scutter cutter and processed for the separation of black powder, plastics and metallic fractions using wet gravity separation techniques. The black powder obtained is processed for the leaching of metals using chemical processing in closed loop system. The obtained black powder is processed under the optimized condition in a leaching reactor as per the CSIR-NML technological know-how and optimized conditions. The leach liquor generated is filtered using filter press to separate the solution from the slurry whereas the leached residue (mainly graphite) is further treated and washed to make saleable graphite. The leach liquor is collected in a storage tank and further processed using advance separation techniques. From, the leach liquor the selective separation of Cu and Ni are made using solvent extraction techniques. The obtained purified solution is processed for the recovery of Co, Li and Mn using precipitation, evaporation and electrowinning techniques.



Complete process flow-sheet for the extraction of Co, Mn, Cu, Ni and Li from black powder of lithium-ion batteries (LIBs).

Know-How for the Extraction of Cu, Al and Au from Waste PCBs (Metaore Recycler Pvt. Ltd., Kolkata)

CSIR-NML transferred Know-How for the extraction of Cu, Al and Au from waste PCBs to M/s Metaore Recycler Pvt. Ltd., Kolkata. In this regard, demonstration, training & license were provided to M/s Metaore Recycler Pvt. Ltd., Kolkata. The plant has well established hydrometallurgical infrastructure and has latest equipments for the recycling of waste PCBs. All the equipments are properly installed and connected in a closed-loop for extraction and recovery of metals from waste PCBs.

Initially, the PCBs are dismantled and depopulated. Further, pre-treatment and beneficiation of the depopulated PCBs is carried out to separate, epoxies and metallic concentrate. Hydrometallurgical recovery of Cu from metallic concentrate of PCBs is carried under the optimized condition followed by recovery of gold from the small depopulated components. Aluminum is recovered from the heat exchanger mounted on the PCBs.

The technology is used for the commercial production as per the flow-sheet.

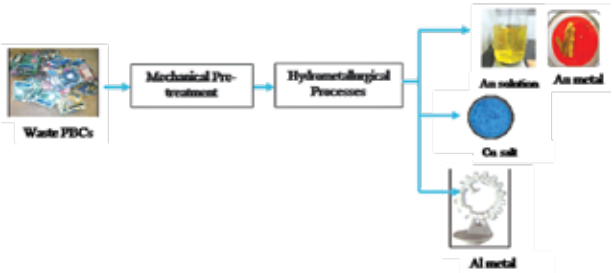
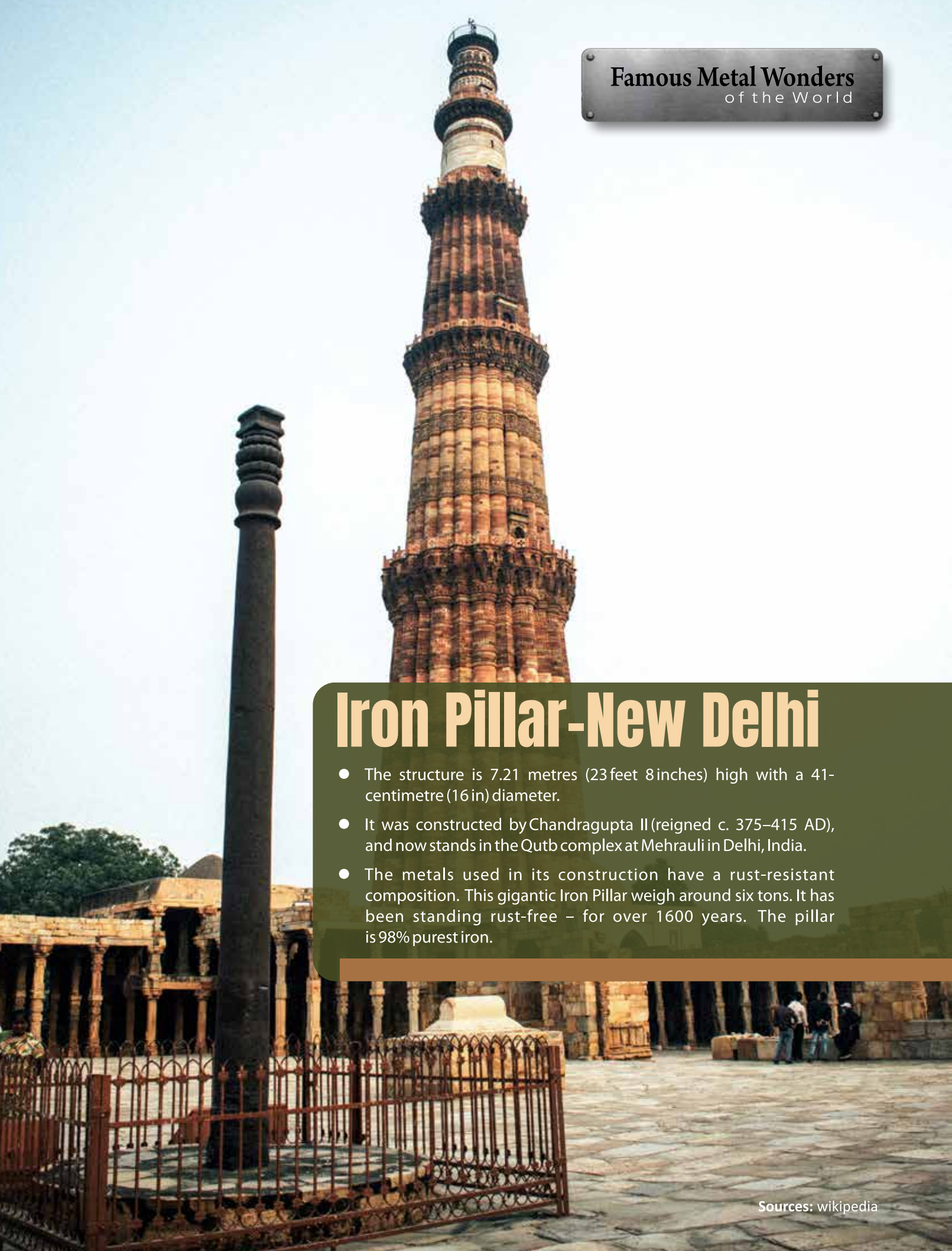


Figure 6: Process flow-sheet for the recovery of metals from waste PCBs



Iron Pillar-New Delhi

- The structure is 7.21 metres (23 feet 8 inches) high with a 41-centimetre (16 in) diameter.
- It was constructed by Chandragupta II (reigned c. 375–415 AD), and now stands in the Qutb complex at Mehrauli in Delhi, India.
- The metals used in its construction have a rust-resistant composition. This gigantic Iron Pillar weigh around six tons. It has been standing rust-free – for over 1600 years. The pillar is 98% purest iron.

Sources: wikipedia

Performance Targets Planned for 2023-2024

	Objectives	Planned
1.	External Cash Flow (ECF)	25.0 Crores
2.	Industrial ECF (a part of ECF)	12.0 Crores
3.	Customer Satisfaction Index	4.9 (Max 5)
4.	SCI Publications	125
5.	Patents	20
6.	Copyrights	5
7.	Technologies to be Developed	5
8.	Technologies to be Transferred	5

Major Technological & Scientific Targets Planned for 2023-2024

Applied & Analytical Chemistry

- A sponsored project from Coal India Limited on "Coking coal assessment through Artificial Intelligence".
- Self-healing coating for corrosion protection of structural steel.
- Benzoic acid reference material for calorimetry /or bomb calorimeter analysis.
- Salvaging Lithium mixed metal oxide and converting into value added product from spent Li-ion Battery.
- Development of alternate reagent for the elimination of mercury effect for reliable analysis of Hg in coal and coal fly ash samples.
- Development of 6063 grade Al disc standard (500Nos.)
- Development of two different grade Pb base disc CRMs (500Nos. of each grade).
- Development of four different grade Chromite ore CRMs (200Nos. of each grade).

Materials Evaluation

- Scaling up of armour steel to achieve TRL-7
- Powder production of superalloys for additive manufacturing

Metal Extraction & Recycling

- Green Steel Making in Induction Furnace/Electric Arc Furnace using Hydrogen based DRI
- To set up pilot scale battery dismantling setup.
- To develop lab scale process for the recycling of discarded solar panels.
- To initiate studies on use of MOF's in post combustion CO2 capture

Advanced Materials and Processes
• Commercialization of the MXene (Ti_3C_2) technology**.** • LTCC based eddy current sensor susceptible beyond 600 °C for real time creep damage monitoring in power plant components. • AI based smart alarm system for predicting critical zone of large industrial structure using embedded FBG sensors. • Integrity assessment of Iron Beams of Konarka Sun Temple. • Predictive model for weld quality assessment based on thermal imaging. • CEMILAC Certification and Patent for Electroplating of Binary Zn-Mn Alloy Coatings from Deep Eutectic Solvents-based Electrolytes (December 2023 onward) • Development of ferrochrome slag coating for continuous steel caster rolls • Development of antimony chalcogenide-based photoabsorber coatings for photovoltaic applications • Development of Zn-Al-Mg based hot dip coating for cold rolled steel sheet (RDCSI)
Minerals Processing
• Pilot scale trials with oily bubble flotation. ❖ Study of Oily Bubble effect on seam 5 coal
• Novel Collector Reagent performance evaluation during flotation of coal ❖ Pilot scale trials with novel reagent and conventional reagent. ❖ Performance evaluation in terms of ash rejection and yield achieved
• Beneficiation of coking coal by hybrid mode: dry and wet processing to reduce the ash forming impurities. (**Ministry of Steel, Two years**) ❖ Dry de-shaling of high ash coking coal to improve the quality of the feed material before wet processing ❖ Dry beneficiation at coarser size using Air fluidized vibrating deck separator (AVFD) to generate pre-concentrate before subjecting to wet methods. ❖ Wet processing of coking coal sample using Dense medium cyclone and Column flotation technique to achieve the targeted ash of 14-17% with maximum yield.
• Development of a process for the production of chromic oxide from chromite beneficiation plant tailing (CSIR funded). ❖ Detailed Characterization of chromite Tailing sample will be carried out. ❖ Bench Scale beneficiation studies in advance gravity concentrator will be done.
• Feasibility study on reduction roasting of high-iron bauxite ore ❖ Roasting followed by Magnetic separation was planned carried out. ❖ It was noted that alumina content enhanced from 26% to around 44% with a yield of 43%. However, iron content in product is high due to isomorphs substitution of Fe atom in alumina.

Flagship Projects

A. Coal Beneficiation

Effective Utilization of Middlings of Coking Coal Washery for Recovery of Carbon Values

Coking coal is a scarce commodity in India. The demand of coking coal in steel sector is increasing day by day due to the expansion of existing steel plants and addition of Greenfield projects in the country. Indian coking coals are characterized by high ash owing to their drift origin and sometimes has inferior coking properties. Therefore, to meet the desired grade of coking coal for blast furnace coke, imported coking coal are blended with the indigenous coal.

Indian coking coal washeries produce three types of products-clean coal, middling and reject. It is found that because of gradual depletion of the high grade raw coal, generation of middling is increasing day by day, while the yield of clean coal is decreasing in the washeries. The middlings generated from Coking coal washeries is about 35-40% with35-42% ash. It contains more than 3000 K Cal/Kg Gross calorific value. Presently this product is used for power plant. This middling could an excellent potential source of coking coal in view of conservation of this scarce coking coal reserve of the nation. Hence, there is a need to beneficiate the middling to enhance the recovery in order to conserve and sustain the scare resource of coking coal.

Objectives of the present research project are to address the characterization of middling and fine coal samples from coking coalwasheries, explore the possibility of recovering the washed coal at about 18%-19% ash from middlings of coking coal washeries by wet and dry process, and to develop process flowsheet for producing a product with 18% ash for enhancing the carbon recovery and reduction of surface moisture of washed products. Two coking coal washeries have been identified to collect the middling samples to carry out the study. From the study it was possible to achieve a product with 18-19% ash from 42-45% middling samplesby reducing the top size of 13mm to -1mm using spiral concentrator. Further work is underway to develop the process flowsheet.

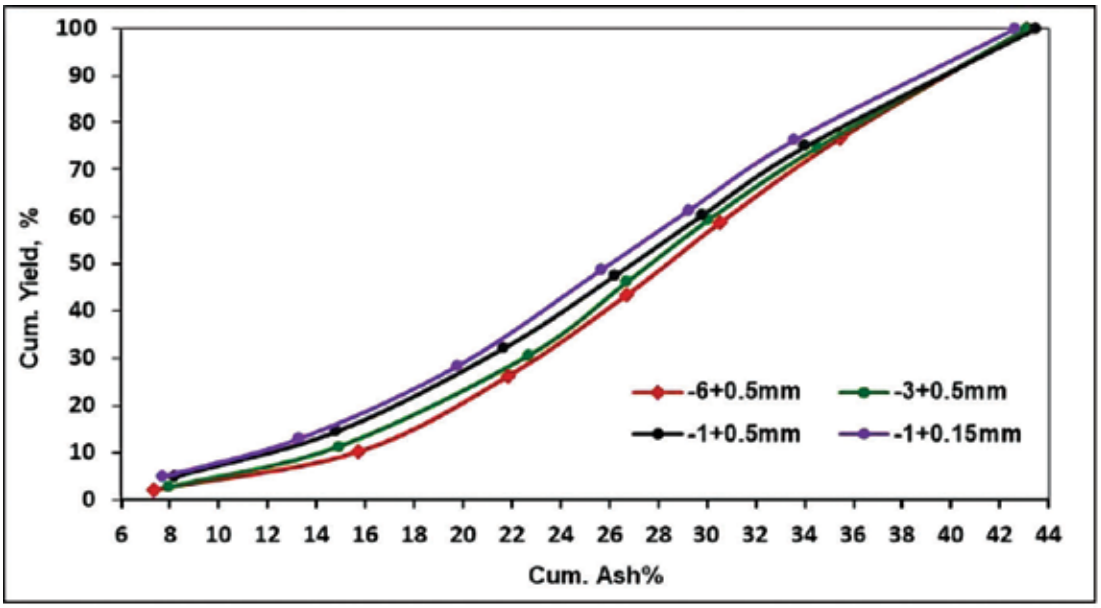


Figure 1: Washability study of middling sample at different top sizes.

Processing of High Ash & High Sulphur Containing Lignite Coal from Gujarat

Lignite coal is often referred to as brown coal. It is a soft brown combustible sedimentary rock that is formed from naturally compressed peat. It is the lowest grade coal having least concentration of carbon and high moisture content. Lignite contains low heating value. It is mainly used in electricity generation. However, small amounts are used in agriculture, as jet, in jewelry.

Lignite samplesfrom different seams of one of the biggest mines of Gujarat containing high sulphur and ash were studied to produce Lignite concentrate with ash below 17% and sulphur below 3%. Washability study of the composite lignite sample (Figure 2) was carried out to assessthe amenability to processing. It was found from washability study that 95% yield could be achieved at 17% ash level. Dry processing of composite lignitesample was studied by different techniques using dry high intensity magnetic separator (DHIMS), FGX-dry coal separator and Air Jig separator with different feed sizes. From the detail dry processing studies, five different process schemes evolving different techniques were developed. The Scheme evolved from theseparation of +50mm fraction by dry sieving followed by dry processing of -50mm fraction by FGX-1 separator results product yield of 84.8% with ash content of 17%.

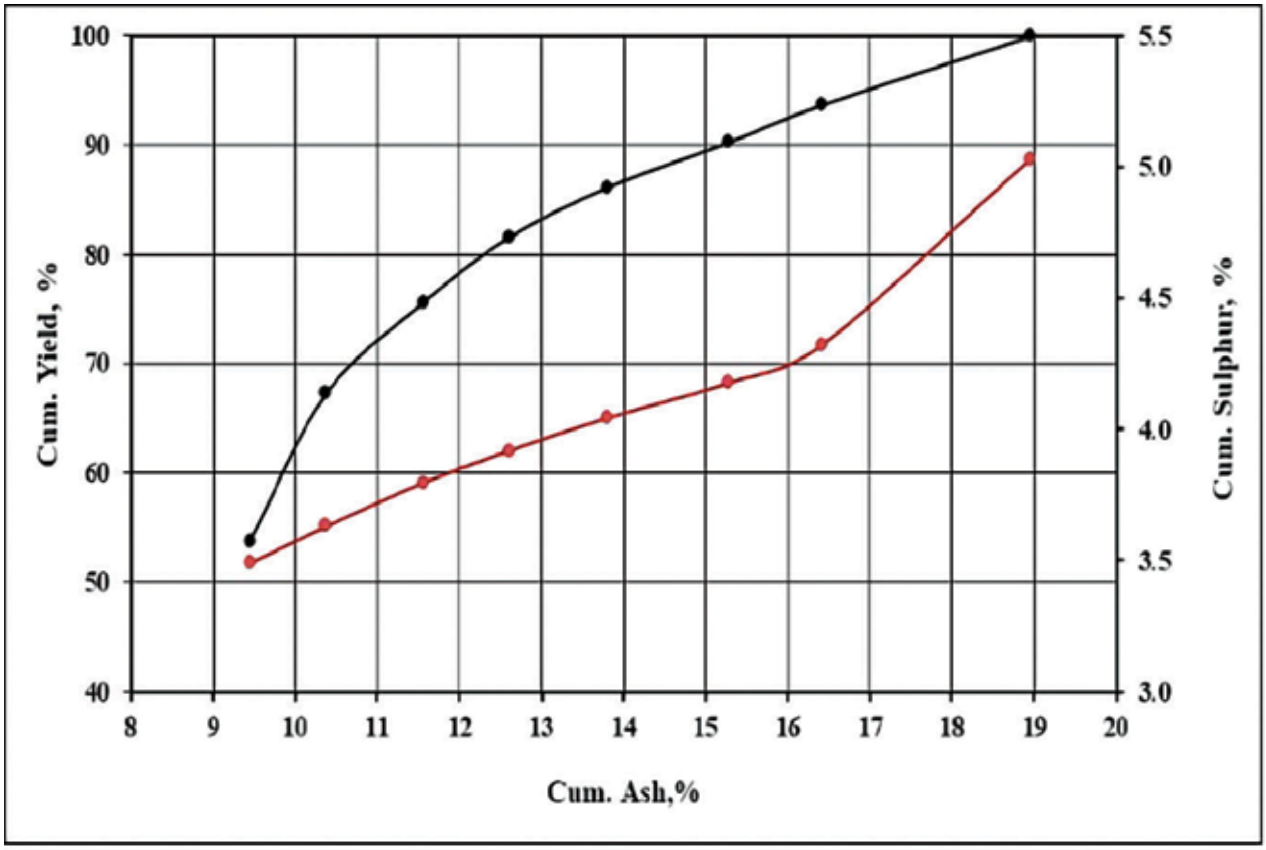


Figure 2: Washability curve of Composite Lignite sample.

B. Railways

Development of standard in collaboration with RDSO for procurement of center buffer coupler (CBC) for Indian Railways; evaluation and assessment of CBC manufactured by Indian vendors (Foundry) for supply to Indian Railway

Centre Buffer Couplers are used for joining freight cars of Indian Railways (Figure 3). Before 2009, the CBCs were imported and were expensive. The indigenized CBCs were supplied to Railways after 2009. However, there were many field failures resulting in revenue losses. During 2010-11, RDSO had approached CSIR-NML to have the root cause analysis of these CBC failures; suggest preventive measures and also help to develop a new standard for supply of healthy CBC to Railways.

Figure 3: (a) Centre Buffer Coupler (CBC) joining two rolling stocks; (b) Different parts of CBC (Yoke, Body, Knuckle)

RDSO in collaboration and consultation with CSIR-NML developed a **standard WD-70-BD** with the following objectives:

(i) Indigenization of Grade E castings used for manufacturing of Center Buffer Couplers (CBC);

(ii) Safety in rail transport;

(iii) Revenue saving

The standard WD-70-BD envisage that the CBC manufactured by foundry need to be evaluated at NML for soundness of casting, mechanical properties, microstructure etc. Presently, several manufactures in India have started manufacturing and supplying CBC to Railways and some vendors are under developmental stage. The contribution mentioned above helped in: Indigenous vendor development for Indian railways, saving in revenue losses resulting from parting of wagons, Safety in rail transport, Spin off projects led to ECF of about 400 Lakhs INR.

Metallurgical Failure Analysis of Railway Wheel Disc

A pre-mature failure of metro rail wheel was reported to CSIR-NML. An investigation was carried out to find out the root cause of wheel damage / failure. The as received wheel discs were shown in Figure 4. Visual examination revealed that one of the wheel discs contained fracture, along with delamination over the edge of tread, opposite to flange. Signature of degeneration also contained spalling at the centre of tread; cracks along the circumference and skidding near fracture of the same wheel are shown in Figure 5. The other part of the particular wheel and the counter wheel of the same assembly (condemned wheel) did not show any degeneration. Chemical composition of the alloy for railway wheel exhibited substantial variation in hydrogen content for both damaged and condemned wheels with respect to EN 13262 ER8 Cat2 standard. H_2 content in the damaged and service exposed condemned wheels was significantly higher with respect to the specification. Cr content in virgin wheel showed marginal deviation. Mechanical properties of the damaged railway wheel were marginally lower than that of the specification near fracture; however away from that particular location, the alloy satisfied the specification. Condemned wheel in this respect

revealed mechanical strength well above the specified limit. Microstructure of rim consisted of ferrite-pearlite aggregate. Partial spheroidization of cementite was observed near fracture. Sub-surface of the damaged location revealed the formation of martensite is shown in Figure 6 (a-b). Perhaps the phase transformation was triggered by rapid heating and cooling during sudden braking and spalling was occurred. Inclusions were present within the matrix of the wheel material; they were MnS and globular oxides for virgin and failed wheel, respectively. The inclusion rating by and large at par with specification, except a meagre variation in one type. Bulk hardness was consistent and satisfied standard for different locations of both damaged and condemned wheels, except the fracture location of damaged wheel. In that region the hardness was increased. The charpy impact energy at ambient temperature and -20 °C of the rim material of fractured wheel and condemned wheel was at par with the specification. The failure was initiated from the microcraking of martensite layer and severely accompanied by hydrogen diffusion to propel crack propagation over time. The hydrogen assisted crack propagation resulted in spalling of material. The spalled region was served as further crack initiation under rolling contact fatigue creating a signature of beach marks. Finally, the component was fractured in quasi-cleavage mode due to limited ductility of the alloy.

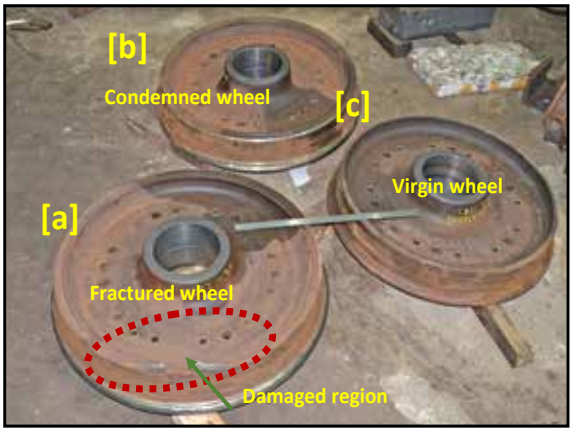


Figure 4. The photographs of as received wheel discs (a) Failed wheel, (b) Service exposed wheel and (c) virgin wheel.

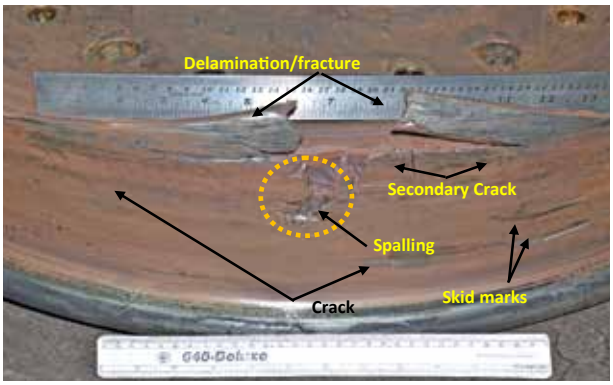


Figure 5: Photograph of damaged wheel showing overall fracture and other signature of different damages on wheel disc.

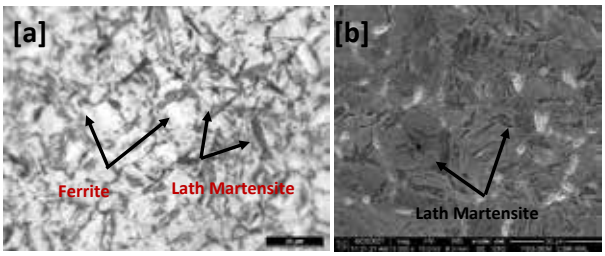


Figure 6. Microstructure showing martensite formation at spalled region due to spalling phenomenon (a) Optical micrographs (b) Scanning electron micrographs

Corrosion Behavior of Different Rail Steels in Varied Environments

The rail steels often seen to be susceptible to three types of corrosion namely atmospheric, microbial and stray current corrosion which result into reduced service life and premature replacement of rails. This study aims to evaluate the comparative corrosion performance comprehensively through standardized test exposures in weathering, saline and microbial environments of six different rail steels developed by SAIL, India. This investigation will facilitate Indian Railways in selection of appropriate rail grade for application in corrosion prone sections based on severity of atmospheric exposure and microbial corrosion. The objective of the present investigation is to study the corrosion behavior of six different grades of rail steel (*Plain carbon 90 UTS rail, Ni-Cu-Cr rail, Cu-Mo rail, High toughness corrosion resistant rails (HTCR-3 and HTCR-4 grades) and 1080 Cr)* in varied environments as mentioned below:

a) Evaluation of relative corrosion resistance of different rail steels through salt spray exposures in 5 % NaCl solution (as per standard ASTM B117).

b) Evaluation of relative corrosion resistance of different rail steels through cyclic humidity exposures in 1 % NaCl, 1 % $CaCl_2$ and 0.1% H_2SO_4 solution (as per standard ASTM G60-01).

c) Evaluation of relative corrosion resistance of different rail steels through spray exposures in synthetic urine solution with or without bacterial species.

Outcomes:

a) Initially, six different grades of rail steels were evaluated for their relative corrosion performance in 5% NaCl foggy environment through salt spray chamber at temp 35 ± 1°C. The time to first rust (yellowish) spot appearance was recorded around 65 min, 50 min, 45 min, 60 min, 70 min and 60 min for NCC, Cu-Mo, 1080Cr, 705, 699 and 90UTS steels, respectively. Further, the corrosion rate trends (in ascending order) were found to be as follow (pictorial depiction is provided.

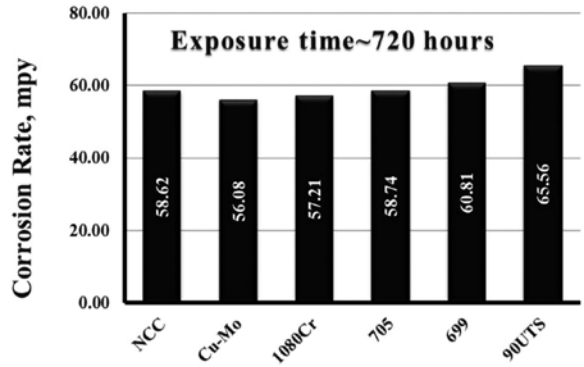


Figure 7. Cu-Mo < 1080Cr < NCC < 705 < 699 < 90UTS.

Corrosion rate of different grades of rail steels in 5% NaCl solutions, exposure time ~ 720 hours.

The localized corrosion (pitting, pit depth) trends were found to be as follows (3D view of topography is represented in ***Figure 1080Cr < NCC < 90UTS < 699 <Cu-Mo < 705,*** whereas uniform thickness loss trends (in ascending order) determined as follows; ***1080Cr < NCC < Cu-Mo < 90UTS < 699 < 705.***

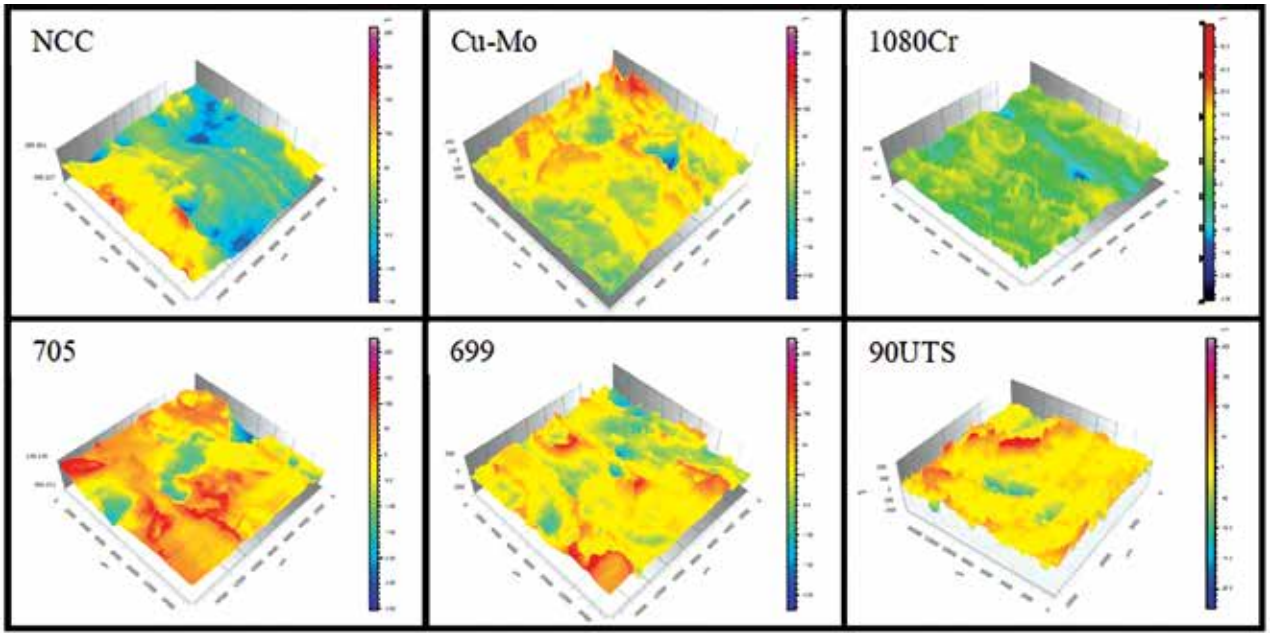


Figure 8. 3D topographical view of corroded surface (after cleaning) after 720 hour's exposure (as per ASTM B117) (Blue color indicates the depth-pit).

Initially, the steel Specimens were exposed to synthetic urine solutions containing no bacterial species at room temperature. The corrosion rate trends (in ascending order) in, were found to be as follow (pictorial depiction is provided in ***Figure NCC < 705 < Cu-Mo < 699 < 90UTS < 1080Cr***

The corrosion rates were found to be almost 10-12 times lower as compared to both salt spray and cyclic humidity environments. The area covered with rust was found to be ~ 29-41% and 42-54% after the completion of 480 and 720 h of exposure, respectively. The localized corrosion (pitting, pit depth) trends were found to be as follows (determined through 3D profilometry); ***NCC < Cu-Mo < 90 UTS < 1080Cr < 705 < 699,*** whereas there wasn't any measurable thickness difference after completion of the exposure duration for all the steels.

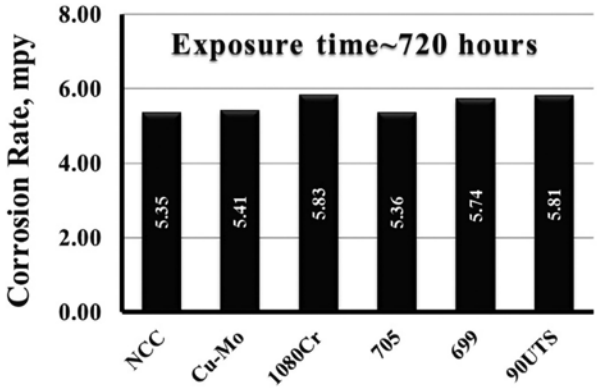


Figure 9. Corrosion rate of different grades of rail steels in synthetic urine solutions without bacterial species at room temperature, exposure time ~ 720 hours.

Further, the steel specimens were exposed to the synthetic urine solutions inoculated with microbial species through immersion method. The bacterial species were isolated and sub-cultured from the corroded rail specimens collected from in-service railway lines (Ranchi & Hatia Railway stations). The corrosion rate trends (in ascending order) in, were found to be as follow (pictorial depiction is provided in ***Figure***); ***NCC < 705 < Cu-Mo < 699 < 90UTS ~ 1080Cr.***

The corrosion rates found to increase by around three folds in presence of the bacterial species in the synthetic urine solutions. Thus, it is concluded that the corrosion of the rail specimens is guided by the bacterial species which further confirmed by the scanning electron microscope (SEM) which shows well grown bacterial colonies on the specimen surface.

The localized corrosion (pitting, pit depth) trends were found to be as follows (3D view of topography is represented in ***Figure***); ***NCC ~699 < Cu-Mo < 1080Cr < 705 ~90 UTS,*** whereas uniform thickness loss trends (in ascending order) determined as follows; ***NCC < Cu-Mo < 699 < 1080Cr < 705 < 90UTS***.

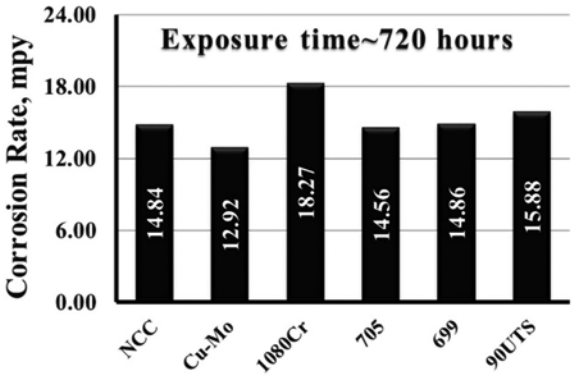


Figure 10. Corrosion rate of different grades of rail steels in synthetic urine solutions with bacterial species at room temperature, exposure time ~ 720 hours.

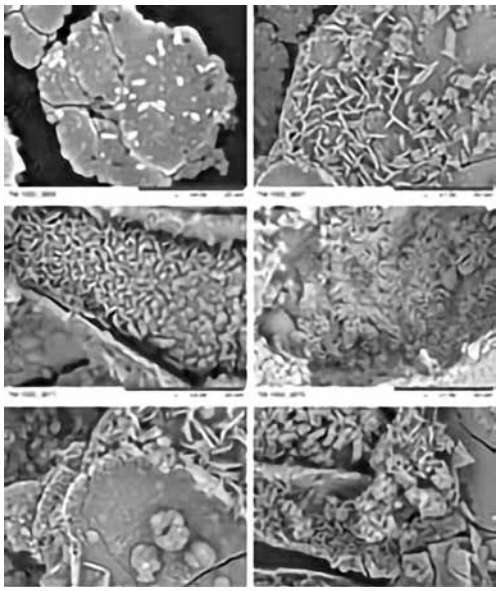


Figure 11. SEM micrographs of the corroded specimens showing the presence of the bacterial colonies on the steel surface; microbial corrosion.

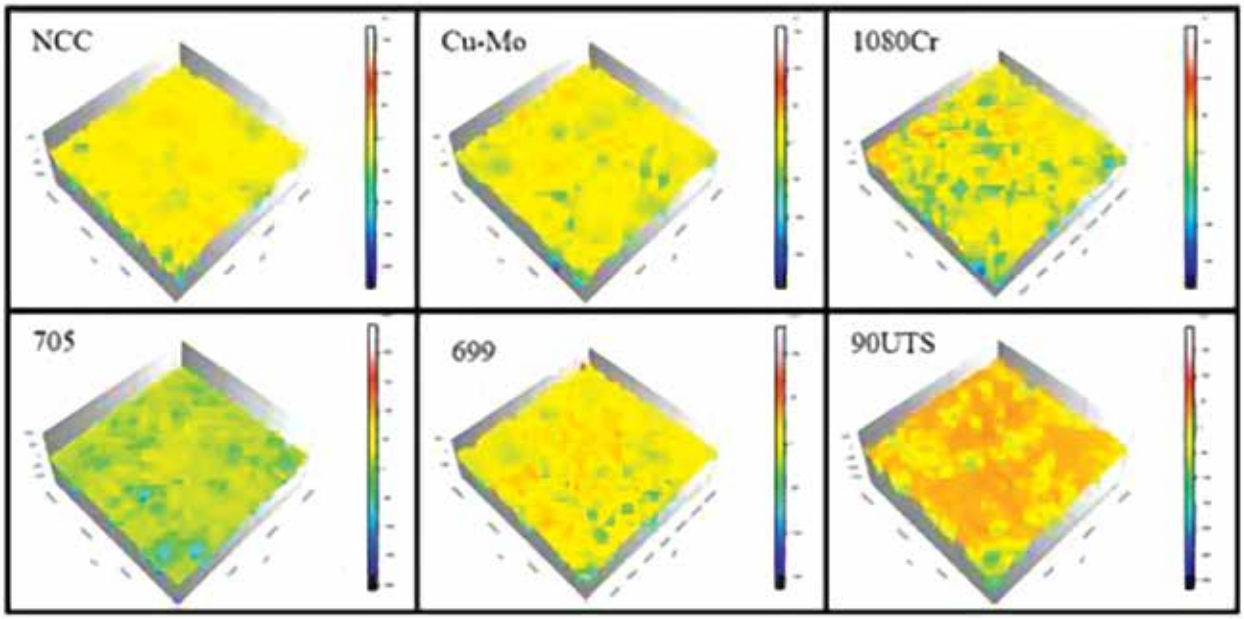
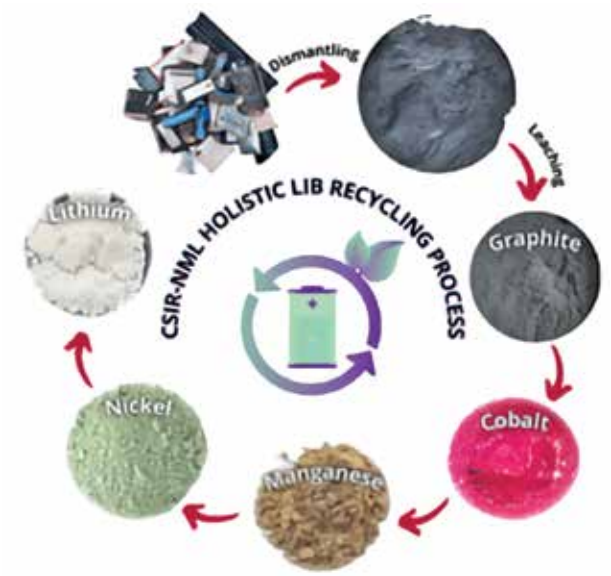


Figure 13. 3D topographical view of corroded surface (after cleaning) after 720 hour's exposure (cleaned as per ASTM G60-01) (Blue color indicates the depth-pit).

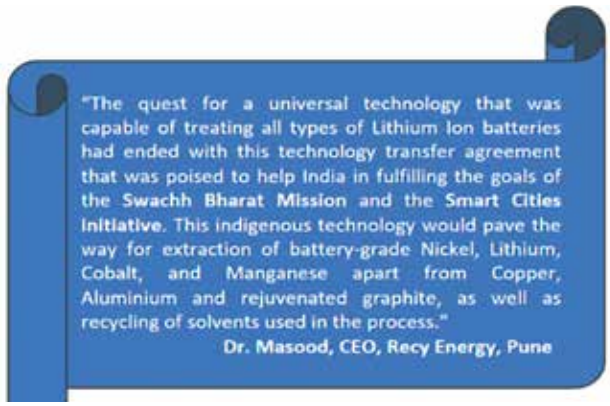
C. Flagship Projects (Extraction Li-Ion Batteries)



Extraction of critical metals form used Li-ion Batteries A Mission Mode Project under CSIR Bulk Chemicals Mission

CSIR-NML, Jamshedpur has developed CSIR's first holistic process that can tackle any type of Lithium based batteries, to extract and separate high pure salt products of Lithium, Nickel, Cobalt, Manganese, Aluminium, Copper, and Reusable Graphite. This process ensures the recovery and yield of Li, Co, Ni, Mn (>95%) with purity >min. 99.6% as carbonate/nitrate/chloride/sulfate/oxide/phosphates (eliminating iron, aluminium, copper) for direct new battery making. It is a blue print tailored patent filed process that can utilize any type of black mass, which provides recyclers a flexibility to buy/collect/use any type of lithium battery and use them to recover all metals or lithium selectively (Patent Appl. No. 202111040164 and 202111040165 dt. 16.09.2021). The process would result in utilization of huge reserves of spent lithium batteries generated in India, and recycling them to recover and supply indigenous metal precursors, which will bring the cost of batteries and in turn the cost of EVs.

The pilot plant is slated to be commissioned at CSIR-NML, Jamshedpur, which shall be first of kind Hire-Operate-Transfer (HOT) platform for MSMEs and Entrepreneurs in India. Currently, it has signed agreements with five Indian firms with whom technology transfer is on anvil, and more are in the queue.

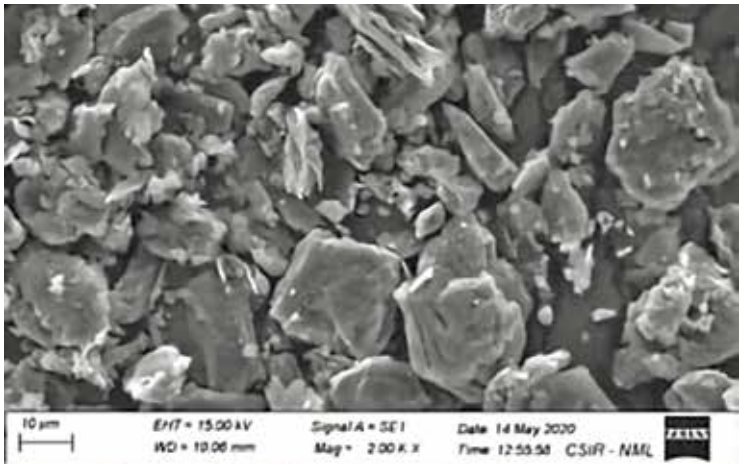


Technology Transfer agreement signed with M/s Recy Energy, Pune (25th May 2022)

https://government.economictimes.indiatimes.com/news/technology/national-metallurgical-lab-collaborates-with-pune-based-recy-energy-for-recycling-used-lithium-ion-batteries/91977577

Recycling of Graphite from Spent Lithium-Ion Batteries for High Energy Li-Ion Capacitors (In Association with IISER, Tirupati)

This project is operated in the close knit association of IISER-Tirupati, NML Jamshedpur and Industrial Partner. The project is based on the objectives of recovery and purification of graphite from spent LIB followed by production of high energy and power LIC (>150 Wh kg^{-1}).



The high pure graphite synthesised at CSIR-NML has been submitted to IISER, Tirupati for trials. The analysis of graphite shows >95% purity on chemical analysis basis and >99% on SEM mapping. The flake graphite shall be conditioned and used in the project deliverables.

Strategic Sector Projects

A. Space

Effect of Processing Parameters on Cryo Impact Properties of Cast Alloys

The project aims to investigate the phase evolution with different heat treatment conditions (quenching and tempering route) and their effect on cryo-impact properties of super-martensitic stainless steel grades. The output of the work would be the assessment of heat treatment parameter on cryo impact properties of existing alloy grade and the design of new alloy composition with its Quenching & Tempering parameter that would give desired mechanical properties.

The objectives of the work are as follows:

I. To assess the effect of heat treatment parameters on cryo-impact properties of as-cast alloy. The proposal aims to study:

- Factors affecting the stability of retained austenite
- Factors affecting the transformation of room temperature retained austenite to martensite at cryogenic temperature (77 K)

II. To design alloy an alloy composition and its Q&T parameter which would give 100 J impact energy at 77K, Room temperature properties: YS 800 MPa, UTS 1050 MPa and Elongation 14%.

A super-martensitic stainless steel having 6.5-8 wt.% Ni was designed with the help of thermodynamic and kinetic simulation in ThermoCalc software, and taken up for the study. A detailed thermodynamic analysis, prediction of Martensite start (M_s) temperature and prediction of retained austenite at room temperature and -196 °C were done. Thereon appropriate heat treatment schedules were designed and experiments were performed. Tensile property (at RT) and impact properties (at RT and -196 °C) testing was conducted, followed by microstructural characterization. The 250 °C tempered sample exhibited good tensile properties (YS: 843 MPa, UTS: 1077 MPa and % El.: 15%) meeting the targeted properties. Also, it exhibited superior cryo impact property of 74 J at -196 °C. The crystal orientation map and phase map of the sample is shown in the Figure 1 below. Transmission electron microscopy analysis indicated no significant partitioning of substitutional solute elements between martensite and austenite during tempering at 250 °C, however, the presence of fine precipitates (<5 nm) was observed in the sample. Further optimization of alloying content and heat treatment was carried out which led to significant improvement in properties: an excellent cryo Charpy impact toughness of ~90 J (at -196 °C) along with yield strength greater than 800 MPa was achieved in the alloy.

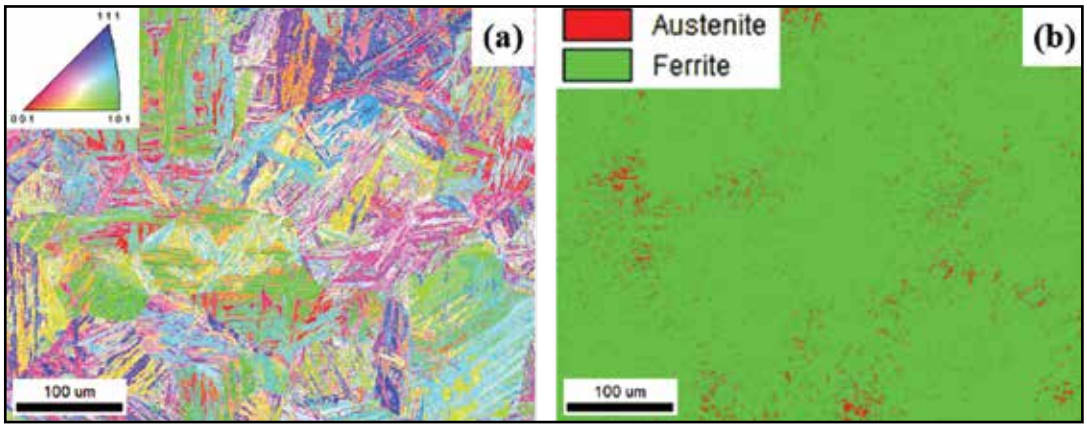


Figure 1: EBSD analysis of the 250 °C tempered sample (a) crystal orientation map and (b) phase map

Electronic Packages for Ultrasonic Flow Meter for On-Board Propellant Gauging of Spacecraft

Spacecraft propellant gauging is one of the important activities that allow estimating the amount of propellant available onboard in a spacecraft. The propellant availability dictates the life of the spacecraft; also the data related to the propellant availability determines the mission sequence and decisions. CSIR-NML along with the collaborator is in this project to fabricate four systems using flight qualified electronics for on-board propellant gauging of space craft based on CSIR-NML technology fluid flow rate detection through a narrow tube. Qualification tests of the devices for continuous and pulsating modes for further use in Indian spacecraft will be carried out on ground in space environment. The electronic package development involves pulser, receiver, onboard storage and signal processing so as to enable acquisition, analysis and delivery of data from spacecraft to the ground stations. After several rounds of project team meetings, design and components for the master module has been confirmed and the fabrication of the master module has been completed. Trials of the master module from 0.1 LPM to 6 LPM flow rate was successfully completed. Fabrication of flight qualified modules are in progress.

Generating Forming Limit Diagram (FLD) of welded and non-welded aluminum sheets using Nakajima Test

The sponsor approached CSIR-NML to develop forming limit diagram (FLD) of non-welded and welded aluminum sheets using Nakajima test. The aluminum sheet thickness for non-welded sheets are in the range of 1~2 mm, while welded sample thickness is 1 mm. Nakajima tests are carried out as per ISO 12004 -02-08 standard in universal sheet metal testing machine with varying blank width from 25 to 200 mm. Figure 2(a) shows the picture of Erichsen universal sheet metal testing machine available at CSIR-NML.

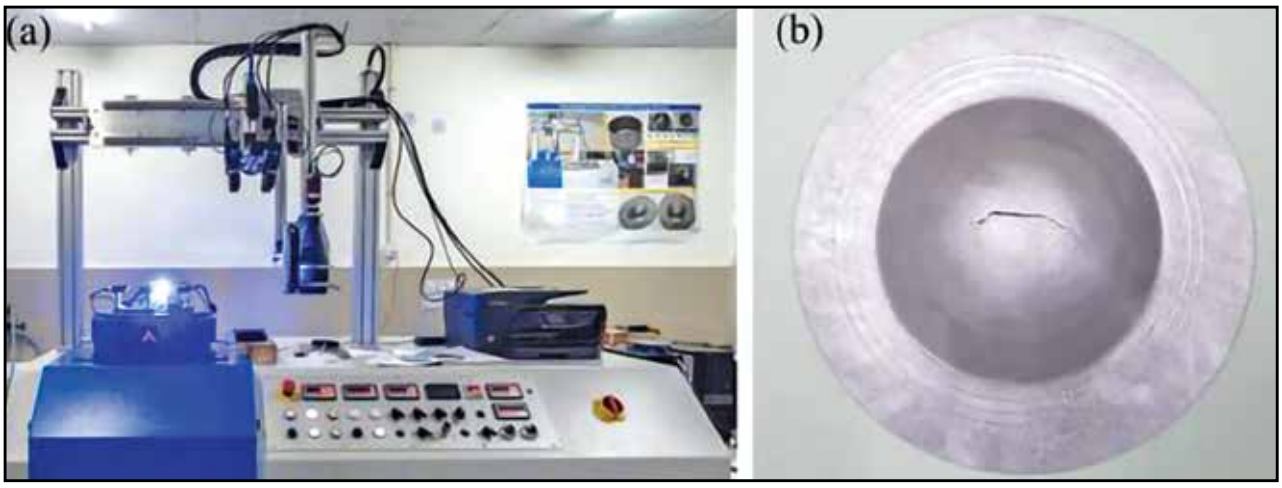


Figure 2: (a) Erichsen sheet metal testing machine, (b) grids generated on aluminium sheet

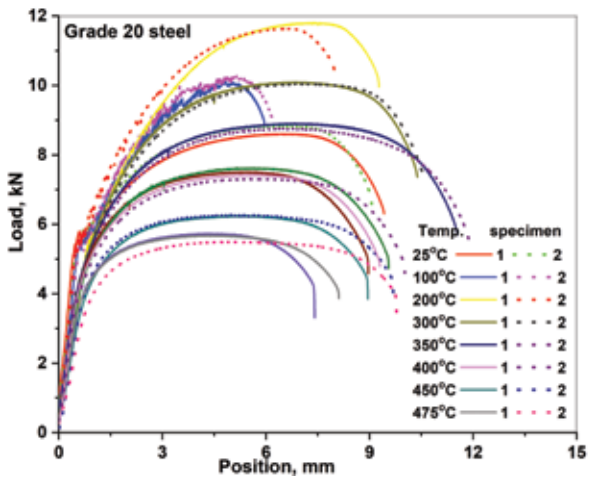
Figure 2 (b) shows a test specimen geometry called dog bone shape blank (waisted blanks with parallel shaft). The widths of the shaft are around 25, 50, 75, 100, 125 and 200 mm for uniform allocation of FLD from uniaxial to biaxial tension. Choice of appropriate grid spacing is essential for quality of the strain analysis. electro-chemical etching is employed to inscribe square grids of 1 mm in dimensions on the aluminum surface, as shown in Figure 2(b). After preparation of grid on the specimen surface, aluminium sheet with proper dimensions is placed in the machine to carry out the Nakajima test based on ISO 12004 standard. Four cameras integrated with the machine perform

in-process measurement of major and minor strains during deformation of the sheet. The drawing punch of 100 mm diameter is used for testing with punch velocity of 60 mm/min. After the test is over, the in-process captured images are analysed by AutoGrid® strain analyzing system to determine the strain paths and subsequently draw forming limit diagram.

B. Navy

Destructive Test / Analysis for Establishing Life Estimation Matrix (LEM) Boiler Tubes

Indian Navy (IN) operates several ships powered by boiler units. As part of regular maintenance efforts formarine boilers, **IN** needed destructive testing and analysis of test results for the sake of establishing life estimation matrix for boiler tubes. Accordingly, tests were carried out for mechanical properties of tensile strength, hardness, stress rupture strength along with microstructural conditions. Boiler tubes in the initial and service-exposed conditions were evaluated. Obtained results were used to establish the life estimation matrix in the initial and service exposed stages.



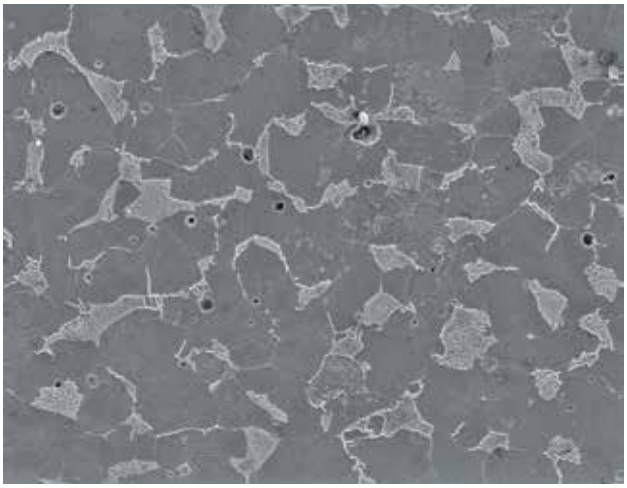


Figure 3: (a) Tensile curves of Grade 20 steel ; (b)Initial microstructure of Grade 20 steel

Metallurgical investigation to explore the damage mechanism of worn out quill shaft.

The Quill shaft of the main fuel Pump of the aero-engine, was worn out during service exposure (as shown in the **Figure** 4 below). To identify the root cause of material damage, the sponsor requested CSIR-NML, Jamshedpur, and accordingly, specimens were received for investigation. Macro observation revealed that the load-bearing surface of the teeth of the quill shaft i.e., on the gear-box side, was damaged. The bulk chemical composition of the virgin and damaged components exhibited deviation in carbide forming elements i.e., Cr and W with respect to the specification. The bulk hardness of the virgin and damaged components were close to each other. The microstructure of the components was tempered martensite containing discrete carbides at the lath boundary. Degradation of microstructure at the core was absent for the damaged component. The cross-sectional structural investigation showed extensive thinning of the teeth. Formation of layered deformed zone and plastic flow of material along the direction of rotation was evident. Surface examination of the damaged teeth (gear-box side) illustrated material flow lines, deformed zone along the surface of the teeth, overlapping of material near edges, and fragmentation of the material.

The investigation confirmed that the damage of gear tooth material occurred under excessive torsional load. The deformation of the gear teeth material gradually thinned down the

tooth alloy and caused extensive material flow near tooth edge. During service under excessive torsional stress, the material was fragmented. Excessive stress beyond the tolerance limit may either have generated from improper lubrication or due to mechanical misalignment.

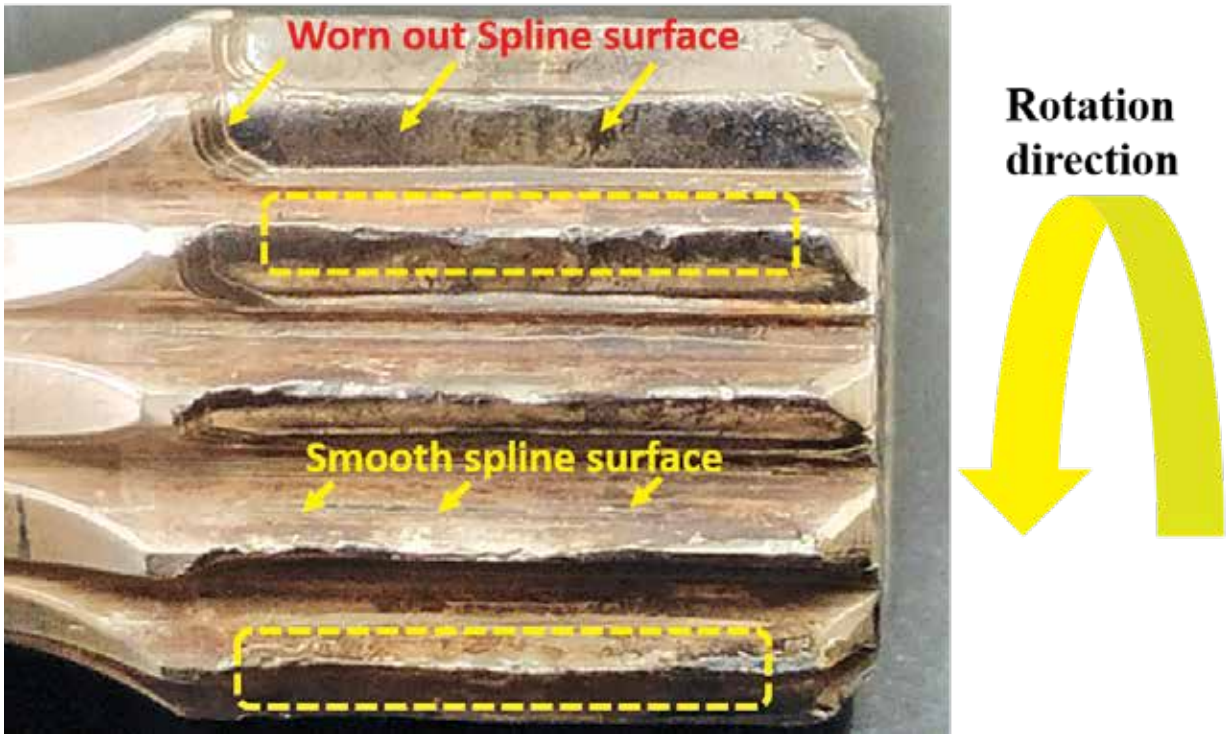


Figure 4: Photograph of the worn out quill shaft component

Analytical & Applied Chemistry

Analytical & Applied Chemistry (AAC) Division has been focusing on the basic and applied research in the areas of Analytical chemistry, Corrosion Inhibitors & Polymeric Coatings, Coal chemistry and Certified Reference Materials (CRMs). The Division is fully equipped with state of the art analytical instruments for analytical support to the ongoing R&D projects of CSIR-NML and provides analytical testing service to outside agencies. The Division is a NABL accredited laboratory for Chemical Testing as per ISO/IEC 17025:2017. Another important activity of the AAC division is to develop and serve Certified Reference Materials (CRMs) for metallurgical products like Ores, Coal, Steel, Ferro-alloys and other metal alloys. The Division has been developing and serving various CRMs in the areas of ores, minerals, coal, steel (powder, gaseous Pin, spectrographic and chip/turning standard) and Ferro alloys. AAC Division is a NABL accredited laboratory for reference materials producer (RMP) as per ISO/IEC 17034:2017. Some of the major achievements/activities of AAC Division in the reporting year are listed hereinafter:

Non-Coking Coal to Coke Making

The prime objective of various projects undertaken in this field of research is to induce swelling and thermoplastic properties in low grade non-coking coal through alteration of structural properties in non-coking coal. This alteration in structural properties has been induced by blending in both natural additives as well as those which are derived from coal. The coke making experiments were conducted on both non-coking and semi-coking coals with lower ash content acquired from different geographical locations. The resultant cokes were characterized using CSR/CRI (Figure 1) and petrographic characterization to ascertain the development of the desired plastic property, strength and mosaic structure.

Figure 1: CRI and CSR facilities to assess reactivity and strength of coke.

Our research team in AAC has successfully completed multiple projects in collaboration with industrial partners assessing the quality of coals of varied geographical origin for their coke making potential. In Indian scenario, successful development of a process to prepare coke by utilizing low grade coals is anticipated to have the following consequence:

- The huge reserved of India's low grade coal, could be utilized for both thermal power plants and metallurgical applications.
- The cost of importing coking coal will reduce significantly, making India self-reliant.

Oil Agglomeration to Beneficiate Indian High Ash Coals

Beneficiation of coal fines using oil agglomeration is known since long time owing to its efficiency and simplicity. The chemical complexity of Indian coals makes the utilization of this process, which is based on selective adsorption owing to difference in surface properties, even more challenging. Extensive research has been done on agglomeration of Indian coals focussing on the various kinds of cost-effective oils which could be employed for the process; however, they were primarily on coking coals. In order to gain an overview of the

behaviour of all the coal types, low grade coals needs equal attention like coking coals, owing to their abundance and application in thermal power plants. They are comparatively more challenging to agglomerate due to their unfavourable hydrophilic surface chemistry. Our research team has conducted extensive research on optimization of all the essential process parameters for oil agglomeration of both prime coking coals and low grade coals (ash content >35%). We have successfully completed two collaborative projects with Coal India Limited (CMPDIL and MCL) on beneficiation of both coking and non-coking coals. An indigenous set up has been developed (Figure 2) for the complete process which can potentially handle up to 2 kg of coal, resulting in demineralization of coals by 50-60% from the original ash content, with high organic recovery (70-80%).

Figure 2: Indigenous oil-agglomeration set up at AAC division.

Extraction of Rare Earth Elements from Coal Ash

Coal ash is the primary by-product of thermal power plants which is generated in huge amount annually. Unfortunately, majority of the waste being generated is being discarded into ash ponds. This apparent waste contains valuable elements, such as rare earth elements and trace elements, which could be potentially extracted. One of such valuables consists of lanthanides along with Sc and Y, collectively termed as rare earth elements (REE). In recent times, due to the ever-increasing demand of REE in every technological sector and restricted primary resource, research on extraction from secondary source such as coal ash has gained momentum. Till date, most of the leaching process has been optimized using mineral acids which are corrosive, destroys the matrix and lacks selectivity. Owing to the environmental concern, development of eco-friendly reagent as a leaching agent is the need of the hour towards designing of sustainable extraction process. Our research team has worked on multiple organic acids (tartaric acid, citric acid, lactic acid and methanesulphonic acid) as potential alternatives to corrosive mineral acids for leaching from coal ash. The optimization of the crucial process parameters such as leaching temperature, acid concentration, reaction duration and solid to liquid ratio along with the experimental challenges thereby has been studied. A bar graph enumerating the leaching potential of REEs from coal ash by various organic acids has been shown in Figure 3. The selectivity imparted by these eco-friendly acids along with the matrix retention ensures further utilization of the residue for construction material, which is typically the biggest use of the waste in the present scenario.

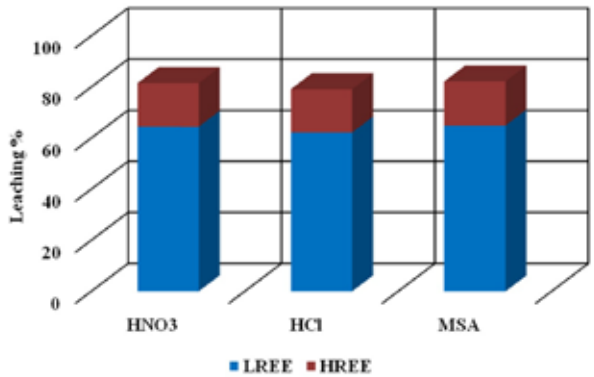


Figure 3: Comparison in leaching % of MSA with respect to mineral acids.

Quantification of REEs, Trace and Major Elements in Soil Sediment Samples

AAC Division has actively involved on the projects sponsored by Geological Survey of India for quantification of rare earth elements (REEs), trace elements, heavy metals (such as Hg) and major elements in soil sediment samples. The study involved development of methodology for

X-ray fluorescence (XRF) instrument analysis and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis including calibration, fusion and digestion methodology for quantitative analysis of various REEs, trace and major elements found in stream sediment samples (Figure 4). The quantified results are validated by NIST SRMs or NIST traceable CRMs.

Figure 4: Digestion and ICP-MS sample preparation of soil sediment samples.

Certified Reference Materials (CRMs)

Reference materials are of critical importance and indispensable for calibration of instrument, method validation, accuracy of analytical results, quality control and quality assurance of products and processes. AAC Division of CSIR-NML is involved in production and marketing of Certified Reference Materials (CRM) for last 50 years. CRM's of NML has created its own market value and has more than 600 Industrial customers across India. We target to develop new CRMs every year. In the FY 22-23, new CRMs for steel such as CRM 216 (0.6 % carbon Steel, turning form) has been developed in a batch size of 1540 bottles (100gm pack) and CRM 220A Stainless Steel, turning form has been developed in a batch size of 205 Bottles (100gm pack). Two nos. of gaseous CRMs such as CRM 204 & CRM 205 for Carbon & Sulfur in Steel PIN form have been developed in a batch size of 210 bottles (100 Pin pack) of each one. Spectrographic CRM 304A for Steel (0.17 % carbon Steel) in Disc form has also been developed in a batch size of 520 nos. All the above CRMs are prepared as per ISO 17034:2016 & Guide 35: 2017 and these are import substitute having notional value for NABL accredited CRMs in India. In addition to the above-mentioned reference materials, CRM Unit, AAC division has developed already 35 nos. of NABL accredited CRMs which are available in brochure uploaded in www.nmlindia.org.

Figure 5: Carbon and Sulfur Standard

Coal Characterization and Analysis

Quality assessment of the coals produced is a job of national importance. AAC Division is recognised as a Referee Laboratory for Coal Analysis. AAC division is actively involved in the coal characterization and analysis such as band by band analysis, seam overall analysis of coal sample received from various subsidiaries (CMPDIL, ECL, BCCL, CCL, SECL, NCL, MCL, WCL etc.) of Coal India Limited. AAC Division carry out quality assessment of both coking and non-coking coals through chemical characterization using its state-of-the-art coal characterization laboratory (Figure 5).

Figure 6: Coal characterization and analysis facility.

Indigenous Development of Benzoic Acid Reference Material for Calorimetry Analysis

Benzoic acid is used as a reference material (RM) for calorimetry analysis such as in bomb calorimeter instrument for calibration. This reference material is hugely used in our country for gross calorific value (GCV) analysis. However, till now there is no Indian manufacturer for producing such type of reference material for GCV analysis. In particular, we are importing this RM from foreign manufacturer. Therefore, indigenous benzoic acid reference material development is an urgent need to meet the demand of benzoic acid reference material production and contribute on the product development for import substitution.

Project Objectives :

- Synthesis and characterization of ultra-pure benzoic acid
- Homogeneity test and stability study of the synthesized material.
- Inter-laboratory comparisons of gross calorific value of the synthesized material
- Statistical analysis and assignment of GCV

In this ongoing project we have synthesized ultra-pure benzoic acid from commercially available raw material. Synthesized product was characterized by NMR spectroscopy, CHN analyzer and melting point measurement. Next, the product was palatalized and gross calorific value (GCV) was experimentally measured. The GCV was found within the range 6305 to 6325 cal/g. GCV value of NIST SRM 39j (Benzoic acid) is 6317.8 cal/g.

Figure 7: Preparation of Benzoic acid and benzoic acid tablet for gross calorific value analysis.

Envisaged deliverables

- ✓ Indigenous development of benzoic acid reference material for calorimetric analysis
- ✓ Production of 200 units, 50gm/unit benzoic acid reference material

Team-AAC

Advanced Materials and Processes

Advanced Materials and Processes (AMP) Division targets the development of advanced materials, processes and techniques for the improvement in performances of materials and components and the mitigation of environmental problems related to materials application in energy, space, oil & gas, iron & steel, biomedical and infrastructure. The division comprises three research verticals namely (i) Surface Engineering (SE), (ii) Functional Materials (FM) and (iii) Non-destructive Evaluation (NDE) Group. The division mainly focuses on (i) Development of advanced materials, coatings for energy, automotive, health, environment, etc., (ii) Development of sensors and devices for non-destructive evaluations and structural health monitoring. The mission of the division is to develop and translate end to end solution to the stake holders with advanced materials and processes under different technological sectors.

Structural Engineering into 3D Macroscopic Architecture with Hierarchical Porosity for Real Application of Energy Storage Devices

By following the objective of this project, several MXenes and carbon based electrode materials for both the energy storage systems like supercapacitor and lithium ion batteries (LIBs) with efficient energy storage performances were successfully developed. For example, a specifically designed 3D carambola shaped SnO_2 wrapped by carbon nanotubes as LIB anode materials which produces long cycling stability was developed and published this work in high impact journal i.e. Chemical Engineering Journal (**impact factor = 16.74**). In another work, a composite of Ti_3C_2 MXene and bi-metallic chalcogenide e.g. NiCoS to apply as supercapacitor electrode material was developed where both EDLC and pseudocapacitive contribution is promisingly controlled its energy storage performance. Ti_3C_2 MXene and conducting polymer e.g. PANI based composite has also been prepared to investigate the effects of a different form of conducting polymers attached to MXene surfaces. Recently, an article was published with **impact factor of 14.51**, where it was found that conventional annealing fails to dope phosphorous into Ti_3C_2 MXene because of the formation of unwanted phosphates. In this work, we proved that an optimized microwave assisted rapid heating method can successfully dope phosphorous into Ti_3C_2 MXene which improves the electrochemical properties further by many folds. We have also published a review article (**impact factor = 19.92**) exploring the integrated ice-frozen assembly techniques for developing various energy materials with suitable architectures. 01 book chapter has also been published in springer-nature, and 03 book chapters are in press. During this project, 03 M.Tech students submitted their thesis, 02 project assistants were trained, and 01 project student joined for his M.Sc. project work. 06 internship students were also trained. A prize was also being won in an image competition held in IIM-ATM 2021. Currently, focus is to demonstrate the practical application of fabricated supercapacitors. We have recently developed a process where waste biomasses were converted to high surface area carbon and metal oxide/phosphate based composites for fabricating symmetric and asymmetric types of supercapacitors and then the demonstration of its practical application by running LED board containing multiple LEDs and also small consumer's electrical instruments like oximeter and calculator. **Figures 1 and 2** are shown to demonstrate the practical use of the prepared supercapacitors from the waste coffee grounds by running one LED board and a pulse oximeter.

Figure 1 & Figure 2: Demonstration of the prepared supercapacitors from the waste coffee grounds

Process Development of High Quality Layered Transition Metal Carbides/Nitrides/ Carbonitrides (MAX)

In this project, an indigenous optimized pressureless sintering process for manufacturing Ti3AlC2 MAX phase having high purity of more than 95 % was successfully developed, as per the proposal. Theoretical calculations have been carried out and integrated with experimental techniques to improve the purity of the developed Ti3AlC2 MAX phase. The current scale of production is 50-80 g which needs to be improved for its successful commercialization. As the MAX phase is the only precursor to develop 2D MXene so, to confirm the suitability of the MAX in the production of 2D MXene, we have derived the Ti3C2 MXene from our developed Ti3AlC2 MAX phase and further explored its application toward clean energy storage system like supercapacitor. We have filed an Indian patent on the process developed for manufacturing Ti3AlC2 MAX phase and also published high-impact publications (**impact factor of 14.51 and 19.92**) on its MXene based energy storage systems. Further, in this project, the possibility of developing another type of MAX phase like Ti2AlC has also been explored, which is also in high demand for its unique electrical and mechanical properties. In the recent attempts, a good quality of 2-5 g of Ti2AlC MAX phase but with some TiC and Ti3Al impurities has been developed, and thus, further optimizations in terms of composition and ball milling and heating conditions are needed to increase the purity and scale of production. During this project, 1st prize in the poster session held in an international conference, and also trained 08 students including a project assistant, M.Tech, and intern students. For summarizing the whole achievements pictorially, please find the figure 3 below.

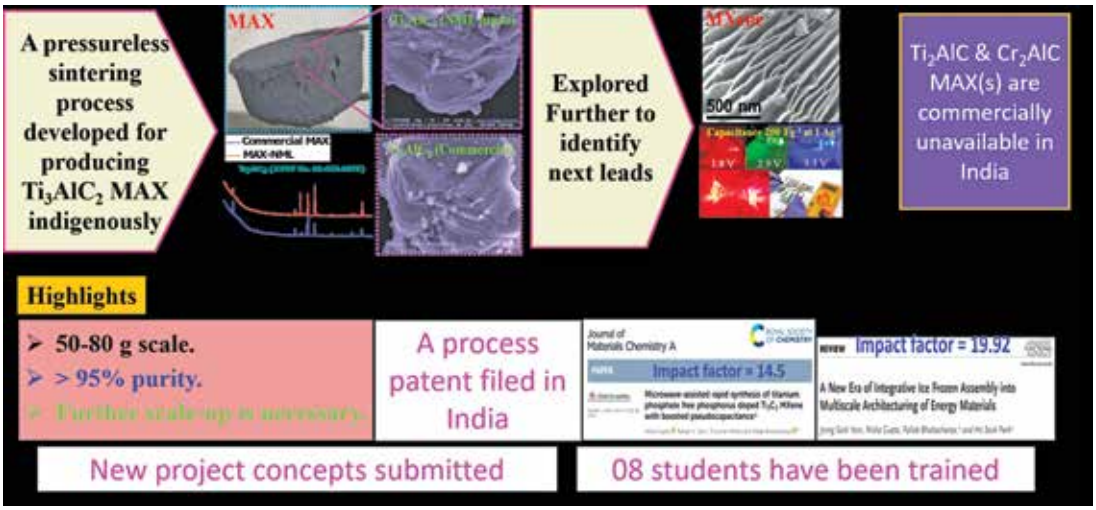


Figure 3 : Achievements in the project MLP3119

Development of Advanced Giant Magneto-Impedance (GMI) Based Sensor for Structural Health Monitoring of Engineering Structure with Enhanced Area Coverage

Magneto-impedance sensors are gaining ground in industrial applications due to enhanced sensitivity and portability of the device. These sensors typically contain amorphous / nanostructured soft magnetic microwires as the sensing element. The earlier developed Giant Magneto-impedance (GMI) sensor has only single sensor element which is a rapidly quenched amorphous microwire of diameter in the range of 80 to 120 micron. Therefore, the area of assessment was small. Thus, to increase the coverage area of evaluation, a project was proposed with the objective of developing a Giant Magneto-impedance based array sensor for detection of carburization in austenitic steels / components used in petrochemical refinery units. Based on CSIR-NML's laboratory experimentation and technical inputs, a device was fabricated and coined as "MagRays".

Achievements:

- **Patent :** An Indian patent filed with the title "A process for arrangement of amorphous / nanostructured microwires in an array for enhancement of signal response in a magneto-impedance sensor" (Appln no: 202111039713 dated 02-09-2021).
- **Device development :** Development of a Magneto-impedance (MI) Array Sensing Device using Nanostructured material. Device is coined as "MagRays".
- **Sensor material :** The sensor element used in the MagRays comprises of a nanostructured material in the form of microwire prepared using CSIR-NML's in-water quenching facility. In the developed device an array of such sensor microwires have been used for large area coverage.
- **Device performance :** Device showed satisfactory performance during laboratory tests on service exposed petrochemical refinery unit component (Johnson screens) and on defective weld.
- **Technology video :** A technology video prepared and uploaded as youtube video to get prospective clients for future applications. The youtube link is https://youtu.be/28mU03M27sk

Figure 4: Magneto-impedance Array Sensor (MagRays) measurement on a Johnson Screen

Figure 5 : Magneto-impedance Array Sensor (MagRays) measurement system

Replacement of Toxic Cadmium Coatings by Electrodeposited Al/Zn-Mn Coatings on High Strength Steels

The objective of the project is : (a) Development of binary Zn-Mn alloy and ternary Al/Zn-Mn alloy from ionic liquids preferably from an affordable, simple and stable ionic liquid, based on choline chloride (ChCl) type deep eutectic solvents (DES) by electrodeposition, approach, (b) Performance of coating should be similar or better than the Cd plating and improve the aircraft maintenance .

Achievements :

(i) As per commitments in the mission, identification of water and air stable ionic liquids & surface pre-treatment process has been established.

(ii) Development of Zn-Mn coatings from an affordable, simple and stable ionic liquid, based on choline chloride (ChCl) type deep eutectic solvents (DES) on high strength steel has been achieved. In addition, a separate aqueous bath was prepared for electrodeposition of Zn-Mn as a comparison material.

(iii) Bend test passed with No Flaking, Electrochemical corrosion tests analysis in distilled water as well as 3.5% NaCl solution, In distilled water : OCP (ZnMn) :- 0.958 V vs. SCE Ecorr (ZnMn) :- 0.965 V vs. SCE In 3.5% NaCl solution OCP (ZnMn) :- 1.05 V vs. SCE Ecorr (ZnMn) :- 1.07 V vs. SCE Ref. Corrosion Science 53 (2011) 1489-1497 (In 3.5% NaCl solution) Ecorr (Cd) :- 0.76 V vs. SCE Ecorr (Zn-Ni) :- 1.11 V vs. SCE

There are three tasks planned for upcoming quarters:

1. Salt-spray test and Hydrogen embrittlement (HE) test for as-coated ZnMn coupons
2. Optimization of Mn content in the coatings (ZnMn) and their correlation in the enhancement of corrosion resistance
3. Initiation of ternary alloy (Al/ZnMn) coatings on high strength steel and their electrochemical corrosion analysis

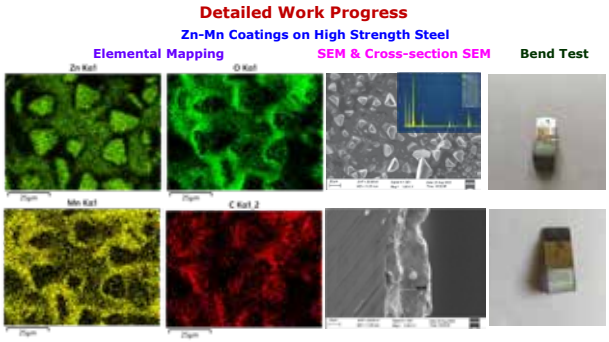


Figure 6: Elemental mapping, SEM & cross-section SEM, and bend test of as electrodeposited ZnMn coated sample on high strength steel sheet

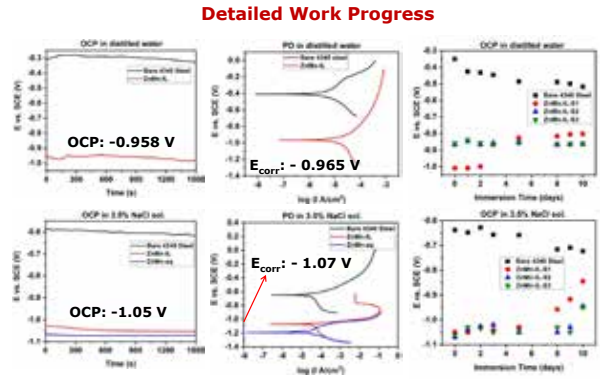


Figure 7: OCP, potentiodynamic polarization and long term immersion OCP studies in distilled water and 3.5% NaCl solution.

Development of Advanced NDE based Diagnosis and Prognosis Protocols for A-USC Power Plants

This project is one of the modules of the consortium project entitled "National Centre for Development of Advanced Materials and Manufacturing Processes for Clean Coal Technologies for Power Applications". The present module aims to address the following:

- NDE for the advanced manufacturing processes like laser and hybrid laser weld quality assessment of Ni-based super alloy.
- Comprehensive data base creation of various NDE parameters to spot onset of damage (Fatigue, Creep Fatigue etc).
- Development of sensor for in-situ structural

health monitoring of engineering components exposed to high temperature and stress.

This module addressed on the development of non-destructive techniques for the advanced manufacturing processes like laser and hybrid laser weld quality assessment of Ni-based super alloy. Hybrid laser-arc welding of nickel-base alloys can increase productivity and decrease costs during construction and repair of critical components in nuclear power plants. The keyhole formed under high laser intensity gives the hybrid welding technique the greater penetration depths compared to arc welding. To assess the quality of welds phased array ultrasonic and ultrasonic imaging were used to measure the level of porosity in terms of their size and locations of the pores inside the weld through proper signal analysis.

Another important objective of this project is multi-parameters NDE measurements of futuristic materials like ODS material. The goal is to develop an appropriate NDT technique for damage evaluation of such kind of components. Under this objective, ODS ferritic steel (Fe Al Cr Ti + Oxide dispersoids) developed at ARCI is characterized using Magnetic Hysterisis Loop (MHL), Ultrasonic(UT), Non-Linear Ultrasonic (NLU) and Eddy Current (EC) based NDE techniques. An Extruded ODS ferritic bent rod with irregular corrugated surface of length 560mm and average dia of 19mm was received from ARCI. As many as 05 specimens were prepared as per ASTM standard that were undergone creep-fatigue interaction tests at two different conditions in interruption mode and subsequently, NDE measurements were performed to generate data-base from the as-prepared till material rupture. The data generated from these measurements could be employed for remaining life assessment of components fabricated of ODS material and operating at high temperature and stress.

The other important aspect of this module is to develop sensor susceptible to high temperature >600°C for real time integrity assessment of power plant components. Assessing and monitoring of such degradation during operation at harsh industrial environment is hindered by non-availability of high temperature (HT) sensors. In this module sensor based on Low Temperature Co-fired Ceramic (LTCC) technology has been fabricated and used for real-time creep damage evaluation at 650°C / 305 MPa till the sample rupture (FIG 1). This will help to overcome the current limitation for real-time integrity assessment of components operating at temperature beyond certain limit and assessment of the extent of damage.

Figure 8: Real-time sensor output during Creep testing at 650°C / 305 MPa using fabricated LTCC-EC sensor

Development of an AI Based Smart Alarm System for Predicting Critical Temperature Zone of Large Industrial Structure

Industrial ducts and pipes carrying fluids at high temperature are refractory lined for protection. Failures of these structures is a catastrophic event causing loss of production and, more importantly, possible loss of life. Despite being refractory lined, these conduits are vulnerable to wear and thermal cracking. A crack in the refractory exposes the pipe to high temperature and thus the monitoring of the thermal condition of these structures is essential. Several examples of such structures exist in a steel plant (e.g. Blast Furnace, Down comer of Pellet Plant etc.). Appearance of a hot spot on the surface of such structure is an indicator of the onset of an unsafe condition. Monitoring hot spots of these structures can be done through thermal camera. Apart from being tedious, such an arrangement is

grossly inadequate as many areas of the structure would not be accessible. Embedded temperature sensors (thermocouples, FBGs etc.) are a viable alternative but embedded sensors sense temperature at discrete points and not all locations in a large structure can be so instrumented. Hence, there is a need to develop an understanding of the thermal conditions of the entire structure through only a few temperature measurements. Under this mission mode project, development of an AI based system that can give the entire thermal picture with acceptable accuracy (90%) based on the minimum number of sensing points was aimed. To develop the AI model, blow pipe of blast furnace was considered. Blast furnaces are an integral part of steel plants, used to produce pig iron from iron ore for subsequent processing into steel. Blowpipe is one of the important components of a blast furnace which transmits preheated air into the blast furnace through the tuyere. During the combustion process in the blast furnace, blowpipes deliver a hot blast of air at 1200 °C and 4 atm. pressure inside the blast furnace. There is a possibility of erosion of the refractory lining of the blowpipe which may result in catastrophe and loss in operations. Due to the erosion of the refractory, the temperature of the blowpipe surface is altered abruptly. Online monitoring of the entire blowpipe surface is essential which is not possible with thermography owing to the inaccessibility of the front portion of the blowpipe. So, there is a need for real-time temperature monitoring of the blowpipe utilizing suitable sensor arrangements considering the environmental constraints. Also, the entire blowpipe body cannot be supported by sensors. So, The Conjugate Heat Transfer (CHT) model of the blowpipe generated via the Finite Volume Method. Multiple hotspots or critical hot zones are created and solved numerically. Based on the CHT model, number of sensors to map the thermal profile of entire blow pipe was optimized to 20. Four arrays of Fibre Bragg Grating (FBG), used as the temperature sensor, each with 5 FBGs were embedded on the surface of a blowpipe. Using the 20 sensor input, an ANN based model was developed to predict the hot spot temperature and an alarm generation protocol was incorporated above the critical temperature. Instrumented Blowpipe is installed at the HBF of Tata Steel in November 2022. Continuous temperature data is getting acquired in the system and prediction of maximum temperature is simultaneously recorded from last 4 months. Figure 9 represents the data logging and hot spot predicting panel of the developed system.

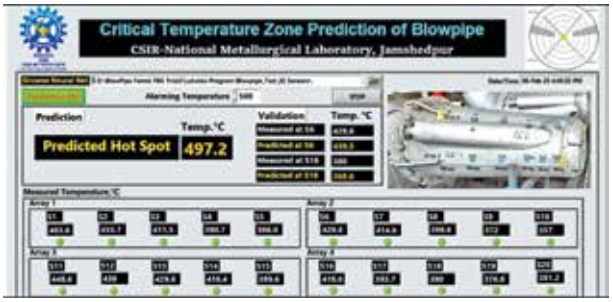


Figure 9: Blowpipe Real-time Data Logging & Hot Spot Prediction Panel

Development of a Multi-Strand Sensing Device with Closed Loop Feedback Control for Real-Time Zinc Coating Weight Measurement In GI Line

Zinc coating is the most effective and widely used process to prevent corrosion and increase the longevity and performance of steel wire. Zinc coating is generally applied to steel wire by hot dip galvanizing (HDG) process. Zinc coating on steel wire gets done by two wiping technologies; Nitrogen (N2) wiping for thick coating lines (100-500 GSM) and pad wiping (30-90 GSM). The N2 wiping system is equipped with sensor-based closed loop zinc control system for controlling individual wire coating weight. In the pad wiping line, as the wires exit the galvanizer, each wire passes longitudinally between a set of two rectangular pads. Individual screw clamping mechanisms are provided to compress each set of pads together to tightly wipe the wire. There is no such real time automatic control system is existing in the pad wiping line. Present practice is to cut a small piece after each shift and measure the coating weight by dissolving

zinc in a solution. This does not assure uniformity of the coating weight along the few km length of the wire. It results over-coating and also under-coating of GI wires. Hence requirement of real time coating weight measurement in the thin coating line to assure uniform coating weight along the length remained as an unmet requirement. CSIR-NML has developed the technology for coating weight measurement of GI line in thin coating line. Under a sponsored project of Tata Steel (CLP 218), a sensing device with two sensors were installated and commissioned at the HDG lines of Tarapur Wire Mill (TWM) of Tata Steel in February, 2022. Positive feedback of the user industry inspired to develop commercially deployable multi-strand system for galvanized system with 10 wires along with closed loop feedback control provision. Under the CSIR Fast Track Commercialisation (FTC) project fabrication of 10 channel system is under process.

Design and Development of an In-House Barrel Electroplating System for Coating Mg-Based Biodegradable Implants

Bone implants are used to fix and position the broken bones during healing. Currently available metallic bone implants are made of titanium alloy, stainless steel etc. Follow up surgery, stress shielding and damage of tissues by using current metallic (titanium alloy, stainless steel) implants motivated us to develop Mg based degradable bio implants but high corrosion rate of Mg demands suitable surface protection, thus the current project is dedicated to in – house development of small size barrel electroplating system to have proper coating on small implants like pin, screw plates etc. By using barrel electroplating, each portion can be coated perfectly, holding / clamping small implants are not needed, this is versatile i.e. plating several objects at the same time and cascading motion produces a more uniformed metal finish.

Design of the barrel electroplating system is done by benchmarking industrial barrel electroplating system. We maintained drum rpm 2 and accordingly designed every component like gear train etc. Samples need to be kept inside drum which is being rotated by motor via gear train. Samples inside the drum is connected to cathode by wire which has been passed through center of drum. The complete experimental set up is shown in below figure.

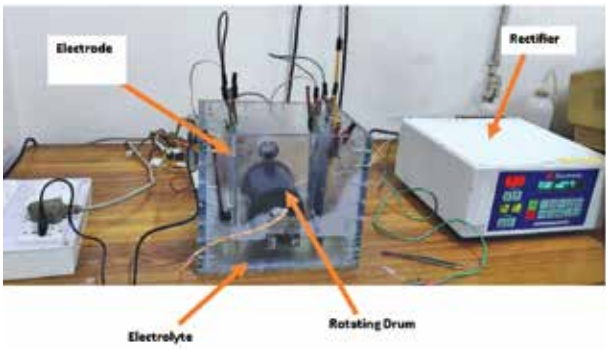


Figure 10: Experimental set-up of Barrel Electroplating System

We successfully developed the barrel electroplating system to coat small implants and able to coat multilayered Zn on bare Mg alloys as shown in below figure. Thus the current project can help us to develop Mg based degradable bio implants which can be commercialized.

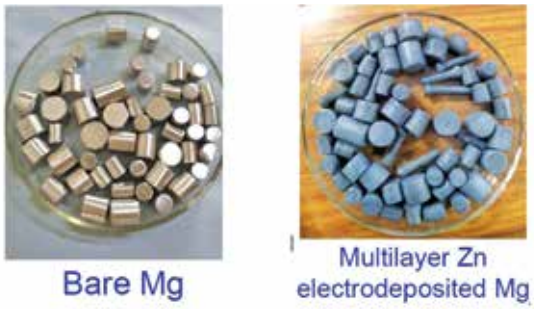
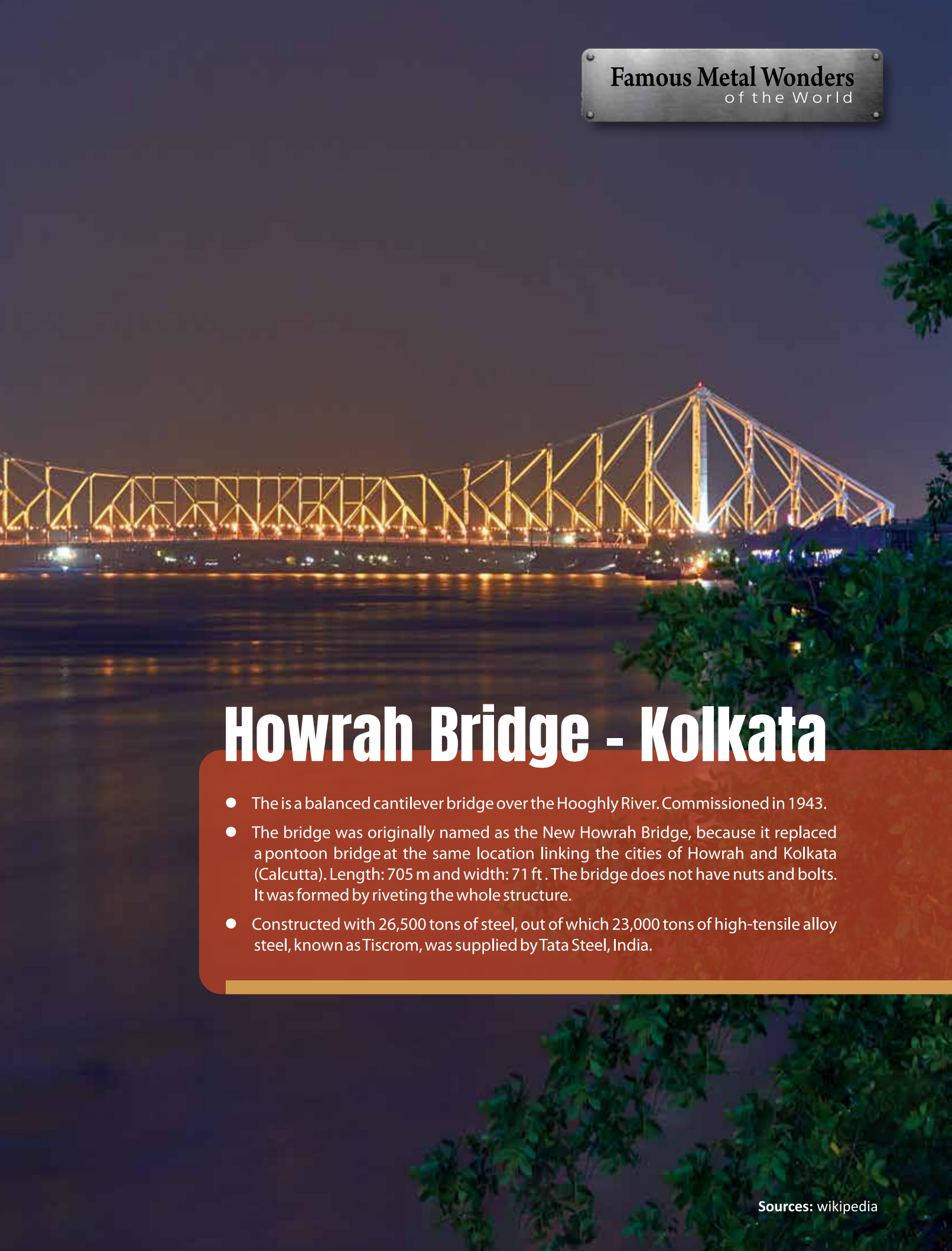


Figure 11: Multilayer Zn electrodeposited on Mg alloy using barrel electroplating

Team -AMP



Howrah Bridge - Kolkata

- The is a balanced cantilever bridge over the Hooghly River. Commissioned in 1943.
- The bridge was originally named as the New Howrah Bridge, because it replaced a pontoon bridge at the same location linking the cities of Howrah and Kolkata (Calcutta). Length: 705 m and width: 71 ft . The bridge does not have nuts and bolts. It was formed by riveting the whole structure.
- Constructed with 26,500 tons of steel, out of which 23,000 tons of high-tensile alloy steel, known as Tiscrom, was supplied by Tata Steel, India.

Sources: wikipedia

Metal Extraction and Recycling

Metals Extraction and Recycling (MER) Division is one of the core R&D divisions involved in process and technology development for sustainable extraction of metal values from primary and secondary resources and valorization of industrial wastes and by-products. The division consists of three major research groups, namely, Ferrous Process, Non-ferrous Process, and, Secondary and Resources Utilization. The major activities of Ferrous Process group are process advancement in agglomeration and utilization of iron ore fines and ferruginous wastes of steel plant, and preparation and quality improvement of different ferro-alloys. The Non Ferrous Process group is actively pursuing research activities in harnessing secondary and lean grade resources for extraction of non-ferrous metal values in either elemental form or as useful compounds and extraction of strategic metals for specialty applications. The Secondary and Resources Utilization group is working on extraction of rare earth and energy metals from secondary resources, and valorization of industrial wastes by converting them to value added products.

Some of the major ongoing programs are urban ores recycling that includes PCB, batteries, magnets, florescent bulb, etc.; and, holistic utilization of red mud (a national mission under the guidance of NitiAyog where three R&D institute namely CSIR-NML, CSIR-IMMT, JNARDDC and three industries namely NALCO, VEDANTA and HINDALCO are participating). The division is equipped with state of the art bench and pilot scale facilities in the areas of hydro, pyro and electro-metallurgy and waste processing. Some of the unique facilities in the division are 'Urban Ore Recycling Centre', Mechano-chemical activation devices, Geopolymer pilot plant, Melting furnaces of various capacities, Solvent extraction units, and many more. Some of the important projects carried out by this division are detailed below.

Development of Briquetting Technique for Utilization of Steel Plant Solid Waste

Several iron oxide fines such as Basic Oxygen Furnace (BOF) sludge, Blast Furnace (BF) sludge, Electro Static Precipitator (ESP) dust, sinter returns, BF flue dust, etc. generated in different units of a steel plant. A major portion of these fines is still unused. The present study aims at utilizing these fines in BOF after producing briquettes. First, the process parameters for good-quality briquettes have been optimized on the laboratory scale. The mix ratio, suitable binder, and its quantity of addition, etc. have been optimized and finally developed cylindrical briquettes in the laboratory scale, which can provide 280 kg/cm^2 cold crushing strength. In the second phase of the project, the large-scale production of briquettes of around 50 tons has been carried out. These briquettes have been used for the plant trial in a BOF of 100-ton capacity to assess its performance. The trial has been conducted successfully in SMS 3 of the Bhilai Steel Plant (BSP). Approximately, 2- 4 tons per heat has been charged in the 160-180 tons capacity converter by replacing a proportional amount of iron ore/scrap as coolant. A total of around 18 heats were conducted in BSP. The furnace operation was smooth. There was no breaking of briquettes during handling, no excessive fumes generation was observed, and better slag formation with normal final slag chemistry.

Smelting of Vanadium Pentoxide for Preparation of Ferro-Vanadium (FeV)

Vanadium is a very important constituent element of several alloy steel which is generally added in form of ferrovanadium during alloy steel making. Due to very limited primary resources in India, a substantial quantity of it is being imported from other countries (Korea, China, Japan, etc.) and a minor quantity is produced from very lean-grade resources and by-products. The present

study aims at preparing Fe-V80 from V_2O_5 by the aluminothermic route. This study develops the process parameters such as the quantity of Al-metal required and its fineness, the requirement of lime, and other conditions to prepare Fe-V from commercial grade high purity V_2O_5 and produce Fe-V80 alloy. The aluminothermic reduction experiments have been conducted at a 5 kg scale to develop the process parameters. Good recovery (>90%) and grade (>80%V) have been obtained. The process has been upscaled to 10 kg V_2O_5 per batch.

Figure 1: Aluminothermic reaction

Figure 2: Product (Fe-V alloy)

Calcined Colemanite / Calcined Ulexite Addition in Pelletizing Hematite Ore To Develop Pellet for Using In Blast Furnace

Colemanite is a mineral of boron which consists of mainly Boron oxide 50%, silicon oxide 7%, and magnesium oxide 2.6%, with a significant amount of combined moisture and other minor impurities. Ulexite is also a mineral of boron which is mainly sodium calcium borate. As B_2O_3 is a very low melting compound, it can decrease the melting point of slag and its viscosity. There may have some beneficial effects of these two B_2O_5-containing materials in the pyrometallurgical system. Therefore, the feasibility of using these two materials in iron ore pelletizing has been studied. It has been found that both calcined colemanite and ulexite can increase the cold-crushing strength of the hematite pellet and may reduce the induration temperature. Reduction degradation properties (RDI) of pellets have also been improved for use of colemanite and ulexite. Other properties need to be investigated to optimize the appropriate addition level of Colemanite and Ulexite.

Development of A Cost Effective Green Technology for Pre Reduction of Chromite Ore in Tunnel Kiln & Production of High Carbon Ferro Chrome in SAF

This project work was sponsored by Ministry of Steel, Govt. of India to utilize chromite ore fines to produce ferrochrome in an innovative way to reduce the power consumption during the process. The proposed process is aimed at application of a tunnel kiln furnace for pre reduction of a mixture of chrome ore, solid reductant, fluxes and binder to around 1350 ^{0}C -1400 ^{0}C to form a direct reduced ferro chrome (DRFC). This DRFC will be further processed in submerged electric arc furnace to produce high carbon ferro chrome. Tunnel Kiln consumes low energy as it is a closed type tunnel furnace with much better heat transfer efficiency and utilization. Hence the pre reduction in tunnel kiln is expected to reduce the overall energy requirement for the production of high carbon Ferro chrome per ton. Conventional SAF process, specific power energy for the production of high carbon Ferro Chrome is approximately 4500 kWH/

Ton to 5000 kWH/Ton. In proposed project the pre reduction of chromite ore in tunnel kiln furnace couple with smelting reduction in SAF furnace would bring down the overall energy requirement to about 3500 kWH/Ton - 4000kWH. Hence the proposed process would approximately save 1000 kWH/Ton of electrical power equivalent. The overall carbon emission of tunnel kiln and equivalent carbon emission of electricity power saved in SAF furnace would reduce drastically. Therefore, the proposed process is expected to an environment friendly process and economically more viable process compared to convention process. Efficiency of subsequent SAF process is also likely to go up due to tap to tap time of furnace will be reduced significantly resulting increased productivity.

23 MT of reduced chrome pellet received at CSIR-NML from M/s MECPL, for reduction smelting trials. 18 pilot plant trails on continuous basis have been conducted on 500 KVA submerged electric arc furnace by varying the reduction parameters to produce 11 MT high carbon Ferrochrome having 52-55% Cr. All the produced 11 MT Ferrochrome alloy and 13 MT slag has been sent to M/s MECPL, Rairangpur to carry out the market survey for commercial use of produced FeCr alloy.

Figure 3: Reduced Chromite in Tunnel Kiln

Figure 4: 500 KVA SAF furnace

Figure 5: Ferrochrome alloy

Hot Stage Engineering of Copper Smelter Slag for Recovery of Iron and Subsequent Use Of Resulting Slag in Blended Cement

Copper slag is a waste produced from copper manufacturing through the pyrometallurgical process. Globally, each ton of copper metal production generates about 2.2-3.0 tons of slag, which is estimated at approximately 40 million tons of slag generation annually. India is generating about 1.7 million tons of copper slag annually. A significantly minimal percentage is utilized for

low-end applications and rest is mostly dumped, thus occupying large space for a longer duration. Till date, this slag has been mostly utilized as aggregates in road construction and concrete, mine backfilling, etc. Few studies highlight to use as supplementary cementitious materials after granulating the molten slag by water quenching. However, its high iron content (~35-60%) and lack of suitable oxide components limit its utilization into blended cement. Therefore, a process that can address both the recovery of high iron value at the molten stage and modify the resulting slag by adjusting chemical composition for subsequent use in blended cement.

The carbothermic reduction smelting of the copper slag by using carbonaceous material, metallurgical coke is carried out to remove Fe from the FeO-SiO_2-(Al_2O_3) slag vis-a-vis modify the liquid slag composition using lime (CaO) to create CaO-SiO_2-(Al_2O_3), which can be a suitable component for blended cement. The raw or pre-calcined limestone is used as a flux. The smelting of the charge mixture is carried out into a 50kVA electric arc furnace at 1500-1600°C temperature and reduced the FeO content into pig iron, which accumulated at the bottom due to inherent high density and finally tapped from the bottom. The chemical composition of extracted metal was 94-96% Fe, 3.5-5% C, and Si 0.5-2%, which can find application in general usage similar to cast iron.

The resulting slag is tapped and water quenched in an indigenously developed granulation tank to get a high reactive glassy material. This modified slag after granulation is grinded and mixed with clinker and tested for Portland slag cement composition. The physical properties of the mortar samples are meeting the Indian standard IS4031:1988.

Scale up Study for the Recovery of Potash Fertilizer and Iron Oxide From Indian Glauconitic Rocks.

This project intends to up-scale the lab scale process for the production of potash fertilizer and iron oxide from Indian glauconitic rocks up to pilot scale level (10-20 kg) for better assessment of techno-economic feasibility. Glauconite is a naturally occurring group of dioctahedral, potassium, iron-rich micaceous clay mineral of marine origin with very low weathering resistant and easily available at surface to sub-surface level. The structure of glauconite consists of dioctahedral T-O-T (Tetrahedral - Octahedral - Tetrahedral) sheets. Potassium and iron were the part of this stable alumina-silicate T-O-T matrix. The biggest challenge in order to utilize glauconite is to break the alumina-silicate structure to recover potassium from this matrix in an economical and eco-friendly way. Along with potassium, iron is also considered as valuable element present in the glauconite. The previously studied and reported processes use high concentration of acid, high solid to alkali ratio, hazardous salts such as fluorides, chlorides etc. to achieve high dissolution of potassium only. For one reason or another, mainly due to availability of highly soluble potash salt of marine origin and process economics, none of these processes has been commercially successful. A careful study of these attempts warrants the statement that solution of this problem depends entirely upon simultaneous recovery of high value by-products along with low value potash.The process developed at lab scale is economic, environment friendly and sustainable in comparison to earlier developed processes. From the overall composition of glauconite and basic structure analysis it is evident that iron is only the week link present in the complex structure of glauconite. It can easily change its oxidation number under different oxidizing and reducing atmosphere thus can break the matrix easily during its conversion to form different species. Therefore, subsequent attempt was made to break the structure by reduction roasting and redox roasting of glauconite before acid dissolution to recover maximum potassium values. The process uses very mild acid for its dissolution that make process cleaner. This process had added advantage

of simultaneous recovery of iron oxides along with the recovery of potash fertilizer. The overall research showed that the recovery of potassium is more than 98% and recovered in the form of soluble salts along with valuable by-product in the form of nano-sized iron oxide particles. Project work is going on smoothly and initial characterization studies are performed. The future/remaining work: Pre-treatment followed by potash and iron oxide recovery from glauconitic rocks.

Impact on Society / Industry :

The final product of this process is potash fertilizer, that is used by fertilizer Industry & iron oxide for pigment industry. This will help more than 60% of India's population whose primary source of livelihood is agriculture. It will also help in reduction the 100% potash fertilizer import.

Development of a Cost-Effective Refractory Lining Materials for Induction Melting Furnace Suitable for Production of Quality Steel: Phase Ii (Industrial Trials)

Generally, the steelmaking route is categorized into two viz are (i) primary steel sector (integrated steel plant) and (ii) secondary steel sector. Primary steel sectors produce the steel through the BF-BOF route whereas secondary steel sectors produce the steel from DRI/Sponge Iron/ Steel scrap using either an electric induction furnace (IF) or an electric arc furnace (EAF). Electric Arc Furnace and Induction Furnace based steel sectors contribute around 57 % of the total steel production in India. The steelmaking through the induction furnace route is approximately 29 % of the total steel production. However, many Indian induction furnaces use acid ramming mass. Due to low spalling resistance and cost, induction furnaces rarely use the basic lining materials. According to BIS standards, the phosphorus content in any structural steel varies between 0.03%.to 0.06% depending on the grade of steel. The presence of high phosphorus in engineering steel components causes cold shortness, i.e. the phosphorus increases the brittle-ductile transition temperature. However, the Induction Furnace route has its own limitations for the refining of liquid metal mainly for the production of low phosphorus and sulphur steel. In view of the above, CSIR NML has developed flux for both sulphur and phosphorous removal in an induction furnace lined with MgO ramming mass to achieve the BIS standards during steelmaking. **Participating institutes:** CSIR–NML, CSIR-CGCRI & NISST

The objectives of the project are to validate the newly developed ramming mass in an industrial induction furnace (a) Suitability of the basic lining mass under basic and oxidising flux (b) To assess the lining erosion pattern during refining (c) Techno-economic feasibility of the lining material. Initially, the laboratory trial in a 40 kg induction furnace at CSIR NML is completed using CGCRI's ramming mass with different varying % of flux materials as per industrial feed ratio. From laboratory experiments, the life of reflationary lining is around 28 heats with treatment with CSIR-NML-developed flux for dephosphorization of steel. The phosphorous in steel is reduced to 0.03-0.04 wt % from 0.10 wt%. with flux treatment on a laboratory scale. As part of this project, the first industrial trials have been conducted in Ispat India on 11-19th July 2022 by NISST, CSIR-CGCRI and CSIR-NML Jamshedpur. Some observations during the above-mentioned plant trials and their preparation for plant trials are as follows:

1. CSIR-CGCRI has supplied 6 tonnes of MgO-based ramming mass to the plant site of ISPAT, Raipur for industrial trial using CGCRI's ramming mass and NML's flux. Moreover, CSIR-NML Jamshedpur has supplied prepared flux to ISPAT, Raipur for industrial trials. However, the trial could not be continued after 9 heats due to bottom leakage.
2. Few operational issues were observed which may be responsible for lower refractory life- i) Improper ramming, ii) power shutdown after ramming, iii) Use of excess water in the top lining iv) water splashing during removal of slag, v) water splashing after each heat to

check lining condition, vi) improper design of the metal forma (vi) Deslagging is the main issue during plant trials. (vii) Temperature is always high (more than 1580 °C).

3. As per lab trials at NML, a minimum of 4-5 wt % flux is required. However, we have added only a max of 3 wt % during the last plant trials. Deslagging is the main issue during plant trials. Temperature is always high (more than 1580 °C) A minimum of 15 minutes of flux treatment time is required and it's crucial as well. However, sometime treatment time may shorten by plant personnel.

4. Phosphorus in steel achieved was 0.035 to 0.045 wt % by flux treatment of 1.5 -2 wt%.

Future Course of Actions:

1. 2nd Industrial trial is required to ascertain the performance of the ramming mass.

2. More no. of trials is required to optimize the flux addition for industrial scale

Figure 6: Melting of DRI and Scrap in 8-Ton Induction Furnace

Figure 7: Deslagging during melting

Figure 8: Treatment of flux in induction Furnace

Figure9: Tapping of steel after flux treatment

Figure 10: Personal from CSIR-NML, CGCRI, NISST and Ispat India

Electrochemical Conversion of CO_2 to Value Added Product

Carbon capture and utilization (CCU) is one of critically important area in Steel and Chemical Industry. The success of CCU relies not only on the capture but also on the recovery of value-added product as the cost of pure CO_2 lies in the lower range. This stresses the point that the valuable product should have high commercial value to accommodate OPEX. In this research proposal,

the electrocatalysis of the CO_2 reduction reaction (CO_2RR) will be explored. This route has potential to produce products of economic value like, CO, acids and alcohols which may have fuel value or can be used as feed stock. Development of economical and efficient catalyst plays a challenging role for the commercial acceptance. In this work, we will develop a two dimensional material supported heterogeneous catalyst for efficient CO_2 conversion to value-added product. The objectives of the project are: Facility creation for electrocatalytic experiments, Development of electrocatalyst, Electrode fabrication, and Performance evaluation of the electrocatalyst for CO_2 reduction. The facilities created under the project are: Single channel electrochemical workstation, Flue gas analyser, Ultrasonic bath sonicator, Type-I and Type-II water purifier system, Analytical balance, Electrochemical cell. With respect to the development of electrocatalyst, procurement of chemicals is going on to synthesize borophene. Ni foam has been purchased for electrode fabrication. After synthesis of the electrocatalyst, Ni foam will be coated. After electrode fabrication, it will be tested for CO_2 reduction.

Figure 11: Electrochemical workstation

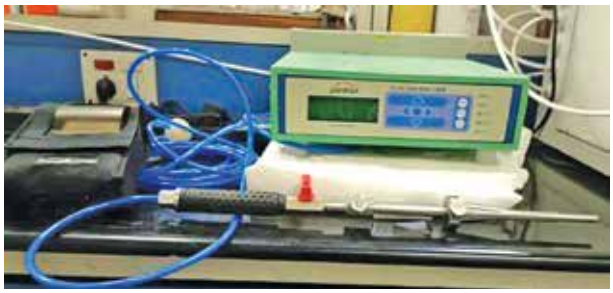


Figure 12: Pantron True gas analyser

Figure 13: Type-I and Type-II water purifier

Technology Development for Holistic Utilization of Red Mud for Extraction of Metallic Values & Residue Utilisation

NITI AAYOG RARE EARTH COMMITTEE chaired by Dr. V.K. Saraswat, paved way for development of a holistic process to extract Al, Fe, Ti and REEs from various red mud samples and its demonstration on 100kg batch per unit operation. This project is being coordinated by CSIR-NML associated with CSIR-IMMT, JNARDDC as R&D labs; and HINDALCO, NALCO and VEDANTA as industrial partners. The project is co-funded by CSIR, Ministry of Mines, and all industrial partners to the tune of Rs. 5.12 crores.

At this stage, Demonstration on 10 kg feed scale red mud has been given to NALCO, HINDALCO, VEDANTA on 16-17th Feb 2023 at CSIR-NML.

The process validation at undergoing for 50kg scale.

Processing of Tin Slag and Technological Extraction of Critical Elements for High Strength Low Alloy Steels

Tin slag is a potential resource of Niobium (Nb), Tantalum (Ta), and other critical metals. With a project supported by Ministry of Steel, it is aimed to recover Nb and Ta as high pure (>95%) salts; and concurrently as ferro-niobium (63% Nb). These products shall be evaluated for applications in steel. The project is governed by objectives to beneficiate tin slag, and use the concentrate/as received sample to extract Nb and Ta, by a non-HF process. At present, the material has been subjected to mineral liberation analysis and flotation circuits. Concurrently, the material has been subjected to hydrometallurgical processing.

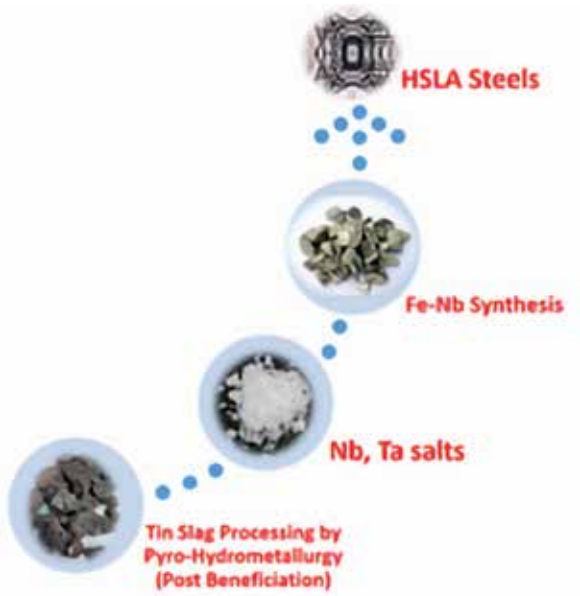


Figure 14: Proposed flowsheet for processing of Tin Slag

Development of Innovative Hydrometallurgical Process for Extraction of Rare Earth Elements From Metallurgical and Chemical Process Wastes (Innova-Rare)

The project aims to extract all metals from RED MUD and PHOSPHOGYPSUM, followed by utilisation of residue for building material and other applications. The work plan of this proposed project (INNOVARARE) are to understand the availability, generation, detailed composition of Red Mud (RM) and Phosphogypsum (PG) Dumps In India, Exploit Them For Efficient

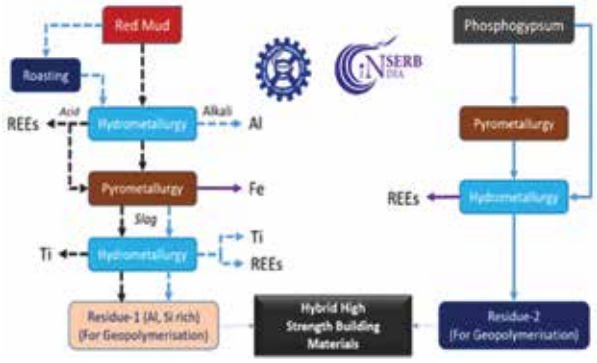


Figure 15: Formulated flowsheet for holistic utilisation of red mud and phosphogypsum

extraction (with individual separation) of Fe, Al, Ti and REEs, and the preparation of new building materials with, followed by scale-up validation and life cycle analysis of process developed. NALCO is the industrial partner in this project.

The work on REE extraction from red mud has been completed. The deliverable to extract REEs from PG is under progress.

Analysis and Upgradation of Subgrade Iron Ore Fines Through Fluidized Bed Reduction with Separation

With the depleting reserves of high-grade iron ore in the world, the high alumina content and the loss on ignition (LOI) of iron ores are expected to gradually increase. Alumina plays a negative role in operation of the blast furnace when the content is higher than the requirement. Therefore, alumina of iron ores should be removed to the low level (lower than 2-2.5 %) to meet the requirement for the feed of blast furnace. Direct reduction in fluidized beds is more appealing, since it is a more environmentally friendly alternative for iron making. To reduce the carbon dioxide (CO_2) emission during iron making operation and make an environment friendly iron making process, the production of iron from low-grade iron ore fines using hydrogen has been used instead of coal /coke in a fluidized bed reactor.

Results

Metallization achieved was:

- 87 % at 1kg scale
- 91% at 250gms scale
- 2.51% Al2O3 was obtained under the optimum conditions

Figure 16: Process Flow Sheet

Geopolymerisation for Radioactive Waste Immobilization

Low level and intermediate level radioactive wastes need immobilization in suitable matrices to restrict their mobility. This is done by stabilizing the radioactive wastes in materials of low aqueous solubility and having good mechanical strength. Encapsulation of low and intermediate level radioactive wastes are typically done in low cost, readily available cement-based substances. Owing to the emergence of novel waste streams, advanced matrices are being explored continuously. This project explores the suitability of geopolymers for such emerging waste streams. The new geopolymer matrix being explored is expected to have a longer durability than that of the cement based matrices, which are currently in use for the purpose. Immobilization of volatile and long-lived fission products (LLFP) such as of technetium, iodine etc. is the ultimate target of this endeavour.

Among the several geopolymer matrices developed, the matrices with fly ash (FA) in combination with ground granulated blast furnace slag (GGBFS) are found to be having the desired characteristics of robustness and low permeability. Based on the compressive strength and porosity values, the formulations with certain proportions of FA and GGBFS were selected. The selected formulations satisfied the other requirements such as durability in water and in various acid media of pH=2.5 (sulphuric acid, hydrochloric acids, nitric acids) also. The samples also conformed to the standard water penetration tests and hydraulic conductivity tests. The leachability of selected elements in distilled water and ground water was within the acceptable limits. The matrix developed (70 mm cubic blocks) were up-scaled to 5kg monoliths initially and then 100 kg monoliths. The preparation of 100 kg product was made utilizing pilot level setup available at CSIR-NML. Radioactive plant adaptation of the process requires a different approach in material handling. Powder/liquid spillage should be avoided. Movement of materials should be minimal during preparation. Owing to the same, options in flowsheets has been provided by NML based on NML's experience and information received from BARC. The figure 1 shows the photographs taken at various stages of 100 kg geopolymer preparation.

Figure 17: Photographs at different stages of 100 kg geopolymer preparation (Clock-wise from top left): Dry mixing, binder addition, transfer to the mold, and vibration

Development of Fire Resistant Lightweight Structural Materials by Hybridization of Inorganic-Organic Polymers

The benefits of using lightweight polymer composites are well known, however their wider adoption has been hindered by uncertainty over their performance when subjected to extreme heat. Lightweight structural materials must retain strength under fire exposure and must be

made from non-flammable or flame retardant materials to limit fire spread, releasing smoke and heat. Significant advantages can be achieved by identifying a material system that is lightweight, fire resistant and has sufficient strength for use in tactical shelters and other structures as well as in aerospace and other transport sectors. In this work, inorganic/organic hybrid geopolymers were synthesized by using metakaolin (MK) and solid organic components comprising an epoxy resin - diglycidyl ether of bisphenol A (DGEBA), and a hardener - dicyandiamide (DICY). Solid organics were chosen to obtain a homogeneous mix upon co-milling all the solid precursors' viz. MK, DGEBA and DICY in a planetary ball mill prior to geopolymerisation. Inorganic/organic hybrid geopolymers synthesized were then characterized for thermal, structural and mechanical properties. Thermogravimetric analysis (TG-DTG) revealed that hybrid geopolymers restricted the degradation of organics (~72% and ~79% organics loss corresponding to 10 mass% and 20 mass% DGEBA addition, respectively) compared to their milled counterparts (~95% and ~100% organics loss corresponding to 10 mass% and 20 mass % DGEBA addition, respectively) suggesting strong inorganic/organic interactions. This was substantiated by structural characterization via X-ray diffraction (XRD) and Fourier-transform infrared (FTIR) spectroscopy. Major changes in DGEBA peak positions (FTIR) and disappearance of DICY peaks (XRD, FTIR) corroborated the MK-DGEBA-DICY reactions during geopolymerisation. Microstructural studies (scanning electron microscopy and transmission electron microscopy) coupled with elemental line scan and area maps, confirmed the homogeneous distribution of organics into the inorganic geopolymer matrix with no phase separation. Figure 18 shows the EDS spectra acquired across a line for a hybridized geopolymer with corresponding elemental distribution profiles shown. Similar distribution profiles of C, Si and Al in the geopolymer gel illustrates the simultaneous presence of the inorganic and organic phases which furthermore implies the chemical reaction and good compatibility between the two. Incorporating 20 mass% epoxy resulted in improved compressive strength from ~20.2 MPa to ~50.6 MPa (2.5 times superior vis-`a-vis only MK-based geopolymer) and higher flexural strength of 5.4 MPa. The significantly enhanced mechanical properties of hybrid geopolymers were indicative of effective inorganic/organic interactions. The physical properties (water absorption, apparent porosity and bulk density) illustrated that the hybrid geopolymers were dense, less porous and lightweight; this corroborated the MIP/BET results. Increased time to ignition and decreased mean heat release rate observed for the hybrid geopolymers demonstrated the flame-retardant effect of hybrids.

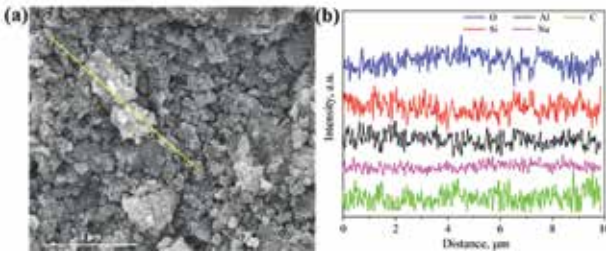


Figure 18: SEM-EDS of the hybrid geopolymer depicting individual elemental distribution profiles across the line.

Team - MER

Minerals Processing

Characterization and Beneficiation Study of Low Grade Iron Ore Sample from Karnataka.

The low-grade Iron ore sample from Bellari District, Karnataka having 50.9% Fe was studied for characterization and detail beneficiation. Objective of the study was to upgrade the Fe content in lumps of +1mm to 58% Fe and fines to 62% Fe. It was found from the characterization study that goethite and hematite are the main iron bearing ore minerals with kaolinite, gibbsite, quartz as gangueminerals (Fig.4). The upgradation of Fe-content in lumps is difficult due to poor liberation characteristics. However, the liberation is quite adequate at finer sizes, below 100 µm. In gravity separation study, air pulsated Batac Jig was used to beneficiate the coarse fraction of -10 +1mm of washed feed. The results show that Fe-content in the product could be possible to enhance to 54.12% with 14.8% yield. Processing of Jig middling with fines produces a product with 60.3% Fe with yield of 23.3% with respect to feed. It has been found that beneficiation of direct fines causes loss of iron values. It was possible to achieve 46.4% product yield with 58% Fe content using a deslimed product of -100 µm feed by two stages magnetic separation.

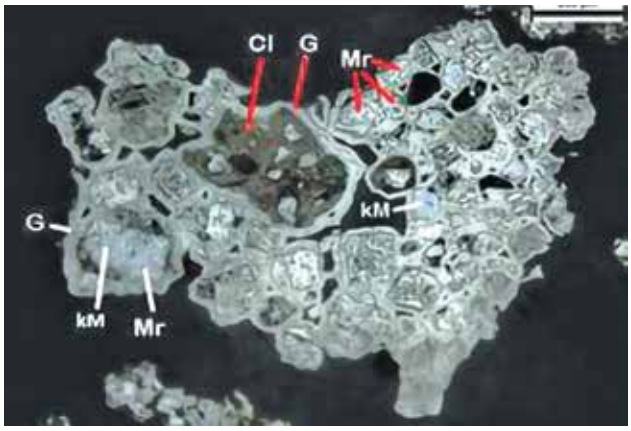


Figure 1: Martite with relict kenomagnetite, clay cemented by colloform goethite. Liberation is possiblebe low 100 micron size

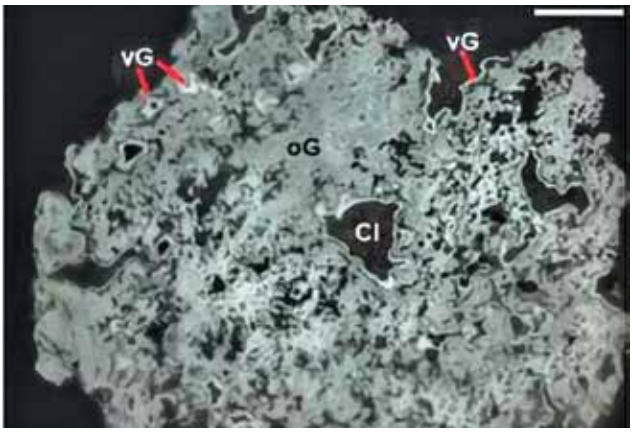


Figure 2: Colloform ochreous goethite and vitreous goethite with clay showing interlocking at very finesize.

Beneficiation of Tailing Samples using Column Flotation

Processing of iron tailing sample is a challenging task as it contains a significant amount of silicates and different types of aluminates as gangue minerals. In any froth flotation process the hydrophobic particles are carried out from pulp zone to froth zone by means of true flotation, but undesirable gangue minerals also report to the concentrate through entrainment and entrapment rather than true flotation. The column flotation process has a substantial advantage over the mechanical batch flotation process for achieving higher grades with reduced maintenance cost as well as better control on the froth depth.

Investigations were carried out to beneficiate two plant tailing samples having Fe-content of around 35% and more than 35% silica with fine particle size distribution (Fig.-2). The objective of the study was to develop a column flotation based process to produce iron concentrate with 55% Fe from 35% Fe. The reverse flotation was found to be effective to improve the Fe-content in concentrate. Different types of cationic collectors were used to float the silicate gangue minerals. It could be possible to achieve more 55-59% Fe with the deslimed feed of

tailing sample.

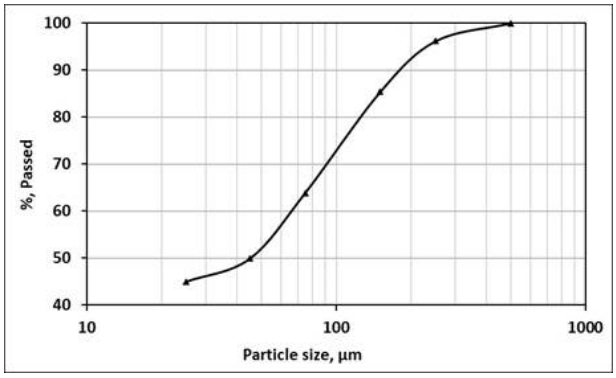


Figure 3: Particle size distribution in as-received Plant tailing sample

Studies on Processing of Iron Ore Sample for Beneficiation Plant at AM/NS, Dabuna

The objective of the project was to undertake studies on the characterization of iron ore samples and accessing the metallurgical performance of hydrocyclone and WHIMS for producing the pellet grade concentrate with a particle granulometry of d_{80}:75 micron (maximum). Studies were undertaken on characterization and assessing hydrocyclone and WHIMS's performance for processing iron ore samples from AM/NS, Dabuna. The as-received sample was assayed 61.60 % Fe, 2.72 % Al_2O_3 with 5.70 % SiO_2, and 2.87 % LOI. A mineralogical study of the sample revealed that the iron ore consists of a substantial amount of goethite and hematite. In a coarser fraction, most of the hematite is interlocked with goethite and clay minerals. The gangue minerals like clay, limonitic clay, quartz, etc., are noticed to be present as fracture filling, cavity filling, vein filling, and grain boundaries minerals. Liberation studies were carried out by modal analysis on different size classes using zoom stereo microscope indicated that interlocking of gangue and ore minerals persists and is significant in coarser fraction. Around 88% liberation of different mineral phases is expected below 0.15 mm. Detailed comminution studies were carried to achieve the desired particle granulometry. Grounded product was processed through hydrocyclone followed by WHIMS to assess the metallurgical performance of the unit operation for the processing of iron ore from Dabuna. Significant variation in concentrate yield (53- 63 wt.%) is observed with 64-66 % iron content. However, considering the desirable particle granulometry around 66-67% by weight (magnetic and middling product), pellet grade is produced with an iron content of around 63.5%.

Figure 4: Laboratory hydrocyclone test rig

Pilot Scale Trial from Oily Bubble Flotation of Coal.

The project was undertaken for analyzing the performance of flotation of coal with the application of an oily bubble. Coal flotation is the most practiced technique to beneficiate coal fines (-0.5 mm) by diminishing impurities. Coal flotation is a multi-phase, complex operation (particles, oil droplets, and air bubbles). The molecules of a reagent and the dissolved ions in water are two examples of additional species with which these phases simultaneously interact. The outcome of the flotation process is determined by the physical and chemical interactions. The main cause of the selectivity issues in coal flotation could be attributed to non-selective particle aggregation resulting from physical and chemical interactions. It can be addressed by physical (conditioning) or chemical (promoters) pretreatment before or during flotation.

In the present work, the collector reagent was purged in the form of vapor along with the air into

the flotation cell to enhance the bubble particle attachment as compared to the Conventional flotation technique. Bubbles coated with a thin layer of oil act as a carrier in flotation ensuring a high collecting efficiency. Oil-coated bubble flotation can eliminate the addition of a collector to the aqueous phase.

Two coal fines (-0.5 mm) samples from two different seams were analyzed and found to be composing ash content of 26.7% and 27.4% respectively. Studies will be carried out with varied parameters like dosage of Collector, frothier, and oil bubble on the flotation of coal fines at the pilot scale of 60-80 kg per hour feed rate. Impactful to coal washery as it can help in reducing the reagent consumption during flotation of coal fines.

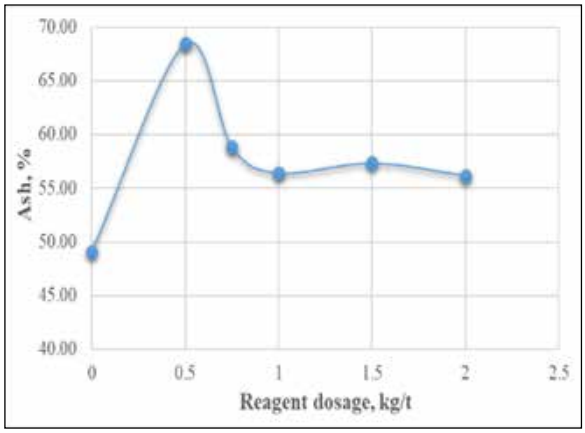


Figure 5: Effect of reagent dosage on Clean coal Ash.

Figure 6: Froth collection during pilot scale trials

A Study on Hydrodynamics Characteristics in Separation of Minerals in a Monolithic Flotation Column (Module-II).

The project aims to develop a monolithic flotation column and to study the effects of Frictional Pressure drop and bubble size distribution in the monolithic flotation column and modeling.

Flotation column is one type of multiphase contacting device where a liquid is in a continuous phase whereas gas and solid are dispersed. It is a function of the probability of particle-bubble collision, attachment, and detachment determining the separation efficiency. To enhance performance of flotation column for beneficiation process, a thorough study of hydrodynamic characteristics has to be carried out as it is difficult to understand the complete behaviour due to their complexity. It has been reported that there is considerable degree of backmixing, low interfacial area due to high coalescence rate, the short residence time of gas bubbles, channeling, non-homogeneous bubble size and its distribution, uneven flow pattern, and pressure drop in the flotation column. All these factors impact and leads to poor separation performance and the targeted output could not be achieved in many industrial flotation columns. In order to minimize the effect of these factors, a monolithic flotation column will be developed. The present study is aimed to explore the effects of pressure drop and the bubble size and its distribution in a monolithic flotation column. Pressure drop measurement helps in the determination of energy required for fluid transportation in a system. Information on dissipation of energy is provided by the pressure drop, which helps in assessment and modeling of the performance of the system. It is also important to obtain information on bubble size and their distribution in the flotation column. Bubble properties determine the gas-liquid interfacial area, an important parameter for the scale-up and design of a system. A higher gas-

liquid interfacial area is available due to the small bubble size, increasing the flotation efficiency. All these research findings will be useful in eliminating the backmixing in the gas and liquid phase, reduce channeling, low coalescence rate and will provide homogeneous bubble size distribution. Modeling and simulation will also be carried out to validate the experimentalfindings. Understanding the effects of frictional pressure drop and bubble size and its distribution will be advantageous in up-scaling the monolithic flotation column. Development of the monolithic flotation column and studying the effects of hydrodynamic characteristics in the monolithic flotation column is ongoing.

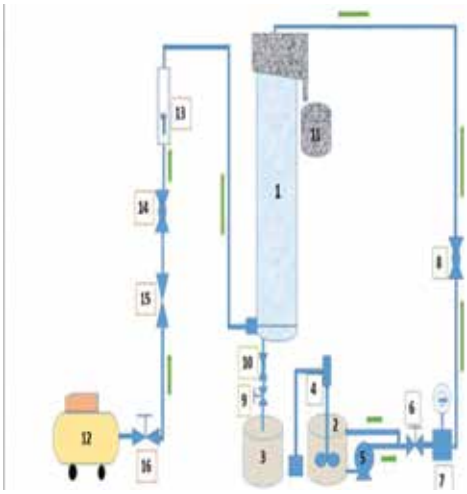


Figure 7: Experimental Set-up of the present work

Figure 8: Newly designed monolithic flotation column Figure

9: Channels inside the column

Continuous Pilot Scale Reverse Flotation of Iron Ore

The increase in production of iron metal in recent times consumes large amount of iron ore as raw material. As a result, there is a depletion of high grade iron ores and the thrust is on beneficiation of low grade ores. Moreover, decrease in threshold value of tailings/reject Fe (< 45%) as per statutory norms demands beneficiation of inferior grade iron ore. These ores comprise hematite, goethite (iron minerals) along with kaolinite, quartz (gangue minerals). Reverse flotation method is used for beneficiation of iron ores wherein silica gangue is selectively floated from iron ore using reagents. The objective of the present study is to obtain an iron rich concentrate with alumina ≤3% with maximum yield and tailings with Fe <45% with maximum alumina from inferior grade iron ore through froth flotation process. The sponsor had carried out studies on different reagent scheme to improve the selectivity of the flotation process. With the encouraging results of batch pilot scale studies (20-25 kg) in earlier project carried out at CSIR-NML, continuous pilot scale flotation of 15 tonnes of de-slimed product of iron ore slime was conducted and validated the bench scale results showed a concentrate of 2.77% Al2O3 with 83.8% yield and tailings with 43.2% Fe at 1kg/ton collector dosage.

Figure 9: Pilot Scale processing of iron ore slime

Dry Beneficiation of Limestone Samples for Removal of Iron Bearing and other Magnetic Impurities

The high-grade limestone resources for white cement clinker production are depleting day by day. With depletion of high cement grade limestone,

presently white cement industry is facing an acute shortage of cement making raw material. To prepare clinker for white cement, it is pertinent to minimize the extent of iron and other transition elements content (titanium, chromium, manganese, nickel and zinc) in the raw mix composition. High-grade limestone containing less than 0.068% Fe2O3 and less than 0.015% MnO is generally used for such purpose. Limestone deposits in Birla White Cement (BWC) mines is highly associated with lateritic coating. The iron in laterite adversely effects the white cement quality. Hence a serious thought is essential not only for detailed exploration of limestone deposits to convert the resources to reserves, but also for development of a cost effective dry beneficiation technique for up gradation of the low and sub-marginal grade limestone.

The current dry magnetic separation results showed the possibility of reduction of iron from 1.5% to 0.08% Fe2O3 for rejected limestone sample and 0.2% to 0.08% for regular limestone. Attempt was also made to reduce the transition elements content from limestone of BWC to improve the clinker quality. Based on characterization and liberation studies, it was explored the beneficiation of limestone through dry magnetic separation and Air table for the separation of contaminants from limestone. In addition, it was also developed beneficiation process for reduction of impurities present in rejected limestone sample at the mining site for its ultimate utilization.

Study on Performance Improvement of Coking Coal Washery Under Coal India Ltd Through Modelling and Simulation Analysis.

The coal quality, its ash content and washability characteristics change from deposit to deposit and even in various seams in a given deposit. So the feed characteristics to washery change over a period of mining. It may affect Plant performance, energy efficiency and cannot be optimized through trial and error method. It needs an evaluation of Washery design, process parameters so as to optimize processing high ash coking coal feed at present. The work aims at steady state plant scale model for unit operations (crushing, classification, flotation, gravity separation) in coking coal washery, and to prediction of optimum parameters for improving the performance of Moonidih coal washery though simulation analysis. Systematic sampling at plant site was carried out and data was generated in the laboratory. The work is under progress.

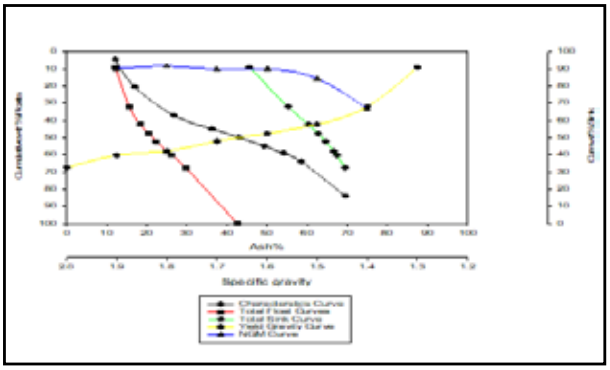


Figure 10 : Washablity Studies (-37+13 mm)

Team : MNP

Materials Engineering

Materials Engineering Division works mainly in four research verticals: Corrosion Engineering, Materials mechanics, Materials processing and Microstructural engineering. The goal of the division is to develop metallic materials, technical support to various industries in materials property evaluation, critical testing, root cause analysis and solution to failed components. The division has state of the art infrastructure: Creep facilities (2nd largest in terms of number of testing points), Fatigue-fracture related equipment, FEG (Field Emission Gun) Scanning Electron Microscopes with EDS, WDS and EBSD as well as FEG Transmission Electron Microscope with EDS and EELS facilities, Gleeble Thermomechanical Simulator, Forming machine for Forming Limit Diagram as well as Hole Expansion Ratio evaluation, Laboratory scale 2 high rolling Mill and various equipment for corrosion rate as well as evaluation of corrosion products.

Effect of Creep-Fatigue Interaction on Disk Forgings

Aero engine manufactures are continuously striving for higher efficiency and therefore, temperature capability of disc alloys is of paramount importance, particularly the 1st stages where the stress and temperature are highest. Temperature gradient in different parts of the disc is schematically shown in Figure 1

Figure 1: Aero engine gas turbine disk's thermal analysis in a high bypass ratio engine showing thermal gradient from Hub to Rim of the disk; Lower the bypass ratio higher will be the temperature

There is a constant endeavor to develop wrought alloys for manufacturing turbine discs with enhanced mechanical properties up to 700°C. Alloy SU 718, which is extensively used for manufacturing turbine discs, is not capable of withstanding temperatures higher than 600°C due to coarsening of γ''. SU 720, which is strengthened by γ' phase, has greater temperature capability and can be processed by conventional forging route. This ability to be processed by conventional route make this alloy a cost effective alternative for application up to 650°C (Please refer to Figure 2). Gas Turbine Research Establishment (GTRE) has also identified SU 720 as a candidate alloy for manufacturing turbine discs for current and future projects and for that extensive experiment on thermal fatigue and creep fatigue interaction behaviour of alloy SU 720 vis-à-vis SU 718 was carried out and shared with the design team of GTRE

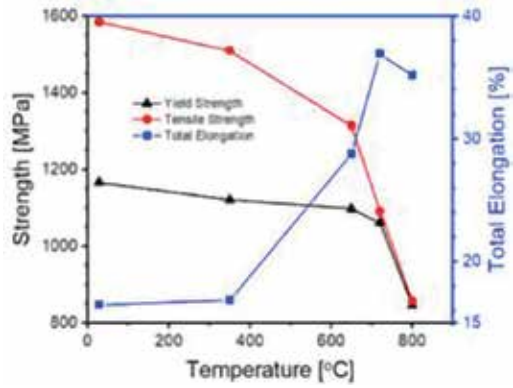


Figure 2 : Variation of tensile properties of SU 720 with temperature. Yield strength remains constant in the temperature range 25 to 650°C.

The fatigue life of SU 720Li alloy is almost 45% higher compare to its predecessor alloy SU 718 tested at 650°C. (Refer Figure 3)

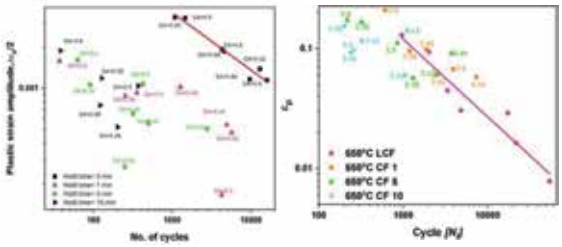


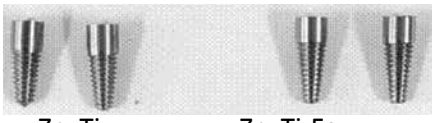
Figure 3: Coffin – Manson plot of SU 718 alloy LCF and CF tested at 600°C and SU 720 alloy LCF and CF tested at 650°C

Multi Component Zr Based Biocompatible Alloys with Modulus ≤50 GPa and Density ~2.8 Gm/Cm³ For Biomedical Application

The primary objectives of the proposed project are a) Development of novel alloys based on the *Zr-Ca-Si-Ti-Fe* system for biomaterial application with

modulus closer to that of bone, b) the targeted alloy modulus should be ≤ 50 GPa and density ~2.8 gm/cm^3, c) Excellent Biocompatible for implant application, Currently development of an ZrTiFe based alloy which is suitable for dental implant application has been achieved. Further, five compositions of ZrTiFe alloy of 450 grams have been prepared at sponsor's premises. Calcium mono Silicide (CaSi) and ZrTiFe master alloy was melted. Consequently, alloy composition of $Zr_{24}.5Ti_{24.5}Fe_2Ca_{24.5}Si_{24.5}$ is modified to $Zr_{24.12}Ti_{24.19}Fe_{1.97}Ca_{20.49}Si_{29.3}$. Very less Calcium was found in developed alloy. Biological test and toxicity test of ZrTiFe alloys are ongoing at the collaborator's premises. It has also been planned to conduct biological test on ZrTiFe alloys and to develop ZrTiFeCaSi alloy.

Relevant images:



$Zr_{90}Ti_{10}$ $Zr_{90}Ti_9Fe_1$

Figure 4: Fabricated ZrTi based dental implant

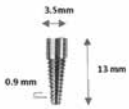


Figure 5: Design of the dental Implant

High Entropy Alloys (HEA) for Hydrogen Storage Application Operable at Room Temperature (Heart)

A CSIR-Mission Mode project having objectives a) Screening of novel HEAs suitable for hydrogen storage through CALPHAD approach, b) development of HEAs using arc melting route with an optimum composition range and c) know-how of bulk scale (1-5 kg) preparation of selected HEAs by induction melting and casting followed by thermo-mechanical processing. This project deals with design and development of multicomponent alloys (often termed as High Entropy Alloys), suitable for reversible solid-state hydrogen storage in ambient temperature. The targeted properties are gravimetric storage capacity of ≥ 2.5 wt.% hydrogen along with near ambient conditions desorption temperatures and pressures. The alloys are intended to possess good hydrogen absorption kinetics as well as cyclic reversibility for possible commercial applications. The final deliverable of the project would be development of high entropy alloy for hydrogen storage. Currently, the project is focusing on activities like CALPHAD based phase equilibria assessment of HEAs focusing on AB_2 type Laves and BCC dominating matrix, arc melting and casting of selected HEAs (05 Nos. (02 Laves and 03 BCC based), microstructural characterization and phase determination of the as-cast state heat treatment study of selected alloys and characterization of hydrogen storage properties of a few selected developed HEAs using Sievert-type PCT apparatus. In future, below activities have been planned:

1. Design of suitable heat treatment schedule to obtain desired phases in the final microstructure
2. Evaluation of the hydrogen storage performance of the arc melted alloys
3. Compositional tailoring based on the hydrogen storage kinetics of the developed alloys
4. Trial for induction melting (1-5 kg) of selected alloys will be taken up for bulk production.
5. Detailed material and hydrogen storage characterization of the alloys

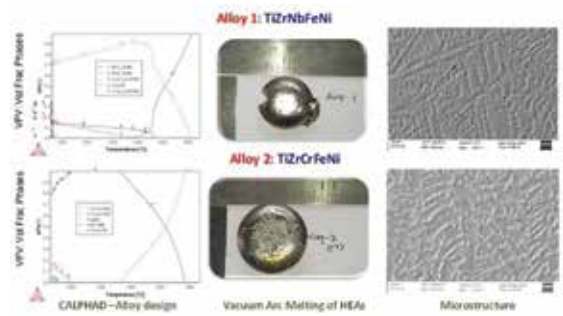


Figure 6: Shows CALPHAD analysis and microstructural characterization of a Alloy

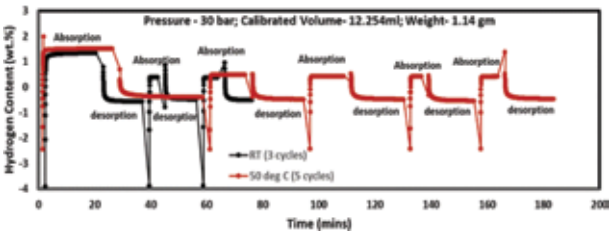


Figure 7: Shows the H_2 absorption not desorption behaviour of Alloy 2

Precipitation Hardened Compositionally Complex Alloys (CCAs) Aided with Hetero-Deformation Induced (HDI) Strengthening

The specific aims of the present work under CSIR-FIRST Scheme are a) to design a new compositionally complex alloy (CCA) along with a process schedule, b) Optimization of the process parameters for superior properties in comparison to some of the existing superalloys and c) to enhance the understanding of heterogeneous deformation

induced (HDI) strengthening mechanism. The project is an effort towards alloy design for high temperature applications using the core concepts of high entropy alloys. Sluggish diffusion and lattice distortion in such multicomponent alloy systems can be beneficial for high temperature stability as well as strengthening. Further, precipitation hardening has been incorporated via design of $L1_2$ phases in face centred cubic (FCC) matrix which is similar to the famous γ-γ′ microstructure observed in superalloys. A suitable thermo-mechanical process schedule for designed alloy/s will be finalized. A suitable design of thermo-mechanical process route for some of the designed alloys seems to be challenging due to high alloying addition and formation of various as-cast precipitates. Mechanical property evaluation to be carried out at room and elevated temperatures. Microstructural stability at targeted temperatures will also be evaluated to assess potential of designed alloys for high temperature applications. Final deliverable will be a novel alloy for high temperature applications, which is expected to exhibit superior mechanical properties in comparison to some of the existing Ni-based superalloys. Ongoing activities of the project are experimental work, design of compositionally complex Ni-based alloys with a high to medium entropy matrix based on CALPHAD approach (Figure 8). All the alloys have been prepared based on induction melting and casting. Initial studies have been carried out on Alloy A and process schedule have been designed for the same. Microstructural analysis of as-cast Alloy A has been carried out (Figure 9). Suitable process schedule design for Alloy A is in progress based on the understanding of recrystallization and precipitation mechanisms (Figure 10). Detailed microstructural characterization of thermo-mechanically process specimens (Figure 11) has been done. The activities planned for future are:

- Design of few more alloys based on CALPHAD approach
- Optimization of thermo-mechanical process route/s for suitable alloy/s
- Detailed characterization of prepared alloys
- Mechanical property evaluation at room and elevated temperatures
- Evaluation of microstructural stability of selected alloys at elevated temperature

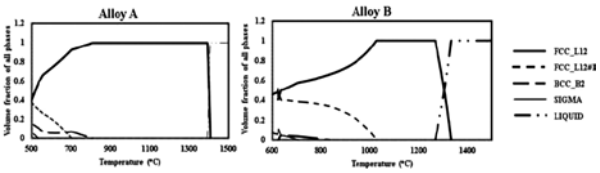


Figure 8: Property diagram designed via CALPHAD approach for (a) Alloy A and (b) Alloy B

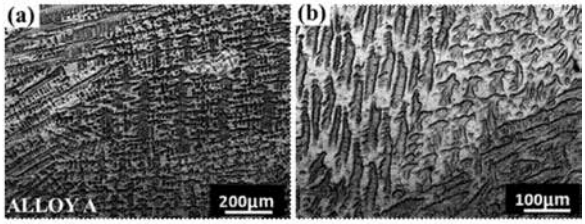


Figure 9: Optical micrograph of Alloy A at (a) low magnification revealing dendritic microstructure (b) high magnification revealing some fine as-cast precipitates at interdendritic regions

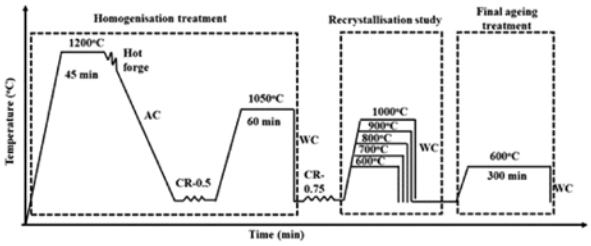


Figure 10. Thermo-mechanical process schedule for Alloy A

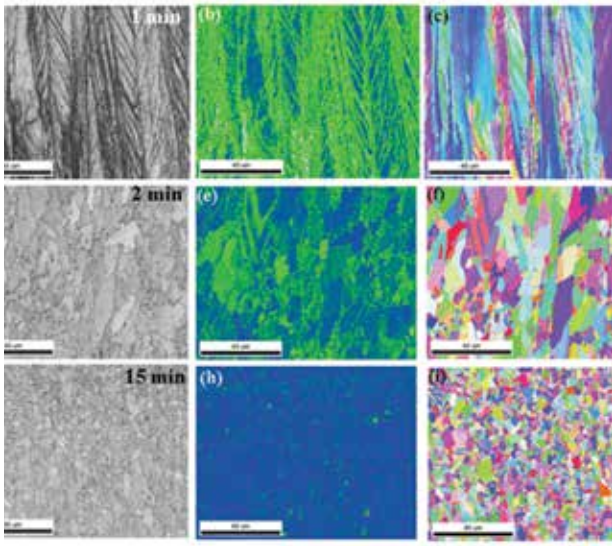


Figure 11: EBSD micrograph of (a-c) 1min annealed sample post cold deformation of 73%. These micrographs show image quality (IQ) map, Kernel Average Misorientation (KAM) map and inverse pole figure (IPF) respectively. (d-f) IQ, KAM and IPF maps for 2 min annealed sample (g-i) IQ, KAM and IPF map for 15 min annealed sample

Investigation on Weldability of 8 and 20 mm Thick High Nitrogen Steel with Strength of about 800 - 1200 MPa

The structure of armoured vehicles is traditionally made by medium carbon low alloy steels with different hardness levels. However, there is always a need for developing newer material which will enable further weight reduction. In this regard, high nitrogen steel (HNS) with high strength and good toughness is a potential material for armour applications. Despite having the desired combination of the properties in the base metal, the weldability of HNS could be an issue due to higher nitrogen content. The objectives **of the work are to** optimize the process parameters in welding HNS of thickness 8 and 10 mm, assess the weldiability of HNS using available filler wires of austenitic and duplex stainless steel grades, evaluate the microstructure, mechanical properties and susceptibility of cracking of welded samples, adopt suitable methodology in controlling porosity within the acceptable limits in the weldments, develop a new filler wire in welding HNS plates with SMAW process based on assessing the weladability using available filler wires. Bulk chemical composition analyses have been carried out for virgin alloy of HNS plates of 8 and 20 mm thickness. The chemical composition (in wt%) of major elements Cr, Mn, Fe and N in both plates are around 19.07, 21.78, 61.30 and 0.5%, respectively. Microstructural characterization has been carried out along longitudinal and thickness direction for both plates. The specimens were examined under optical (Make: Leica DM2500M) and scanning electron (Make: Zeiss EVO18) microscopes to reveal global and specific characteristics, respectively. Figures 2(a)-(b) show the optical images of 8 mm thick plate in longitudinal and transverse directions, respectively. Similarly, Figure 12(c)-(d) exhibit the optical images of 20 mm thick plate in longitudinal and transverse direction, respectively. By and large microstructure exhibited the existence of polygonal austenitic grains containing twins. Qualitatively, 8 mm thick plate exhibits finer grain structure of 7.4 – 9.4μm as compare to 20 mm thick plate of 14.3 – 17.6μm.

The bulk hardness measurement for both type of plates was determined using Vicker's Micro-hardness tester (Model : NVH-AUTO, Make: OMNI-TECH) with load and dwell time of 30 kg and 10 s, respectively. The average values of hardness were 333 – 352 and 252 – 254 HV for 8 and 20 mm thick plates, respectively. The Charpy impact testing has been attempted using instrumented Charpy Machine (Make: Zwick-Roell) for both plates and the toughness was around 40 (±2.7) J at room temperature.

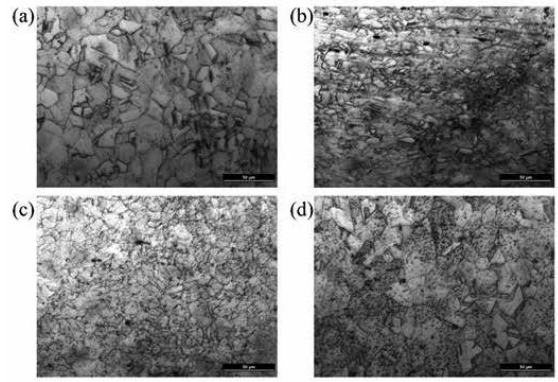


Figure 12 : Optical images of 8 mm thick plate in (a,b) longitudinal and transverse directions, and 20 mm thick plate in (c,d) longitudinal and transverse directions

The tensile tests have been performed in a 50 kN INSTRON 8800 universal tensile testing machine at a crosshead speed of ~0.5 mm min^{-1}. Figure 13 shows one of the representative plots of engineering stress vs. engineering strain of 8 mm thick plate. Reproducibility of data was confirmed by repeating the test for same type of samples three times. The yield strength, ultimate tensile strength, and % elongation of the particular plate were ~975 MPa, ~1137 MPa and ~36.1%, respectively. Other experimentations like fabrication of joints, structural and mechanical characterization of assemblies, corrosion study are in progress as per the commitment portrayed in project proposal.

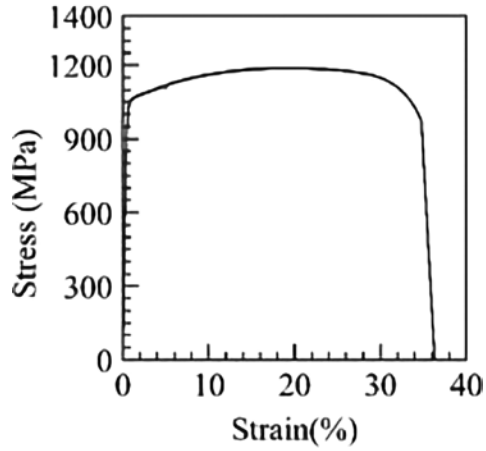
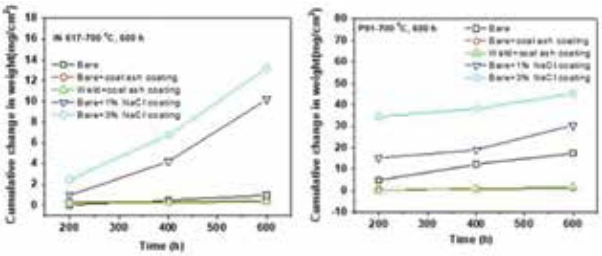


Figure 13: Engineering stress-strain curve of 8 mm thick plate

High Temperature Oxidation and Hot Corrosion Behavior of Selected Materials for Clean Coal Technologies for Power Plant Applications

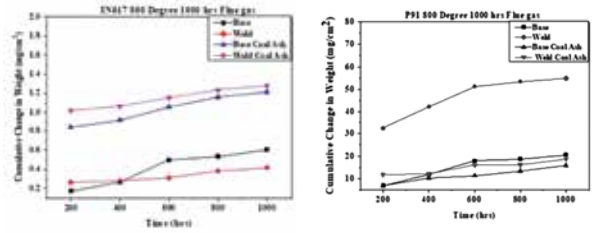
The hot corrosion studies were carried out on unwelded & LH welded IN 617 and P 91alloy samples. The samples were coated with (i) coal ash and (ii) salt coating. The coated samples along with uncoated samples were exposed at 600-800 °C in flue gas environment for 600-1000 h. The major objectives of the study were: oxidation and hot corrosion studies (varied salt elements and proportion thereof) of boiler materials (IN617, P91, T23, T24 and SS347) under varied salt proportions and cyclic loading effects during short and long term exposure, optimization of laser hybrid (LH) welding parameters for their influence on oxidation and hot corrosion behavior, creep-hot corrosion simulation at predefined loads/stress and time, post exposure characterization of specimens and oxide scales subjected to creep-hot corrosion tests and Evolution of possible degradation mechanism.

The hot corrosion studies were carried out on as-received IN 617, P 91 alloys and laser welded IN 617 (W) and P 91(W) alloys with and without coal ash coating exposed to 600-800 °C in flue gas environment for 600-1000h. The hot corrosion kinetics at 600 °C was found to be the lowest for IN 617 (base) followed by IN 617(weld), coal ash coated IN 617(base) and coal ash coated IN 617(weld). While for P91 alloys, the lowest oxidation kinetics were observed for coal ash coated P91 (base) followed by coal ash coated P91 (weld), P91(base) and P91(weld). The change in mass per unit area was found be very low for IN 617 alloy and ranges in 0-1.5 mg/cm^2 while for P91 it is 0.1-7 mg/cm^2. The oxidation kinetics at 700 °C (Figure 14) was found to be the lowest for coal ash coated IN 617(weld) and coal ash coated IN 617(bases) than IN 617 (base). In case of salt-coated samples, the corrosion kinetic was increasing on increasing NaCl from 1-3%, similar kind of behaviour was also observed for the P91 alloy samples. The change in mass per unit area was observed be very low for IN 617 alloy (0.1-12 mg/cm^2) while for P91 it is relatively much larger and ranges from 0.1-40 mg/cm^2. The oxidation kinetics at 800 °C (as shown in Figure 15) was lowest for IN 617(weld) followed by IN 617(base), coal ash coated IN 617(base) and coal ash coated IN 617(weld). For P91 alloys, the lowest oxidation kinetics were found for coal ash coated P91 (base) followed by coal ash coated P91(weld), P91(base) and P91(weld). The change in mass per unit area was low for IN 617 alloy (0.2-1.1 mg/cm^2) while for P91 is (0.1-55 mg/cm^2). The oxide phases formed on hot corroded specimens of the base and welded P91 alloys at various corrosive conditions as identified by XRD. The XRD patterns indexed reveal the major diffraction peaks of Fe_2O_3 and $FeCr_2O_4$ for base and weld specimens (without coal ash coating) of P91 alloys. In case of coal ash coated wot corroded base and welded specimens of P91 alloys, the oxide scale mainly comprised of $FeCr_2O_4$ in addition to other oxides such as Cr_2O_3, $(Na, K)_2SO_4$ and Al_2O_3. The SEM/EPMA characterization of as-received IN 617, P 91 alloys and laser weld IN 617 (Weld) and P 91(Weld) alloys with and without coal ash /salt coating depicted the top surface morphology. On comparison the SEM images, it was obvious that the roughness of the oxide scale formed on IN 617 (Weld) is larger than IN 617 (Base) followed by its corresponding coal ash coated counter parts. The bulk EDS spectrum reflects peak of Ni, Cr, Fe, and O elements which corresponds to presence of $NiCr_2O_4$ in the oxide scale delineated by XRD. The outer surface morphology of the oxide scale formed on base and welded P91 alloys with or without coal ash coated and hot corroded at 700 °C in flue gas environment exposed for 600h. SEM images analysis confirmed, the roughness of the oxide scale formed on base P91 (Base) alloys was larger than P91(Weld) followed by coal ash counter parts. The bulk EDS spectrum on the top surface contained peak of Cr, Fe, and O elements corresponded to formation of Fe_2O_3 and $FeCr_2O_4$ as identified by XRD.



(a) (b)

Figure 14: Weight change per unit area of the specimens hot corroded at 700 °C for 600 h: (a) IN617 alloys and (b) P91 alloys.



(a) (b)

Figure 15: Weight change per unit area of the specimens hot corroded at 800 °C for 1000 h: (a) IN617 alloys and (b) P91 alloys.

Development of High Ballistic Strength Armour Steel with 2 GPa Tensile Strength and Min 50mpam$^{1/2}$ Fracture Toughness

The project aims at the development of an indigenous technology for armour steel with enhanced ballistic performance, which will be extremely useful for Indian Defence. Considering the strength of currently available armour plates, the present work also envisages achieving higher strength to reduce the thickness of steel plates, which will lead to light-weighing. The developed technology can have low cost of production due to no requirement of tempering process, elimination of isothermal holding in conventional Q & P process and reduced and cost-effective alloying additions. In the current project, the steel compositions have been designed with minimal alloying additions and apply novel or recently developed processing scheme to achieve a multiphase microstructure. In addition, the industrial feasibility, i.e. production of these steels with existing facilities has also been considered to avoid difficulties in industrial translation in future. Four different alloys have been designed based on the theoretical simulations, literature review and patent search. These alloys have been treated through various processing schemes, i.e. through (i) 'continuous cooling' to room temperature at various cooling rates and (ii) 'quenching and non-isothermal partitioning' in the bainite and martensite regions (Figure 16). The above-mentioned processing has been applied to eliminate the isothermal holding as required in the tempering and/or conventional quenching and partitioning processes. All the designed alloys have been heat treated, followed by evaluation of microstructure and mechanical properties. The microstructure of steel shows the presence of martensite and retained austenite with some amount of carbides and bainite in some cases. The mechanical properties achieved for the developed alloys are shown in Figure 17, and compared with literature and DMR 1700 data. The results so far suggest the achievement of tensile properties closer to the project target (2 GPa ultimate tensile strength and 7-10% total elongation). Based on these lab scale findings/optimization, one of the best alloy has been chosen for large/pilot scale processing. All of these above research activities are expected to provide an optimized alloy composition and process technology for plant trial in future, followed by indigenous production of armour grade steel. The project could develop a) medium carbon low alloy steel through energy-efficient quenching and non-isothermal partitioning route b) developed an optimized process methodology to achieve advanced high strength combined with good ductility and impact toughness.

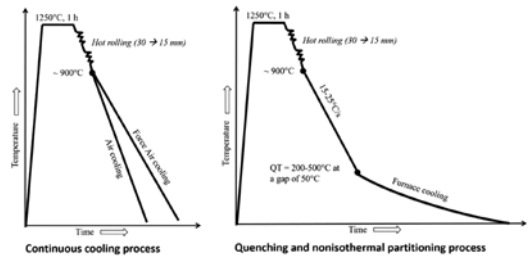


Figure 16: Schematic of the applied processing schedule on designed alloys

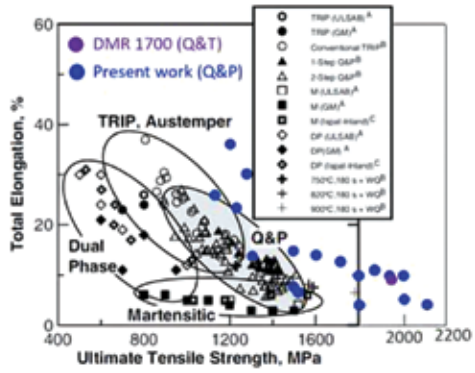


Figure 17: Mechanical properties achieved for the developed alloys compared with literature and DMR 1700.

Unveiling Abnormal Grain Growth Mechanism in Grain Oriented Silicon Steels

The project has objectives of (a) Statistical assessment of the evolution of crystallographic character of grain boundaries surrounding Goss grains by EBSD and its variation with primary recrystallization texture,

(b) Correlations of the evaluated GBCD with the evolution of pinning effect of inhibitors present on the corresponding boundary segments.

Grain-oriented (GO) steels with a strong Goss texture ({110} <001>) are predominantly used in transformers for power generation and distribution. The rapidly expanding power sector of India demands indigenous technologies and know-how for GO steel production, in order to facilitate high-cost import substitution. However, the major challenge in the development of GO steels lies in identifying the suitable precursor

Unveiling abnormal grain growth mechanism in grain oriented silicon steels

Grain-oriented (GO) steels with a strong Goss texture ({110} <001>) are predominantly used in transformers for power generation and distribution. The rapidly expanding power sector of India demands indigenous technologies and know-how for GO steel production, in order to facilitate high-cost import substitution. However, the major challenge in the development of GO steels lies in identifying the suitable precursor microstructure and texture that can exhibit effective abnormal grain growth (AGG) of Goss grains during the secondary recrystallization (SRX) step. The proposed work aims to identify the responsible mechanism for abnormal grain growth of Goss grains in GO steels, for which two 3.2 wt.% Si steels with different aluminum contents (0.02 wt.% and 0.04 wt.%) have been prepared by vacuum induction melting and casting. The variation in aluminum content has been made basically to attain a consequent variation in AlN precipitate fraction, which would act as the major inhibitor (along with minor effect from MnS) for grains other than Goss oriented grains during SRX, thereby allowing AGG. Figure 1 depicts: the process (consisting of vacuum induction melting, casting, hot forging and hot rolling) adopted for lab scale development of hot bands wherein the desired microstructural gradient (i.e. fine recrystallized/partially recrystallized grains at surface and recovered/deformed grains at center) and texture gradient (strong Goss texture at surface and mixture of gamma fiber and alpha fiber at center) are achieved.

Current Status: CALPHAD based phase equilibria assessment; Homogenization of the cast ingots followed by hot-forging till thickness suitable for lab scale hot rolling; Real time cooling profile measurements using thermocouples welded at the center of samples, during each pass (and after each pass) of designed hot-rolling schedule; Microstructural and microtextural characterization of as forged and as rolled specimens (after quenching post each pass of hot-rolling) to understand the microstructural and textural evolution; Rigorous large area precipitate analysis using scanning electron microscopy based energy dispersive x-ray spectroscopy (SEM-EDS) of the hot rolled samples (post each pass) so as to understand the precipitate evolution in terms of fraction, size distribution, position (i.e. at grain boundaries or within grain matrix) and morphology; Design of customized high temperature furnace for annealing under controlled atmosphere along with quenching facility so as to enable various treatments such as decarburization, nitriding, PRX and SRX.

Future Deliverables: Cold rolling and secondary recrystallization annealing process optimization, crystallographic character of GOSS grains and effect of inhibitors on GBCD evolution.

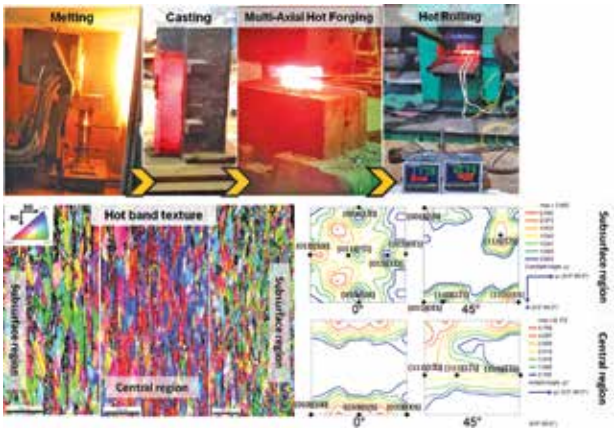


Figure 18 : Processing of the CRGO steel upto hot rolling stage and its hot band texture.

The following activities have been completed with respect to the designed alloys:

- CALPHAD based phase equilibria assessment
- Homogenization of the cast ingots followed by hot-forging till thickness suitable for lab scale hot rolling

- Real time cooling profile measurements using thermocouples welded at the center of samples, during each pass (and after each pass) of designed hot-rolling schedule
- Microstructural and microtextural characterization of as forged and as rolled specimens (after quenching post each pass of hot-rolling) to understand the microstructural and textural evolution
- Rigorous large area precipitate analysis using scanning electron microscopy based energy dispersive x-ray spectroscopy (SEM-EDS) of the hot rolled samples (post each pass) so as to understand the precipitate evolution in terms of fraction, size distribution, position (i.e. at grain boundaries or within grain matrix) and morphology
- Design of customized high temperature furnace for annealing under controlled atmosphere along with quenching facility so as to enable various treatments such as decarburization, nitriding, PRX and SRX.

Future Deliverables : Cold rolling and secondary recrystallization annealing process optimization, crystallographic character of GOSS grains and effect of inhibitors on GBCD evolution.

Material Analysis and Reclamation of Gas Collector for GTG 1250-2E

The objectives of the project are : Development of an in-depth understanding of the Gas Collector material and use it to further its mechanical properties from its existing level, Reversal of the degradation of the material due to service exploitation by selective annealing cycles and Design of a heating process and device for component-level annealing. Our study demonstrated that the microstructure degradation that occurred due to service exploitation could be reversed by heat treatment above the service exploitation temperature. Based on these observations a two-stage annealing/heat treatment cycle is suggested and which is found to recover the deteriorated microstructure

Remaining Life Assessment of Crude and Vacuum Heater Tubes

Crude Distillation Unit-2 which was commissioned in the year 1996 has two heaters i.e. Crude Heater and Vacuum Heater tubes, were operated for more than 21 years and 11 years respectively in stringent conditions. These tubes are prone to exhibit creep related failure due to long-term thermal exposure. The main objective of the present investigation is to assess remaining life of Crude and Vacuum heater tube material supplied by MRPL after service. Residual Life Assessment (RLA) of Crude and Vacuum Heater tubes will be carried out through destructive testing to arrive at remaining life prediction of the heater tubes during shutdown of the plant. Operating parameters were maintained and controlled to avoid overheating failure during service. However total economic loss during shut down of the plant.

Team - MTE

Burj Khalifa - Dubai

- It is the world's tallest manmade structure, having height of 829.8m. Using a bundled tube design to reduce the amount of steel required.
- Constructed with the 31,400 metric tonnes of steel rebar. The building is also made up of 39,000 metric tonnes of reinforced steel and 166,800 sq ft of embossed stainless steel.

Sources: wikipedia

CSIR NML Madras Centre

Research and Development activity related to Flotation and Column flotation of different minerals has been the mainstay of CSIR-NML Madras Centre for the past three decades, as flotation accounts for more than fifty percent of the ore/mineral concentrates generated globally. Additionally, materials evaluation activities are also carried out. The research carried out in the reporting year are indicated below.

Consultancy on Design, Erection, Commissioning of Flotation Column at a Coal Processing Unit

The project work of design, erection, commissioning of 200 tpd flotation column at the Coal Preparation Plant of sponsor for beneficiation of coal fines was executed in collaboration with our engineering partner, M/s McNally Sayaji Engineering Co. Ltd. Bengaluru. The erection of all the mechanical equipment, piping work, electrical and instrumentation was completed. Initial water trials followed by coal slurry feed trials in the flotation column was completed and the plant was commissioned and has been in operation since then.

The below images show the 200 tpd flotation column installed at the Coal Preparation Plant of the sponsor.

Figure 1: 200 tpd flotation column installed at Coal Preparation Plant

Figure 2: 200 tpd flotation column commissioned at Coal Preparation Plant

Figure 3: Image showing froth formation during coal flotation in 200 tpd flotation column

Development of Graphene-Based Membranes from Graphite Ore for Desalination

The project was executed in collaboration with CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram. The objective of the project was to develop a novel, innovative

approach for scalable synthesis of graphene from low-grade graphite ore. This low-grade ore was beneficiated using a newly developed non-petroleum and natural product-based environment friendly flotation reagent as collector for graphite. The graphite concentrate with 4% ash content after six stages of cleaning of rougher float was obtained by flotation of graphite ore. This concentrate was used for the synthesis of graphene powder. The SEM image of the graphite concentrate obtained after beneficiation by the reduction of associated impurities like quartz and silicate minerals in the separation process that intrinsically intercalate graphite, as shown in the figure below, depicts the micro-scale graphite thick layers with exfoliated morphology. Flotation process parameters optimization was carried out using statistical design of experiments (DoE). The flotation performance evaluation of this bio-collector was compared with that of conventionally used hydrocarbon oil as collector. The graphite concentrate obtained by flotation using bio-collector was found to produce concentrate with lower ash content than conventional reagents. This research work on value addition of graphite mineral provides an opportunity for the development of new and cost effective technologies for the production of high quality graphene and its composites.

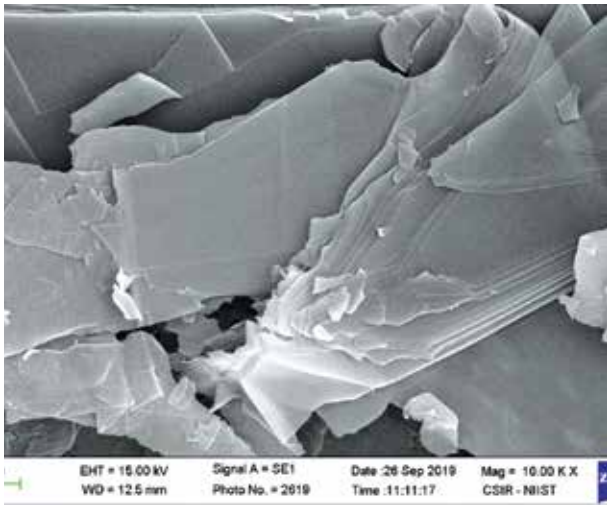


Figure 4: SEM image of graphite final concentrate obtained using the bio-collector

Failure Investigation of Molybdenum Electrode in Glass Melting Furnace

A comprehensive study was undertaken by the Centre. Various metallurgical characterisation techniques were used to establish the failure namely Optical microscopy for micro-structural studies, Scanning Electron Microscopy for microstructural analysis and Fractography studies and energy dispersive spectroscopy for surface corrosion deposits analysis. Based on the results obtained on the failed molybdenum electrode and supported with relevant scientific literature, the molybdenum electrode in the glass melting furnace failed mainly due to the intergranular corrosion / grain boundary corrosion resulted by the exposure of Mo electrode material to corroding elements present in the glass melt. Grain boundary corrosion or intergranular corrosion was due to possible formation of corrosive oxide deposits at the grain boundaries in different combinations which resulted in the grain boundary weakening.

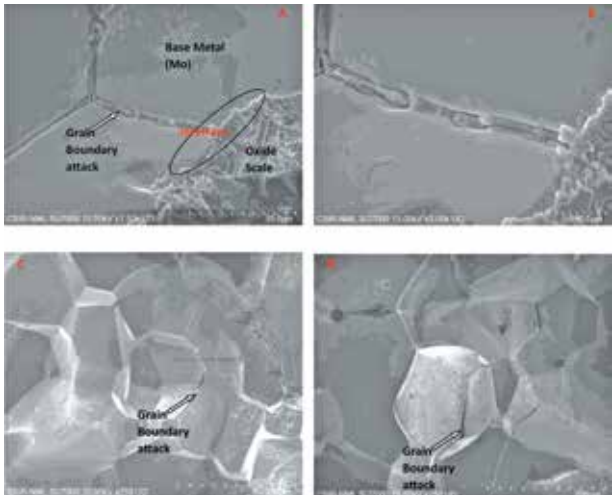
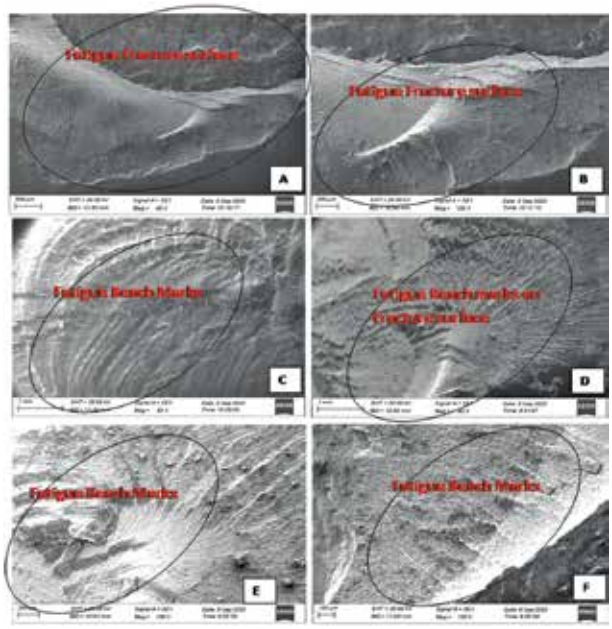


Figure 5 : Microstructural Images

Failure Analysis of Rollers in Slew Bearings of GOTTAWALD make Harbour Mobile Crane

Various metallurgical characterisation techniques were used to establish the failure namely Optical microscopy for micro-structural studies, Scanning Electron Microscopy for microstructural analysis and Fractography studies and energy dispersive

spectroscopy for surface corrosion deposits analysis. Based on the results obtained the failed rollers samples confirmed the fatigue features with beach marks at the crack initiated fracture surface, pitting on the failed surface, spalling on the surface and the elliptical crack opening on the surface and the prevailed damage characteristics on the failed roller samples were clearly confirmed the operation of *rolling contact fatigue (*RCF) on the roller surface.



Metallurgical Failure Analysis of Boiler Tubes of Thermal Power Plant

Various metallurgical characterisation techniques were used to establish the failure namely Optical microscopy for micro-structural studies, Scanning Electron Microscopy for microstructural analysis and Fractography studies and energy dispersive spectroscopy for surface corrosion deposits analysis. Based on the results obtained, it was concluded that the waterside of the tubes were undergone uniform corrosion to the depth of 0.1-0.15 mm from the surface. The firesides of the tubes werere exposed localised corrosion and damage was progressed up to 0.15 - 0.2 mm. Normal localized Iron oxide corrosion was observed on the fireside surface of the tube due to the exposure of tube to atmosphere, and Sodium, Phosphorous and oxygen induced uniform corrosion was observed on the waterside of the tube surface.

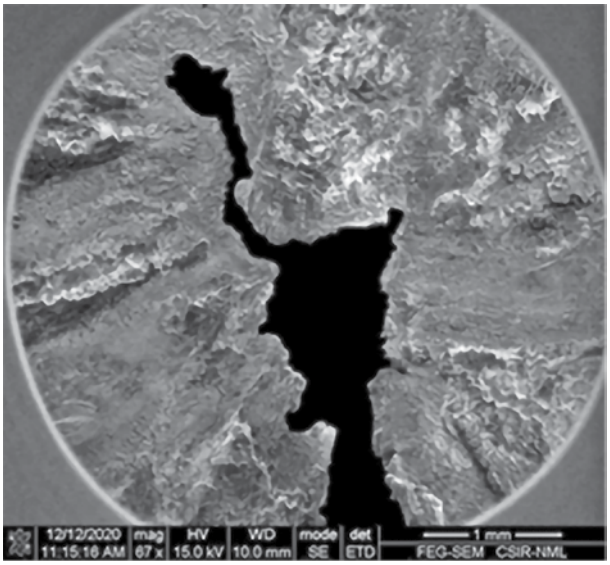


Figure 7: Fracture surface shows the deformation around the crack region and crack tip..

Feasibility Studies on Beneficiation of Low Grade Goan Iron Ore

The project was sponsored to study the feasibility of beneficiation of low grade iron ore from 48-50% Fe to 55-56% Fe by the reduction of alumina and silica content with optimum recovery by adopting suitable beneficiation techniques. The photomicrographs for characterization of the ore are shown in below figures.

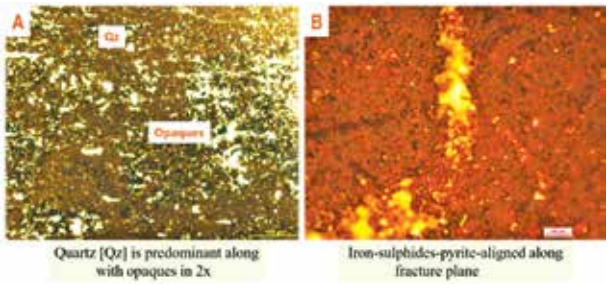


Figure 8: Petrology images of low grade iron ore

From the pertrology studies, the quartz was alternating with opaques and ferro-amphiboles at places. Magnetite phase is isotropic and the polished sections of iron ore sample showed some sulphide specks and concentration along fracture/shear plane. The opaques seen in incident light are clearly

brought out in reflected light in 10x magnification. The liberation and process optimization studies involving multiple unit operations for obtaining a concentrate with 55-56% Fe was carried out by jigging for coarser size-fraction and flotation for fines. A concentrate of 55.64 Fe% was obtained from feed grade of 48-50% Fe under optimized jigging process conditions. Flotation of ultra fines was found to be encouraging.

Feasibility Studies on Flotation of High Magnesia Limestone from Maharashtra

The project was undertaken to study the feasibility of beneficiation of high magnesia limestone sample sourced from Maharashtra by flotation with the objective of obtaining a concentrate with maximum possible recovery and reduction of SiO_2 and MgO. The characterization of limestone sourced from Maharashtra for mineralogy is shown in the below figures.

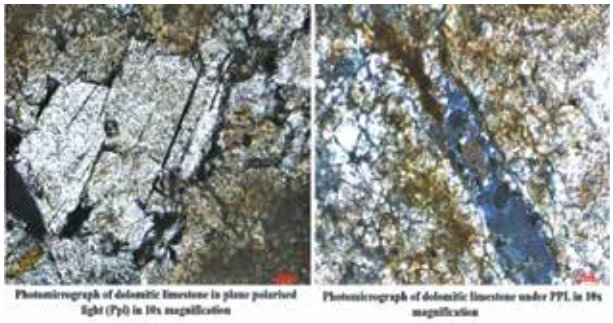


Figure 9: Petrology images of high magnesia limestone

Petrology study of the sample showed medium to fine grained rock and colourless in plane polarized light, rhombohedra cleavage was seen clearly and there was change in relief on rotation of stage. These images show crystalline shapes confirming the presence of siliceous matter. Rhombohedron crystal blocks with non-metallic lustre indicated the presence of calcite and dolomite. Dolomite occurs frequently as a diagenetic alteration of calcite. Secondary dolomite often forms a mosaic of rhombic crystals. The laboratory scale feasibility studies on limestone with a grade of 41.72% CaO, 6.04% SiO_2 and 8.05% MgO for reduction of MgO by flotation using different collectors was carried out. A flotation concentrate with CaO content of 47.44%, 3.57% SiO_2 and 5.19% MgO at optimized process parameters was obtained using eco-friendly collector. It was observed that the sample responds to value addition or quality improvement by substantial reduction of silica and MgO.

Feasibility Studies on Flotation of High Silica Limestone from Rajasthan

The project was undertaken to study the feasibility of beneficiation of high silica limestone sample sourced from Rajasthan by flotation with the objective of obtaining sweetener and cement grade concentrates. The pertrological studies of the high silica limestone revealed that the compaction of the rock compresses it in some directions but opens up tiny fractures in others. The fractures are filled with more carbonate crystals, but these new ones are free of the tiny grains of opaque matter that give the rock its grey colour as shown in below figures.

Figure 10: Petrology images of high silica limestone

Laboratory scale feasibility studies on high silica limestone sourced from Rajasthan analysing 42.21% CaO, 15.71% SiO_2 and 1.22% MgO were taken up for the reduction of SiO_2 and improving the CaO content so as to meet the sweetener grade (CaO ≥ 50% and SiO_2 < 5%) and cement grade (CaO ≥ 43% and SiO_2: 10-12%) for cement manufacturing. A flotation concentrate of 45.60% CaO, 11.4% SiO_2 with 82.97% concentrate weight recovery for cement grade and 48.84% CaO, 5.64% SiO_2 with 43.76% concentrate weight recovery for sweetener grade was obtained by flotation using eco-friendly collector.

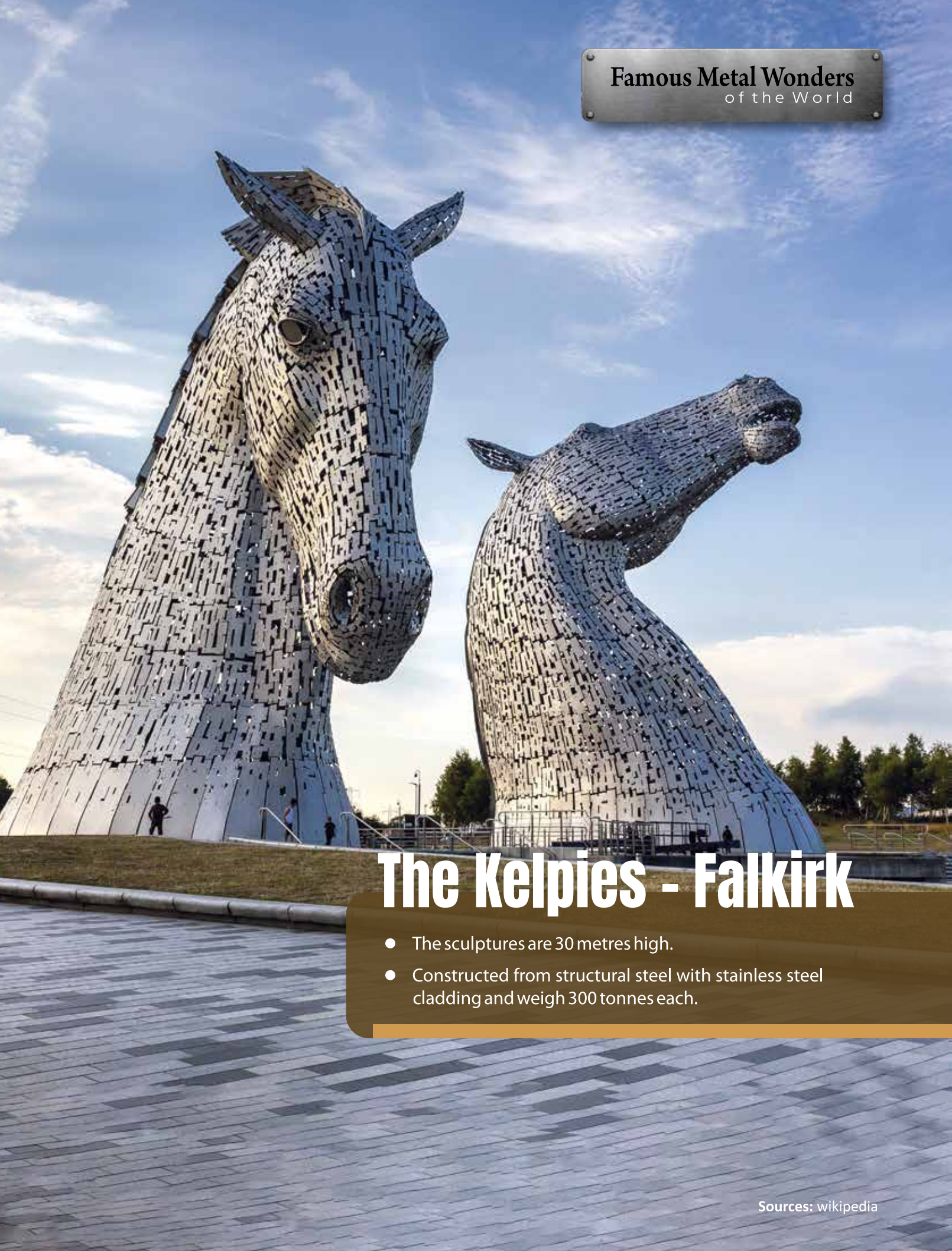
Preparation of DPR on Modernization and Improving Mineral Recovery in Mineral Separation Plant of Sponsor

The project was undertaken to prepare the DPR for modernization and mineral recovery improvement due to the ageing of the plant equipment and advent of modern technologies. The objective of the project also includes assessing the performance of the existing plant. The performance of the wet mill circuit and dry mill circuits of the Mineral Separation Plant was evaluated. The bottlenecks and underperformance of the circuit were identified and necessary remedial measures are being suggested based on the collected plant data.

Preparation of DPR on Wet Concentration Plant No.1 Upgradation & Separating Sillimanite Rich Fraction from the Concentration Plants No.1 & 2 for Sillimanite Recovery Circuit in Ms Plant of Sponsor

The project was undertaken to prepare the DPR for upgradation of wet concentration plant and improving sillimanite mineral recovery. The objective of the project was to analyze the plant's performance by sample collection from the operating plant, identify the bottlenecks and suggest measures for upgradation to achieve optimal performance. The possibility of using floatex density separator for improving the heavy minerals recovery, especially that of sillimanite, is being evaluated.

Team - CSIR-NML-MC



The Kelpies - Falkirk

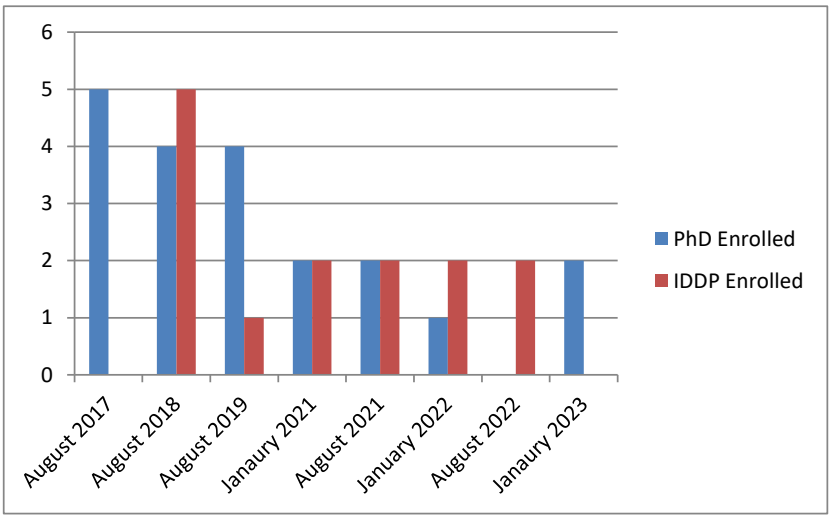
- The sculptures are 30 metres high.
- Constructed from structural steel with stainless steel cladding and weigh 300 tonnes each.

Sources: wikipedia

AcSIR

New Admission Details

January 2023		
Student Name	**Program**	**Sponsorship**
Roshan Kumar	PhD	Internal Candidate
Neelam Sharma	PhD	Self Sponsored



Student Enrollment

Total Number of Students :

PhD : 27

IDDP : 7

The students who complete their doctoral degree in the Academic Session 2022-2023 are-

1. Dr. Dilip Makhija (Industry Sponsored, Tata Steel Ltd.)- June, 2022
2. Dr. Ammasi A. (Senior Scientist, CSIR-NML)- July, 2022
3. Dr. Premkumar M. (Senior Scientist, CSIR-NML)- December, 2022
4. Dr. Biraj Kumar Sahoo (Senior Scientist, CSIR-NML)- February, 2023

Harbour Bridge -Sydney

- World's largest steel arch bridge (not the longest)
- Constructed with 52,800 tonnes steel, with 39,000 in the arch.
- International symbol of Australia. Its 49m wide deck carries eight lanes of traffic, two train lines, a footpath and a cycle path.
- It took nine years to construct the iconic bridgewith the aim of connecting the city's Central Business District to the North Shore. It is the tallest steel arch bridge in the world, measuring 134m above water level.

Sources: wikipedia

Intellectual Property

Patents Filed in FY 2022-23

S.N	Application No.	Title	Inventors	Provisional Filing Date	Complete Filing Date
1	202111039713	A MAGNETO-IMPEDANCE [MI] ARRAY SENSOR AND A PROCESS FOR ARRANGEMENT OF AMORPHOUS / NANOSTRUCTURED MICROWIRES IN AN ARRAY FOR ENHANCEMENT OF SIGNAL RESPONSE	ASHIS KUMAR PANDA, SOMNATH DAS, TARUN KUMAR DAS, PREMKUMAR MURUGAIYAN, RAJAT KUMAR ROY, ABHISHEK KUMAR SINGH	02-Sep-21	13-May-22
2	202111040165	A PROCESS FOR SELECTIVE EXTRACTION-SEPARATION-RECOVERY OF LITHIUM FROM SPENT LITHIUM BASED BATTERIES OF ANY/MIXED CHEMISTRY	Abhilash, Pratima Meshram, Sanjay Kumar	04-Sep-21	01-Sep-22
3	202111040164	A closed-loop process for separation and recovery of Lithium, Nickel, Cobalt, Manganese and Graphite from Spent/Waste/Scrap Lithium based batteries of mixed chemistries	Pratima Meshram, Abhilash, Sanjay Kumar, Vikash Bharti	04-Sep-21	02-Sep-22
4	202211013669	A PROCESS TO RECOVER LITHIUM (Li) AND MANGANESE (Mn) FROM EFFLUENT AND BLACK CATHODIC MATERIAL OF SPENT LIBs	Manis Kumar Jha, Ranjeet Kumar Singh, Jhumki Hait, Pankaj Kumar Choubey, Rekha Panda	11-Mar-22	03-Mar-23
5	202211029391	HIGHLY PURE TITANIUM-BASED MAX PHASE AND PROCESS FOR PREPARATION THEREOF	Pallab Bhattacharya, Nisha Gupta, Trilochan Mishra, Himangshu Bapari	---	20-May-22
6	202211044096	A novel arrangement for clay mould preheating and thereof resin recovery for energy efficient melting-furnace	NIMAI HALDAR, ROHIT BUDDHAM MESHRAM, USHA YENNI, PALASH PODDAR, KANAI LAL SAHOO	---	01-Aug-22
7	202211046652	POST FUNCTIONALIZED METAL ORGANIC FRAMEWORK AND ITS COMPOSITE POLYMER BEADS FOR SEPARATION OF RARE EARTH METAL	Shivendra Sinha, Devabrata Mishra, Kamla Kanta Sahu, Saurabh Shekhar, Archana Agarwal	---	12-Aug-22
8	202211048085	Improved Water-Cooled Rotating Wheel to Produce Thin Alloy Strips	USHA YENNI, NIMAI HALDAR, PREMKUMAR MURUGAIYAN, RAJAT KUMAR ROY, UDAYA BHASKARA RAO MODAVALASA, RAJNEESH KUMAR, ASHIS KUMAR PANDA	23-Aug-22	---

S.N	Application No.	Title	Inventors	Provisional Filing Date	Complete Filing Date
9	202211051486	Magnetically enhanced Dry Gravity Separator	Ganesh Chalavadi, Ranjeet Kumar Singh, Abhishek Kumar, Ajit Kumar Swain, R K Rath	---	08-Sep-22
10	202211059358	A Process for the Production of electrolytic grade Cu, Ni, Co, Mn from the purified leach liquors of e-waste	Manis Kumar Jha, Jhumki Hait, Ranjeet Kumar Singh, Sanchita Chakravarty, Pankaj Kumar Choubey, Rekha Panda, Om Shankar Dinkar	17-Oct-22	----
11	202211076610	Producing Iron-copper alloy and blended cement from smelter copper slag using coal and process thereof	Navneet Singh Randhawa, Susanta Kumar Nath, Sanjay Kumar, Jayati Priya	28-Dec-22	---
12	202311010693	PROCESS FOR EXTRACTION OF LITHIUM AS HIGH PURE LITHIUM CARBONATE FROM SPODUMENE ORE / CONCENTRATE	Devabrata Mishra, Kamala Kanta Sahu, Saurabh Shekhar, Manoj Kumar Mohanta, Shobhana Dey, Kalicharan Hembrom, Tanusree Dutta, Rahul Kumar	---	16-Feb-23

Copyright(s)

Title	CSIR ref. No.	Authors
In-Agreement"- A web-based information system to manage the MoUs of CSIR-National Metallurgical Laboratory	065CR2022	Beena Kumari and SK Pal

Patents Granted FY 2022-23 :

S.N	Title	Inventors	Proisional Filing Date	Complete Filing Date	Application No.	Grant Date	Patent No.
1	AN IMPROVED COKE BASED ENERGY EFFICIENT NON-FERROUS MELTING FURNACE	KANCHAN KUMAR PAUL, DURBADAL MANDAL, PALASH PODDAR, KANAI LAL SAHOO	01-Mar-13	14-Feb-14	0596DEL2013	25-Apr-22	395305
2	An improved process for the production of titanium oxide and metallic iron from Ilmenite	SRINIVASAN RANGANATHAN, DEEPAK CHANDRA SAU, C RAGHU KUMAR, T VENUGOPALAN	---	27-Jul-13	0878KOL2013	07-Jun-22	398702
3	A PROCESS THE RECOVERY OF MAGNETITE AND IRON FROM BAUXITE RESIDUE BY SEGREGATION ROASTING	MAITRYEE BHATTACHARYA, SRINIVASAN RANGANATHAN, SHOBHANA DEY	---	13-Sep-17	201711032401	16-Jun-22	399314

S.N	Title	Inventors	Proisional Filing Date	Complete Filing Date	Application No.	Grant Date	Patent No.
4	AN IMPROVED PROCESS FOR UTILISATION OF POTSH VALUES FROM GLAUCONITIC SANDSTONE	RASHMI SINGLA, RAKESH KUMAR, THOMAS C ALEX	---	08-Jun-18	201811021505	24-Jun-22	399966
5	A PROCESS FOR THE PRODUCTION OF PURE TUNGSTEN POWDER FROM TUNGSTEN-COPPER BORINGS	MANOJ KUMAR, MAITREYEE BHATTACHARYA, DEEPAK CHANDRA SAU, ARCHANA AGARWAL	30-Aug-12	12-Feb-13	2685DEL2012	20-Sep-22	407163
6	A PROCESS FOR THE RECOVERY OF POTASH FROM GLAUCONITIC SANDSTONE	SAURABH SHEKHAR, KAMALA KANTA SAHU, DEVABRATA MISHRA, ARCHANA AGRAWAL	---	05-Jan-17	201711000452	22-Sep-22	407381
7	A PROCESS FOR THE RECOVERY OF POTASH AND HIGH PURE IRON OXIDE FROM IRON RICH GLAUCONITIC CLAY	SAURABH SHEKHAR, SHIVENDRA SINHA, DEVABRATA MISHRA, ARCHANA AGRAWAL, KAMLA KANTA SAHU	---	23-Jan-19	201911002747	28-Sep-22	407825
8	Portable Automated Ball Indentation (PABI) device for In-situ Evaluation of Mechanical Properties of Metallic Components	GOUTAM DAS, KANCHAN KUMAR PAUL, SOUMITRA TARAFDER, SWATANTRA PRAKASH, NANDURY VENKATA SATYANARAYANA, MOUSUMI DAS	---	28-Feb-12	0549DEL2012	20-Oct-22	409500
9	A BIOMIMETIC PROCESS FOR THE PREPARATION OF STEEL FIBER REINFORCED HYDROXYAPATITE POLYMER NANOCOMPOSITES USEFUL AS BONE GRAFTS	SUBHADRA GARAI, ARVIND SINHA, CHITRANGDA SINGH	---	27-Nov-14	3438DEL2014	31-Oct-22	410500
10	A PROCESS FOR THE PREPARATION OF NICKEL-CADMIUM FERRITE FROM SPENT Ni-Cd BATTERIES	Kamala Kanta Sahu, Archana Agrawal, Devabrata Mishra	---	18-Feb-16	201611005646	31-Oct-22	410576
11	A PROCESS FOR CONVERTING NON-COKING COAL TO COKING COAL USING EXPANDABLE GRAPHITE AND MOLASSES	Chakravarty Sanchita, Mohanty ashok kumar, Chakladar Saswati, Sharma Mamta, Das Biswas Rupa, Mallick Subhajit	---	06-Jun-18	201811021093	02-Nov-22	410829
12	AN ENVIRONMENT FRIENDLY NICKEL ELECTROPLATING PROCESS ON MAGNESIUM ALLOY IN NON-AQUEOUS BATH	CHARU SINGH, RAGHUVIR SINGH, SHASHI KANT TIWARI	---	27-Nov-18	201811044639	04-Nov-22	410996

S.N	Title	Inventors	Proisional Filing Date	Complete Filing Date	Application No.	Grant Date	Patent No.
13	A PROCESS FOR THE RECOVERY OF RARE EARTH METALS FROM SCRAP FLUORESCENT TUBES	MANIS KUMAR JHA, AMRITA KUMARI JHA, JHUMKI HAIT, VINAY KUMAR	---	30-Jan-14	0280DEL2014	06-Dec-22	413758
14	An improved process for preparation of briquettes for iron making using iron ore slime and jhama coal	JAGANNATH PAL, SANJAY KUMAR	---	31-Oct-13	1246KOL2013	23-Dec-22	415294
15	A DEVICE BASED ON HIGHER HARMONIC ANALYSIS OF ULTRASOUND WAVES FOR STRUCTURAL DAMAGE EVALUATION OF IN-SERVICE COMPONENTS	SARMISHTHA PALIT SAGAR, NILIMA DAS, INDRANIL CHATORAJ	---	04-Sep-13	2618DEL2013	27-Dec-22	415532
16	A NON-INVASIVE PROCESS FOR SORTING OF ALUMINA RICH IRON ORES	ARPITA GHOSH, TARUN KUMAR DAS, BIBHU RANJAN NAYAK, SARMISHTHA PALIT SAGAR	---	06-Aug-12	2446DEL2012	28-Dec-22	415868
17	Auxiliary Cold Chamber for an improved Annealing Simulator Device	B Ravi Kumar, S K Mandal, Nimai Halder, R K Sharma	---	30-Mar-15	0352KOL2015	04-Jan-23	416702
18	A PROCESS FOR THE PREPARATION OF HIGH CHROMIUM CAST IRON FOR GRINDING MEDIA APPLICATIONS	Minal Shah, Swapan Kumar Das, Kani Lal Sahoo, Gautam Das, Palash Poddar, Sandeep Ghosh Chowdhury, Moolchandra Gupta, Manmohan Rathi, Bharat Kumandas Tanna, Narendra Kumar Singh	---	12-Apr-18	201811013970	06-Feb-23	420589

In-house Project Support Group (i-PSG)

In-house Project Support Group (*i*-PSG) at CSIR-National Metallurgical Laboratory strives to achieve excellence in in-house research by enabling the researchers and supporting their aspirations. The group supports the research in pre-identified thematic areas, on technology development initiatives and researches of scholastic nature leading to masters or doctoral degrees. The aim of these projects is directed towards improvement in performance, relevance and impact of research undertaken. A total of forty-two i-PSG supported projects were in progress during the year 2022-23. Some of the significant outcomes/achievements of these projects are as follows:

- Indigenous development of a planar flow caster (PFC) system at CSIR-NML, which is first of its kind in India. Continuous strip of 5-meter length with average thickness of 250 microns can be obtained at a casting speed of 15 m/s.
- Development of a magnetic hydrocyclone for separating fine magnetic particles from non- magnetic particles. The system is beneficial during beneficiation of iron ore slime. The permanent magnets used can be replaced by electromagnets for having better variability in magnetism.
- A prototype established for producing magnesium at the scale of 15 kg charge with 2.5 kg Mg. This is based on retort technology (Pidgeon process) for Mg metal production using dolomite as primary material.
- "Influence of temperatures on structure, thermoelectric and mechanical properties of nanocrystalline SnSe thin films deposited by thermal evaporation" published in Mater. Today Commun. 32 (2022) 103880.
- "Optimization of selective laser melting (SLM) additive manufacturing process parameters of 316L austenitic stainless steel" published in Transactions IIM 76 (2023) 335–345.
- "Effect of nickel addition on enhancing nano-structuring and suppressing TRIP effect in Fe40Mn40Co10Cr10 high entropy alloy during high-pressure torsion" published in International Pournal of Plasticity 150 (2022) 103193.

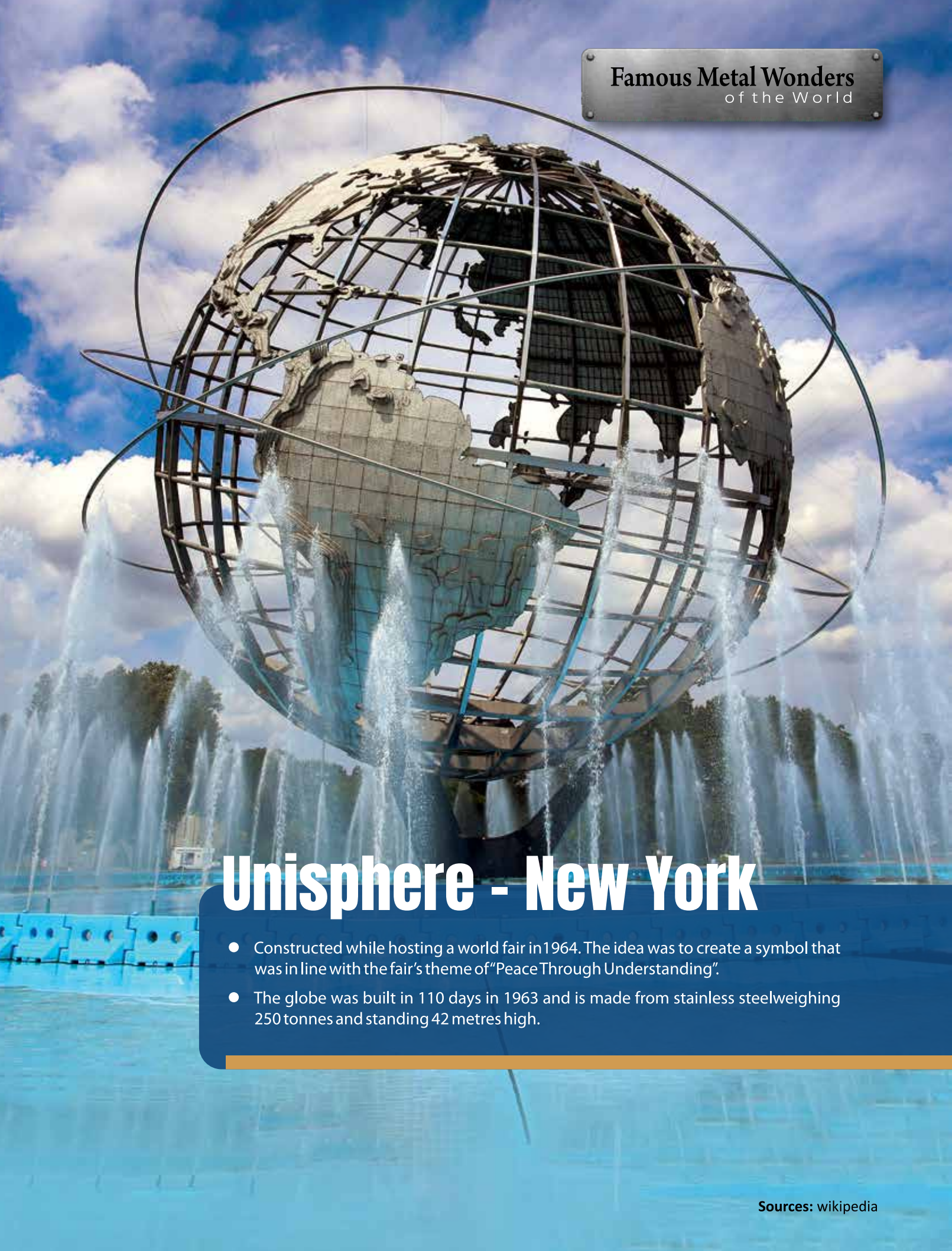
Professor Shilowbhadra Banerjee award for the best in-house project completed in 2020

Dr. Ashok K

Dr. A K Upadhyay

Dr. A K Mohanty

Dr. Ashok K and his team received '*Prof. Shilowbhadra Banerjee award 2022*' for the best in-house project 2020 entitled "Preparation and certification of Hydrogen Standard (CRM) in Steel" from Professor T N Singh, Director, Indian Institute of Technology, Patna, during 73rd CSIR-NML Foundation Day function held on November 26, 2022, in Jamshedpur.

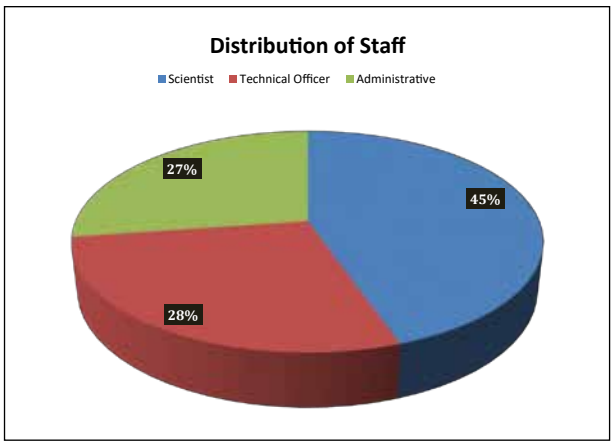


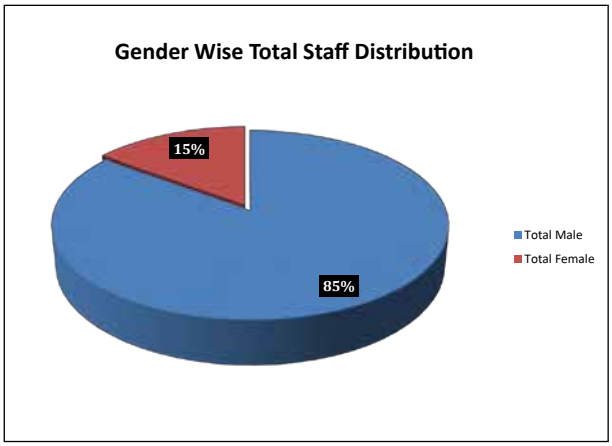
Unisphere - New York

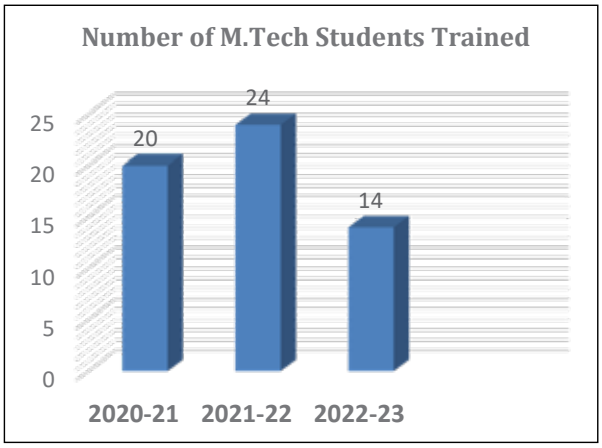
- Constructed while hosting a world fair in1964. The idea was to create a symbol that was in line with the fair's theme of "Peace Through Understanding".
- The globe was built in 110 days in 1963 and is made from stainless steelweighing 250 tonnes and standing 42 metres high.

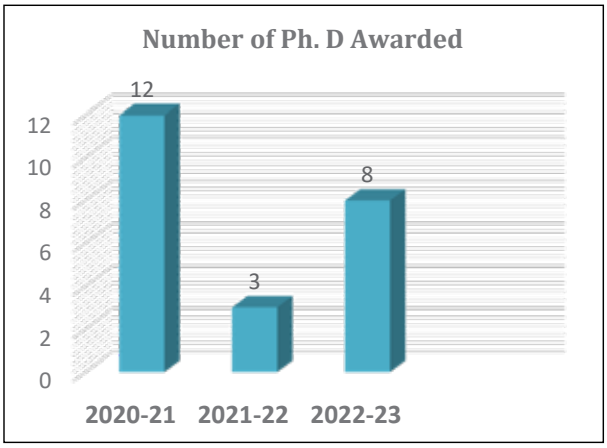
Sources: wikipedia

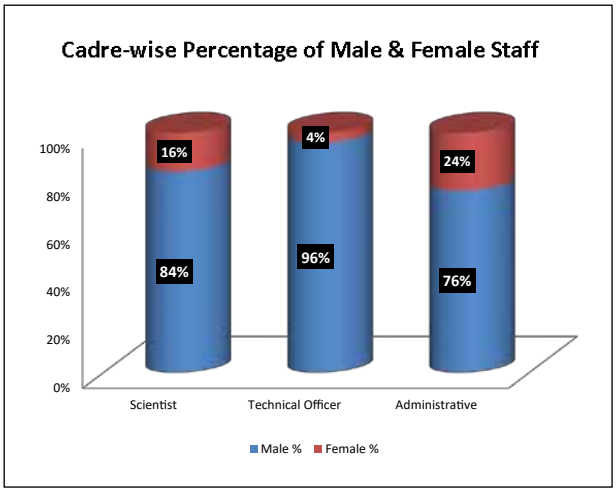
Human Resource

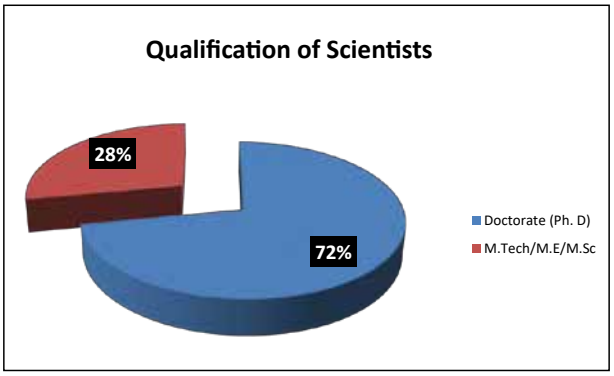


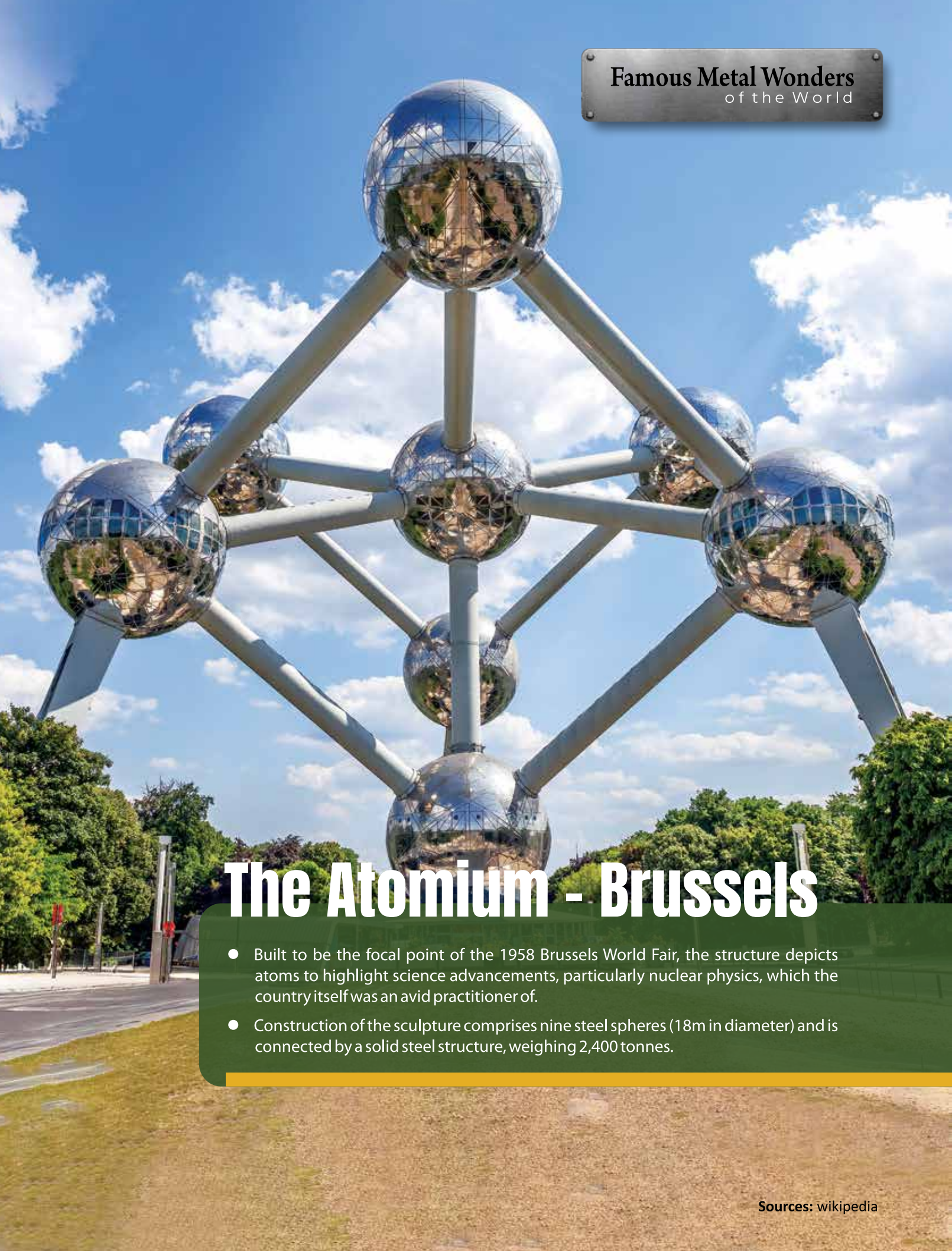












The Atomium - Brussels

- Built to be the focal point of the 1958 Brussels World Fair, the structure depicts atoms to highlight science advancements, particularly nuclear physics, which the country itself was an avid practitioner of.
- Construction of the sculpture comprises nine steel spheres (18m in diameter) and is connected by a solid steel structure, weighing 2,400 tonnes.

Sources: wikipedia

Staff News

NEW JOINEE(S)

(Welcome to the new joinees and wishing them a rewarding career ahead!)

Mr. Ranjeet Kumar
Scientist
D.O.J. 18-08-2022

Dr. Animesh Jana
Senior Scientist
D.O.J. 18-08-2022

Dr. Sreeda P
Senior Scientist
D.O.J. 18-08-2022

Mr. Mudila Danunjaya Rao
Scientist
D.O.J. 18-08-2022

Dr. Satyajit Mukherjee
Senior Scientist
D.O.J. 26-08-2022

Mr. Vankadoth Shiva
Scientist
D.O.J. 28-08-2022

Dr. Mousumi Gharai
Scientist
D.O.J. 28-08-2022

Dr. Nikhil Kumar
Scientist
D.O.J. 02-09-2022

Dr. Vinod Belbanshi
Scientist
D.O.J. 21-11-2022

Mr. Ankur Sharma
Scientist
D.O.J. 25-01-2023

Dr. Alok Kumar Mehar
Scientist
D.O.J. 07-02-2023

Dr. Kuldeep Singh Gour
Scientist
D.O.J. 27-02-2023

STAFF TRANSFERRED FROM SISTER LABORATORY TO JOIN CSIR-NML

Transfer from CSIR-CSIO, Chandigarh

Dr. Suman Tewary
Scientist
D.O.J. 04-04-2022

Transferred from CSIR Headquarters, New Delhi

Mr. Aditya Mainak
Administrative Officer
D.O.J. 14-11-2022

Transferred from CSIR-CGCRI

Dr. (Mrs.) Ranu Verma
Section Officer (G)
D.O.J. 21-11-2022

Transferred from CSIR-IMMT

Mr. Anil Kumar Dash Choudhury
Stores and Purchase Officer
D.O.J. 12-12-2022

STAFF TRANSFERRED FROM CSIR-NML TO JOIN SISTER LABORATORY

"We wish them success in their future endeavors"

Transferred to CSIR-CGCRI, Kolkata

Ms. Monalisa Bhattacharya
Section Officer (G)
16-11-2022

Transferred to CSIR-IMMT, Bhubaneswar

Mr. Ratnakar Behera
Controller of Finance & Accounts
18-11-2022

Transferred to CSIR-IICB, Kolkata

Ms. Rubai Ray
COSP
14-12-2022

STAFF SUPERANNUATED

"We Thank Them For Their Dedicated Survives"

Mr. Tapan Kumar Chakraborty
Multi-Tasking Staff
D.O.J. 30-06-2022

Mr. Ramkumar
PS to Director
D.O.J. 31-08-2022

Shri Abhijit Ghose
Section Officer (G)
D.O.J. 31-10-2022

Shri T. K. Saha
Principal Technical Officer
D.O.J. 31-10-2022

Shri A.K. Arya
Sr. Technician(2)
D.O.J. 30-09-2022

Dr. Indranil Chattoraj
Director
D.O.J. 30-09-2022

Mr. Vimal Kumar Dixit
Laboratory Assistant
D.O.J. 30-11-2022

Dr. Lokesh Chandra Pathak
Chief Scientist
D.O.J. 30-11-2022

Mr. T.K. Mohanty
Sr. Technician (2)
D.O.J. 31-12-2022

Shri Satrughan Singh
Lab Assistant
D.O.J. 31-01-2023

Dr. Arvind Sinha
Chief Scientist
D.O.J. 31-01-2023

Dr. Kapildeo Mehta
Senior Principal Scientist
D.O.J. 31-01-2023

Dr.(Ms.) Archana Agrawal
Chief Scientist
D.O.J. 31-01-2023

Shri. Ramashray Ram
Senior Technician (2)
D.O.J. 31-01-2023

Shri. Mihir Desai
Multi-Tasking Staff
D.O.J. 31-01-2023

Shri. Mahabir Prasad
Multi-Tasking Staff
D.O.J. 28-02-2023

Deputations

International Deputations

Sl. N.	Name & Designation	Participation As	Event/ Purpose	Place of Visit / Organized By	Duration of Visit
1	Dr. Pratima Meshram, Principal Scientist	Researcher	Raman Research Fellowship for 2020-21	Univ. of British Colombia, Canada	20th August-19th November 2022
2	Dr. Sarmishtha Palit Sagar, Chief scientist & GL -NDE & MM Group	Speaker	Invited talk on NDT in AIMTEK-2022:One day Int. Conference	Biz Events Management; AIMTEK International, Abu Dhabi, Yas Island	07th June 2022
3	Mr. Avanish Kumar Chandan, Senior Scientist	Delegate	Symposium on "High Entropy Alloys: Potential For Industrial Applications"	Fraunhofer Institute For Material And Beam Technology IWS, Germany	12th May 2022

National Deputations

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
1	Dr. Sanjay Prasad, Principal Scientist	International Conference on "Powder Metallurgy" and 47th annual technical meeting of PMAI 2022	Association Of Powder Metallurgy, Mumbai	18th -20th April 2022
2	Dr. Sanjay Agarwal, Senior Principal Scientist	Conference on "Technological Advancement In Ferroalloys & Opportunities For Growth"	Steel Tech, Kolkata	11th April 2022
3	Md. Dr. Murtuja Hussain, Principal Scientist	ICS Annual Foundation Day Celebration-2022	Indian Ceramic Society, Jamshedpur	20th April 2022
4	Dr. Sanghita Mridha, Project Scientist-I	9th International Mining, Equipment, Minerals & Metals Exhibition	MGMI & TAFCON, Kolkata	04th -07th April 2022
5	Dr. Aniket Kumar Dutt, Project Scientist-II			
6	Dr. S.K. Nath, Principal Scientist	International Conference on "Refractories"	ICS Jamshedpur Chapter, CSIR-NML, CSIR-CGCRI, Jamshedpur	05th May 2022

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
7	Mr. Chandan Dutta, CSIR-SRF	IEEE IAS Global Conference on "Emerging Technolgies (Globconet) For Humanity"	IEEE Industry Application Society, Greater Noida, New Delhi NCR & Online (Hybrid)	20th -21st May 2022
8	Mr. Aniket Kumar Dutt, Project Scientist-II	International Conference on "Additive Manufacturing and Allied Technologies"	NIT, Tiruchirappali	10th-11th June 2022
9	Mr. Mahesh Gulab Walunj, Senior Scientist	International conference and Exhibition on "Metal, Corrosion & Inspection Technology" (MCI-2022)	MatCorr, New Delhi	23rd -24th June 2022
10	Dr. Manis Kumar Jha, Chief Scientist	National symposium on "Electrochemical science and Technology(NSEST-2021)"	The Electrochemical society of India, Bengaluru, ARCI, Hyderabad, Telangana	24th-25th June 2022
11	Dr. Pankaj Kumar Choubey, Senior Project Associate			
12	Dr. Asit Baran Panda, Senior Principal Scientist	International Workshop on "Water Purification Technologies, Arsenic Removal from Groundwater and Integrated Water Management (IWWPT-2022)"	CSIR-CSMRI, Bhavnagar	28th -30th June 2022
13	Dr. Sanjay Prasad, Principal Scientist	International Conference on Frontiers in Materials for Technological Applications	IMMT, Bhubneswar	03rd-05th August 2022
14	Dr. Arvind Kumar Upadhyay , Senior Technical Officer	6th Proficiency Testing Providers (PTP) / Reference Materials Producers (RMP)	Bengaluru, Karnataka	25th -26th August 2022
15	Dr. Abhilash, Senior Principal Scientist	One Day Workshop on NEP-2020	Karim City College, Jamshedpur and NASI Jharkhand	05th September 2022
16	Dr. Sanchita Chakravarty, Chief Scientist	Annual Meeting and Symposium of "The International Committee for Coal & Organic Petrology (ICCP 2022)"	CSIR- Central Institute of Mining and Fuel Research, Kolkata	18th -25th September 2022
17	Ms. Riya Banerjee, Project Associate-II			
18	Dr. Rajen Kundu, Scientist			
19	Mr. Alok Kumar, Sr. Scientist			
20	Ms. Saswati Chakladar, Senior Project Associate II			
21	Mr. Mahesh Gulab Walunj, Senior Scientist	A Course in "Atomistic Modeling for Microstructural Evolution"	Indian Institute of Technology, Bombay	19th-30th September 2022
22	Dr. Sushanta Kumar Nath-Principal Scientist	Conference on "Valorization of Fly Ash & Steel Slag: Challenges, Innovation & Future Trend"	Tata Steel, Jamshedpur	22nd-23rd September 2022
23	Dr. Ammasi A, Senior Scientist			
24	Mr. Aniket Kumar Dutta, Project Scientist			
25	Ms. Sanghita Mirdha, Project Scientist			
26	Dr. Rachit Ghosh, Principal Technical Officer			
27	Ms. Sonam Kumari, Project Associate			
28	Mr. Surojit Kundu, Scientific Administrator			

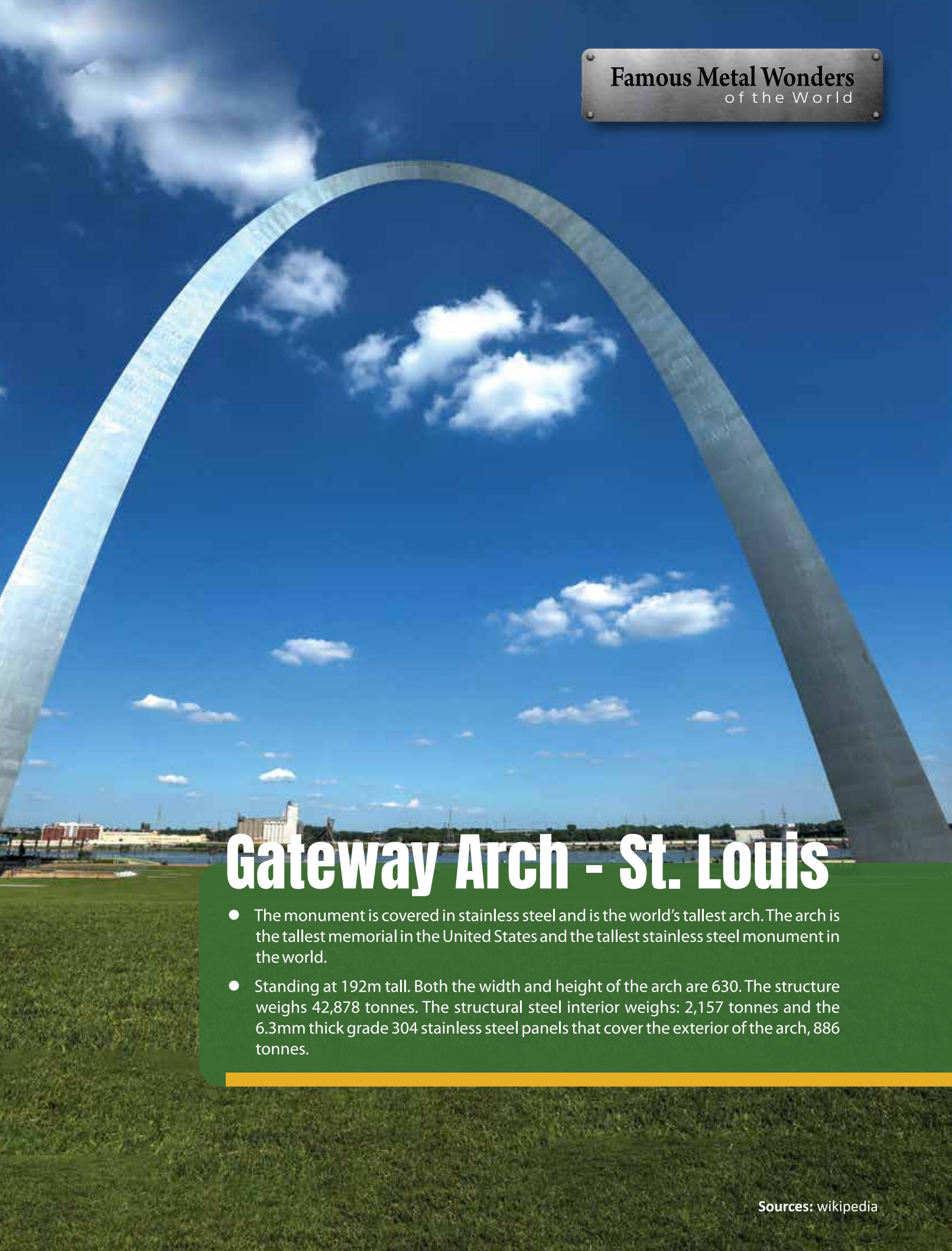
Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
29	Mr. Mahesh Parmanik, Field Worker	Conference on "Valorization of Fly Ash & Steel Slag: Challenges, Innovation & Future Trend"	Tata Steel, Jamshedpur	22nd-23rd September 2022
30	Dr. Sanjay Kumar, Chief Scientist			
31	Dr. Madan M, Principal Scientist			
32	Dr. Navneet Singh Randhawa, Senior Technical Officer(2)			
33	Dr. S.K Sahu, Senior Principal Scientist	National Conference on "Science, Technology and Applications of Rare Earths (STAR-2022)"	Rare Earth Association of India, Tirupati, Andhra Pradesh	22nd-23rd September 2022
34	Dr. Mita Tarafder, Chief Scientist	Training of Master Trainer	Management & Entrepreneurship and Professional Skills Council	26th September- 01st October 2022
35	Dr. Rajen Kundu, Scientist	Online Training on "ISO/IEC 17025:2017 Requirements" and Internal Audit	Dr. S.K Breja, Quality Guru	11th-14th October 2022
36	Mr. Pankaj Kumar, Senior Technical Officer(1)	Workshop on "Capacity Building in Manufacturing Aligned Technology"	CMERI, Durgapur	11th-14th October 2022
37	Mr. Roshan Kumar, Scientist			
38	Mr. Nimai Haldar, Senior Technical Officer(1)			
39	Dr. Manoj Kumar, Senior Principal Scientist	Conference on "Advances in Materials & Processing: Challenges & Opportunities"	Indian Institute of Technology, Roorkee	17th-19th October 2022
40	Mr. Gaurav Kumar Bansal, Scientist			
41	Mr. Snehashish Tripathy, Senior Scientist			
42	Mr. Vikash Kumar Sahu, GATE-JRF			
43	Mr. Vaibhav Gaur, AcSIR Student			
44	Dr. Shobhana Dey , Chief Scientist	International Conference & "Exhibition on Mineral Business Development"	Mineral Information & Development Centre and Federation of Indian Mineral Industries, Nagpur, Maharashtra	10th-12th November 2022
45	Mrs. Y Usha, Senior Scientist	Conference on "Applied Mechanics"	National Institute of Technology, Jamshedpur and Society of Applied Mechanics	11th-13th November 2022
46	Mr. Mohana Rao Andavarapu, Technical Officer	Symposium on "Accelerated Materials Design and Additive Manufacturing: Scientific & Technological Perspectives"	Indian Institute of Metals, Hyderabad & Visakhapatnam	13th-16th November 2022
47	Mr. Bhupendra Kumhare, AcSIR PhD			
48	Dr. Arvind Kumar Upadhyay, Principal Technical Officer	Training Program on "Characterization and Assessment of Homogeneity and Stability of Referential Material"	National Accreditation Board for Testing and Calibration Laboratories, Gurugram	15th-17th November 2022
49	Dr. Asit Baran Panda , Senior Principal Scientist	Conference on "33 rd AGM of MRSI & 4 TH Indian Materials Conclave, IUMRS-ICA 2022"	International Union of Materials Research Society, Market Research Society of India and Indian Institute of Technology, Jodhpur	19th-23rd November 2022

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
50	Mr. Amit Prakash, Senior Technical Officer (3)	Faculty Development Program on "Advanced Remanufacturing Technology"	National Institute of Advanced Manufacturing Technology, Ranchi	19th-23rd November 2022
51	Mr. Abhishek Kumar, Senior Scientist	Seminar on "Engineering Simulation using ANSYS & CFD"	Engineering Staff College of India	21st-25th November 2022
52	Dr. Vinod Belwanshi, Scientist	2nd International Conference On "Advances In Materials And Manufacturing Technology (ICAMMT- 2022) "	Maulana Azad National Institute of Technology Bhopal, MP, India	22nd-26th November 2022
53	Mrs. Y Usha, Senior Scientist	Conference & Exhibition on "Non-Destructive Evaluation"	Indian Society of Non-Destructive Testing, Pune, Maharashtra	24th-26th November 2022
54	Dr. S. Palit Sagar, Chief Scientist			
55	Mr. Chandan Dutta, Senior Project Associate			
56	Dr. Avijit Kumar Metya, Principal Scientist			
57	Dr. Tarun Kumar Das, Senior Principal Scientist			
58	Mr. Aniket Kumar Dutt, Project Scientist	Workshop on "National Creativity Olympiad 2022"	The Institution of Engineers, XLRI Campus, Jamshedpur	26th-27th November 2022
59	Ms. Sanghita Mirdha, Project Scientist			
60	Mr. Mahesh Pramanik, Field Worker	Online Training on "Training Program- Office Assistant Job Role"	Management & Entrepreneurship and Professional Skills Council	28th November – 02nd December 2022
61	Ms. Sanghita Mridha, Project Scientist			
62	Mr. Om Shankar Dinkar, Senior Project Associate	Seminar on "Industrial Metal Finishing, Electroplating Technologies & Aerospace Chemical Processes"	The Electrochemical Society of India, Indian Institute of Science, Bengaluru, Karnataka	01st-03rd December 2022
63	Dr. Pankaj Kumar Choubey, Senior Project Associate			
64	Mr. Aniket Kumar Dutta , Project Scientist	International Conference on "Corrosion and Coating"	Indian Institute of Metals Jamshedpur Chapter in Association with Tata Steel, CSIR- NML & NIT, Jamshedpur	07th-08th December 2022
65	Ms. Sanghita Mirdha, Project Scientist			
66	Mrs. Shubhada Kar, GATE-Senior Research Felloships			
67	Mr. Vikas Shivam, SERB-National Post Doctoral Fellowship			
68	Ms. Alka Kumari, PA			
69	Dr. Lalit Kumar Meena, Senior Scientist			
70	Md. Dr. Murtuja Hussain, Principal Scientist			
71	Dr. Shailendra Kumar Jha, Principal Scientist			
72	Mr. Roshan Kumar, Scientist			
73	Mr. Mohit Kumar Singh, Project Associate			

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
74	Dr. Asit Baran Panda, Senior Principal Scientist	International Conference on "Corrosion and Coating"	Indian Institute of Metals Jamshedpur Chapter in Association with Tata Steel, CSIR- NML & NIT, Jamshedpur	07th-08th December 2022
75	Mr. Mahesh Gulab Walunj, Senior Scientist			
76	Dr. Gorja Sudhakar Rao, Senior Scientist			
77	Dr. Biraj Kumar Sahoo, Senior Scientist			
78	Dr. Sumanta Kumar Pradhan, Scientist			
79	Dr. Subhajit Ghosh, Senior Project Associate			
80	Dr. Ashok Kumar Mohanty, Senior Principal Scientist			
81	Mr. Chandan Dutta, Senior Project Associate			
82	Mr. Prabir Kumar Roy, Principal Technical Officer	International Conference on "Global Trends in Traditional to Space Ceramics"	Indian Ceramics Society & Indian Institute of Technology- BHU	08th-09th December 2022
83	Mr. Raju Das, Project Associate-I			
84	Dr. Vinod Kumar, Principal Technical Officer			
85	Dr. Sushant Kumar Nath, Principal Scientist			
86	Mr. Arindam Sen, Project Associate	International Conference on "Net- Zero Emission Technologies for Sustainable Development, Challenges and Opoortunities"	Indian Institute of Technology- Indian School of Mines, Dhanbad	12th-13th December 2022
87	Dr. Rajen Kundu, Scientist			
88	Mr. Sudip Kumar, Project Assistant			
89	Dr. Ammasi A, Senior Scientist	International Conference on "Science and Technology of Iron making and Steelmaking"	Department of Metallurgical Engineering and Materials Science, IIT Bombay	13th-16th December 2022
90	Dr. Sanjay Agarwal, Senior Principal Scientist			
91	Mr. Vaibhav Gaur, Academy of Scientific & Innovative Research	International Conference on "International Conference on Frontiers in Materials Engineering"	Indian Institute of Technology- Indore.	14th-16th December 2022
92	Dr. Asit Baran Panda , Senior Principal Scientist	International Conference & Convention on "59th Annual Convention Chemists and Recent Trends in Chemical Science"	Indian Institute of Metals Jamshedpur Chapter in Association with Tata Steel, CSIR- NML & NIT, Jamshedpur	16th-18th December 2022
93	Dr. Vinod Kumar, Principal Technical Officer	National Workshop on "Advancement in Minerals Processing Techniques with Special Reference to Iron Ore and Coal"	Department of Metallurgical Engineering and Materials Science, NIT Jamshedpur	20th-24th December 2022
94	Mr. Mohan Rao Andavarapu, Technical Officer			
95	Dr. Vinod Belwanshi, Scientist	Initiative Industry 4.0 - Nascent Technologies and Sustainability for 'Make in India' Initiative	Bharatiya Vidya Bhavan's Sardar Patel College of Engineering (SPCE), Mumbai	22nd-23rd December 2022
96	Dr. Navneet Singh Randhawa, Senior Technical Officer (2)	"Manganese/Chromo Ores, EMM and Ferro- Alloys" Summit	Federation of Indian Mineral Industries, New Delhi	04th January 2023
97	Dr. Sanjay Agarwal, Senior Principal Scientist			

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
98	Ms. Sanghita Mrida, Project Scientist	108th Indian Science Congress	The Indian Science Congress Association, Nagpur, Maharashtra	03rd-07th January 2023
99	Mr. Aniket Kumar Dutt, Project Scientist			
100	Dr. Animesh Jana, Senior Scientist			
101	Ms. Mausmi Sarkar, Scientific Administrative Assistant			
102	Ms. Pragati Jha, Project Associate			
103	Ms. Manoti Kumari , Field worker	108th Indian Science Congress	Indian Science Congress Association	03rd-07th January 2023
104	Mr. Abhishek Kumar, Senior Scientist	International Conference on sintering & Pelletizing 2023	M/s Tata Steel Ltd., Jamshedpur	18th-19th January 2023
105	Dr. Ammasi A , Senior Scientist			
106	Dr. Ranjeet Kumar Singh, Principal Scientist			
107	Dr. Jagannath Pal, Chief Scientist			
108	Dr. Sushant Kumar Nath, Principal Scientist	National Conference on "Valuing Low-grade Ore and Waste: Challenges and Remedies"	The Institutions of Engineers (india), Durgapur Local Centre	21st-22nd January 2023
109	Dr, Vinod Belwanshi, Scientist	International Conference on "Micro/ Nano Electronics Devices, Circuits & System"	NIT, Silchar	29th-31st January 2023
110	Dr. Nikhil Kumar, Scientist	Seminar on "SCO Young Scientist Conclave"	Department of Science and Technology, Bengaluru Karnataka	06th-10th February 2023
111	Dr. Shailendra Kumar Jha, Principal Scientist	Conference on "Electrochemistry for Industry, Health and Environment"	BARC, Mumbai	07th-11th February 2023
112	Dr. Ganesh Chalavadi, Senior Scientist	Meeting on "Project Evaluation of 3 Districts for INSPIRE Award"	District Education Department	08th February 2023
113	Dr. A K Pramanik, Senior Principal Scientist	International Conference on "Electron Microscopy & XLI Annual Meeting of Electron Microscope Society of India"	Electron Microscopy Society of India & University of Delhi	8th-10th February 2023
114	Mr. PS Manoranjan Jena, GATE-SRF			
115	Dr. Biraj Kumar Sahoo - Senior Scientist			
116	Mr. Rattanvir Singh - Project Associate-II			
117	Dr. Premkumar M - Senior Scientist			
118	Dr. Sreeda P, Senior Scientist	Induction Programme for the Newly Recruited Scientists	CSIR- Human Resource Development Centre, Ghaziabad	10th-20th February 2023
119	Dr. Saurabh Shekhar, Senior Scientist	International Conference on "Global Zinc Summit"	International Zinc Association	16th-17th February 2023
120	Mr. Shivendra Sinha, Senior Scientist			
121	Dr. Sandip Ghosh Chowdhury, Chief Scientist	International Conference on "Recent Advances in Composite Materials (ICRACM-2023)"	SRM Institute of Science & Technology, Kattankulathur	22nd -24th February 2023

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
122	Mr. Shivendra Sinha, Senior Scientist	International Conference on "Management and Recycling of Metallurgical Wastes"	Indian Institute of Technology- BHU	27th-28th February 2023
123	Dr. Saurabh Shekhar, senior Scientist			
124	Mr. Rajanikant Choudhari, Technical Officer			
125	Dr. M. Malathi, Principal Scientist			
126	Dr. Dayanand Paswan, Principal Scientist			
127	Mr. Krishna Kumar, Senior Scientist			
128	Dr. Mudila Dhanunjaya Rao, Scientist			
129	Mr. Rohit B. Meshram, Senior Scientist	International Conference on "Management and Recycling of Metallurgical Wastes"	Indian Institute of Technology- BHU	25th February-01st March 2023
130	Mr. Arindam Sen, Project Associate	International Conference on "Recent Advances in Materials Chemistry and Catalysis"	Dibrugarh University	01st-03rd March 2023
131	Mr. Ajit Kumar Swain, Principal Scientist	Online Course on "USIM PAC Simulator"	Caspeo, France	01st-05th March 2023
132	Dr. Atanu Das, Senior Scientist	International Conference on "Advanced Materials and Manufacturing Processes"	Jawaharlal Nehru Technological University-Gurajada Vizianagaram, Andhra Pradesh	03rd-04th March 2023
133	Dr. Premkumar M , Senior Scientist	Conference on "Advance Nanomaterials and their Applications"	Central University of South Bihar (Gaya)	13th-22nd March 2023
134	Mr. Tipu Kumar ,Senior Technical Officer(1)	National Workshop on "Physical Simulation of Thermal-Mechanical Processing of Materials"	School of Mechanical Engineering (KIIT Deemed), Odisha	16th-18th March 2023
135	Dr. Ranjeet Kumar, Scientist			
136	Dr. Sandip Ghosh Chowdhury, Chief Scientist			
137	Dr. Sunil Kumar, Senior Scientist	International Conference on "Green Hydrogen for Global Decarbonization"	Pandit Deendayal Energy University Gandhinagar, Gujarat	17th-18th March 2023
138	Mr. Roshan Kumar, Scientist			
139	Dr. Ranjan K Sahu, Chief Scientist			
140	Dr. Mousumi Das, CSIR-Senior Research Associateship	International Conference on "Mechanical and Production Engineering"	World Research Forum for Engineers and Researchers	19th March 2023
141	Dr. Alok Kumar Meher, Scientist	Training Programme on "Laboratory Quality Management System and Internal Audit as per IS/ISO/IEC 17025:2017"	The Bureau of Indian Standards, India	21st-24th March 2023
142	Ms. Rupa Das Biswas - Senior Technical Officer	Training Program on "Characterization and Assessment of Homogeneity and Stability of Reference Material"	National Accreditation Board for Testing and Calibration Laboratories	23rd-25th March 2023



Gateway Arch - St. Louis

- The monument is covered in stainless steel and is the world's tallest arch. The arch is the tallest memorial in the United States and the tallest stainless steel monument in the world.
- Standing at 192m tall. Both the width and height of the arch are 630. The structure weighs 42,878 tonnes. The structural steel interior weighs: 2,157 tonnes and the 6.3mm thick grade 304 stainless steel panels that cover the exterior of the arch, 886 tonnes.

Sources: wikipedia

Distinguished Visitors

#	Visitor		Date	Topic of Lecture(s)
1.	**Professor Gordana Medunic,** Full Professor of Environmental Earth Science, University of Zagreb, Faculty of Science, Department of Geology, Croatia		23rd May 2022	"Collaboration between Croatia and India and Erasmus Project"
			24th May 2022	"Opportunity on Post Doc Fellowship under European Union"
2.	**Professor Cemal Basaran**, University of Buffalo, New York,		02nd June 2022	"Low and High cycle fatigue"
3.	**Mr. Rajeev Nair**, Coach, Cricket, Tata Sports Complex, Tata Steel, Jamshedpur and Director Indian Institute of Yoga and Management, Haryana		21st June 2022	"Importance of Yoga for a Healthy Life"
4.	**Dr. John S Thella,** Application and Business Development Specialist, ZEISS Research Microscopy Solutions		06th July 2022	"Zeiss Advanced Automated Mineralogy Work Flows"
5.	**Mr. Mukund Sahay,** Ex-COA, CSIR		29th August 2022	"CCS Conduct Rules, Sexual Harassment of Women at Workplace and RTI"
6.	**Mr. BVA Patnaik** , Associate Director, Gas Turbine Research Establishment (GTRE)		06th September 2022	"Gas Turbine Engine Phenomena from Structural Engineering Perspective"

#	Visitor		Date	Topic of Lecture(s)
7.	**Mr. Binay Kumar Kar**, Ex. Sr. COA, CSIR-IICB		30th October 2022	"Cultural remedy for preventing corruption"
8.	**Professor T. N. Singh**, Director, IIT Patna		26th November 2022	"E-Waste Recycling"
9.	**Prof. Arun Majumdar,** IIT, Kharagpur		15th December 2022	"Application of Artificial Intelligence in Mineral Processing"
10.	**Mrs. Shalini Sulakshna** Ramesh, Head-Ethics Department, Tata Steel		19th December 2022	"Elimination of all forms of violence and discrimination against women and on sensitization for employees to make them aware about the provisions of the Sexual Harrassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013 and towards the need of upholding the dignity of women and end gender stereotypes so as to encourage more and more women"

Hindi Cell

Official Language Implementation

CSIR-NML has an active program for the Implementation of the official language, Rajbhasha Hindi. In addition to the regular official works and various translations into Hindi, CSIR-NML proactively initiates a series of activities throughout the year, which include publications, conducting trainings, workshops, talks, annual competitions, and divisional inspections for enhancement of Hindi use in the divisional activities.

Publications in Hindi

Annual Report, CSIR-NML Newsletter and Brochures have been published in Hindi, which are circulated to CSIR units and various organizations of the Govt. of India. Press releases were issued in Hindi and published in daily newspapers.

Promotional Activities for Hindi Implementation

- Four inspections were conducted by the Hindi Officer covering various divisions for identifying the areas of Hindi implementation and enhancing the use of Hindi in divisional activities.
- Incentive Scheme for working in Hindi has been introduced and employees are actively participating Eleven Employees Shri Parmarth Suman, Shri Sudhir Kumar, Shri C.R. Chakraborty, Md. Nayeem Ansari, Shri Santosh Kumar Ray, Shree Nandlaal Paswan, Shree Anil kumar, Shree Jyoti Kumar, Shree Ravi Ranjan Kumar, Shree Rohit Mudi and Shree G. Dharma Rao were given awards in this scheme.

Hindi Workshop

Four Table Workshops were conducted in the Administrative sections. The objectives of the workshops were to address the issues encountered for preparing the Quarterly Hindi Progress Report, Hindi Noting and Drafting and imparting training of Unicode.

Hindi Competition

Hindi Competitions were organized from 1st to 9th September, 2022, for CSIR-NML Employees. The competitions included discussions on implementation of Hindi, self-written poetry recitations and singing, etc. The program had wide participation by NML employees.

World Hindi Day

On the "World Hindi Day", technical lectures were organized on 10th January, 2023, on different scientific topics. In this event, many senior scientists, research scholars and members of the technical lecture organizing committee of CSIR-NML participated with enthusiasm. The dedicated scientific lectures in Hindi language were simple, easy-to-communicate and very comprehensible. The lecturers included Dr. Arvind Sinha, Chief Scientist & Advisor Management, Dr. Pratima Meshram, Principal Scientist, Dr. S.K. Jha, Principal Scientist, Dr. Krishna Kumar, Sr. Scientist, Mr. Somnath Das, Project Assistant-II, Mr. Ajit Gangwar, Project Associate.

Activities of Hindi implementation for TOLIC, Jamshedpur

CSIR-National Metallurgical Laboratory is the Secretariat of Town Official Language Implementation Committee (TOLIC), Jamshedpur. It has 62 Members from all the Central Govt. offices located in and around Jamshedpur, with the Director, CSIR-NML as Chairman of this committee. Under the aegis of the Town Official Language Implementation Committee, Jamshedpur, a literary and Culture Programme was organised on 7th September, 2022 at CSIR-National Metallurgical Laboratory, Jamshedpur. More than three hundred officers from different Central Government offices

graced the occasion. Along with the staging of a short play "Khamosh Adalat Jari Hai", Songs, Ghazals by famous artists were also performed. The presence of all Heads of different central Government organizations infused enthusiasm into the function.

Prize Distribution Ceremony for the Winners :

Popular Drama Staged by Artists :

Knowledge Resource and Information Technology

The division deals with knowledge resource management and offers IT infrastructural support to CSIR-NML. There are two independent groups, led by group leaders :

1. Knowledge Resource Group (KRG)
2. Information technology Group (ITG)

Knowledge Resource Group (KRG)

KRG manages the library resources including e-library, develops multimedia content, publishes the Journal of Metallurgy and Materials Science (JMMS) and conducts CSIR integrated skill trainings. The other significant activities of KRG includes website development and maintenance, maintenance of Online Public Access Catalogue (OPAC) and institutional repositories (e-prints), development of contents for CSIR Virtual Laboratory, public information delivery through RTI responses and PG Portal, scientometric analyses, conducting CSIR Jigyasha - an outreach program for schools and colleges, taking responsibility of the institutional branding through exhibitions, press releases, advertisements, and, maintenance of the archives and museum.

A. CSIR-NML Library

During the financial year 2022-23, KRC (library) added 196 documents, including books and bound-volume journals, and subscribed to 13 periodicals in the area of minerals, metals, metallurgy, and materials science. Besides these, the CSIR-NML KRC has received databases and standards through NKRC consortia like ASTM standards, Clarivate Analytics- Web of Science, iThenticate, etc. The library currently has 55941 documents, including textbooks, reference books, technical reports, conference proceedings, standards, and bound volumes of journals.

B. In-house Publication :

Journal of Metallurgy and Materials Science (JMMS) publishes original articles, review reports and short communications in the areas of minerals, metals and materials tracing the overall life cycle of structural as well as functional materials. The JMMS is a quarterly publication. In 2022-23, the volume 64 consisting of two issues (January to June) were published.

C. Knowledge Delivery

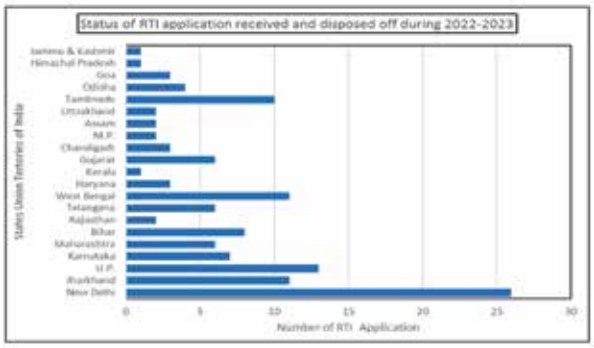
The laboratory is implementing CSIR Integrated Skill Training Initiative since 2017, with the objectives of utilizing CSIR knowledgebase and infrastructure for contributing to national skill mission through special up-skilling/training for societal benefits and improving national skills, and promoting entrepreneurship/ technopreneurship.

The different categories of training programs provided at CSIR-NML include Corporate Training Programs (CTP) and Professional Training Programs (PTP), which are paid trainings for professionals, NSDC Training Programs (NTP) and Societal Training Programs (STP), which are low cost or free training provided to school drop outs, and, International Training Programs (ITP) for international clients on demand. Special free training are also conducted for women from economically weaker sections.

D. Public Information Delivery

During 2022-2023, CSIR-NML received 128 RTI applications from 21 states and union territories of India. A maximum 26 application received from the New Delhi followed by the Uttar Pradesh has filed 13 applications whereas from the Jharkhand and the West Bengal sent us an equal number of the eleven application. The overall distribution of the RTI application among others states are highlighted in figure. We have also received 10 appeals, which were successfully disposed of, as per RTI guidelines. Most of the RTI queries were related to the Administration. The CSIR-NML Transparency portal

(http://transparency.nmlindia.org) contains all the information as per the requirement of THE RIGHT TO INFORMATION ACT, 2005. This information is updated periodically.



In addition to mandatory public information, information about the strengths and achievements of CSIR-NML is disseminated through its Annual Report, Equipment Brochure, CSIR-NML Technology videos, CSIR-NML Technology Handbook, and many other publications, both soft and hard.

E. CSIR Jigyasa : Outreach Programs for Schools

CSIR-Jigyasa Virtual Laboratory Project under the CSIR-Jigyasa program is an initiative taken by CSIR during its Platinum Jubilee year, which was inspired by our Honourable Prime Minister's vision of a new India and Scientific Social Responsibility (SSR) for CSIR. The project "CSIR-Jigyasa Virtual Laboratory" aims to encourage students to learn science effortlessly with fun and enthusiasm. Under this project, CSIR-NML aims to organize various types of scientist interaction programs for school students and teachers, to create innovative learning tools and contents through Virtual Laboratory (VL) by utilizing advanced digital technology focusing on the areas of minerals, metals, materials, and metallurgy. The targeted beneficiaries of this project are school students from Std. VIII to XII, focusing on Government-funded schools located in rural areas. In FY22-23, CSIR-NML organized the following scientist interaction programs for school students and teachers: I. Visit of scientists to different schools. II. Scientists and science teachers' conclave. III. Teachers training on innovation. IV. Mentoring of Atal Tinkering Labs (ATL) of different schools V. Popular lecture series on various technical and scientific topics. VI. Global Battery experiment. Additionally, CSIR-NML developed Solenoid and Gas Detector "DO IT YOURSELF" (DIY) Kits for school students to understand the science with fun and enthusiasm. In Solenoid DIY Kit, students can make a solenoid using paper, copper wire, a nail, and a battery, which will help students to understand the concept of the solenoid. Using Gas Detector Kit, students can make and understand the working of the gas detector. During school visits, CSIR-NML scientists demonstrated the DIY kits to school students. Under the Virtual Laboratory part of this project, CSIR-NML developed various digital contents like, "Crystallographic structure of metals", "Why materials fail", "Additive manufacturing process", "Heat engines", and others. In FY22-23, CSIR-NML organized the following Programme: One-day NML visit of school students and teachers. II. Visit of scientists to different schools. III. World Youth Skills Day. IV. Popular Lecture Series on Fractal Geometry, Basics of Computational Materials, Decontamination of drinking water a technological and social challenge, Global Battery Experiment, and National Creativity Olympiad. Almost 1284 students and teachers were involved in all these activities.

Visit of St. Joshep High School Golmuri, Jamshedpur at CSIR-NML

Connecting CSIR Jigyasa Program with **Atal Tinkering Lab (ATL)** is one of the initiatives of CSIR. This initiative includes adoption of schools with ATL facility which are in the proximity of CSIR Labs. CSIR-NML adopted three schools which have Atal Tinkering Labs, namely, Kendriya Vidyalaya, Surda; SS High School, Childag Angara; and, DAV Public

School, Barkakhana. On 10th Feb. 2022 and 15th March 2022 a team from CSIR-NML visited Kendriya Vidyalaya, Surda and SS High School, Childag to foster students' ideas through do-it-yourself (DIY) model, to develop innovation skills, and to teach students various methods of learning.

Information Technology Group (ITG)

The Information Technology Group [ITG] caters to and co-ordinates the lab-wide needs for IT resources and management in terms of creation of IT infrastructure, its services & maintenance. The group is mainly looking after the development and services of IT facilities & infrastructure at CSIR-NML from basic to advanced needs. The group is well equipped with computational facilities in terms of hardware and software. The team IT consists of scientists and technologists who are actively involved to support the lab level R&D activities by providing reliable and efficient IT infrastructure with uninterrupted Internet service.

CSIR-NML is making use of the IT infrastructure primarily for data transfer, communication, exchange of manuscripts and data with authors and referees, generation of knowledge base through internet, Email communication, ERP, conducting HR interviews/assessments, important project meetings around the globe through video conferencing/ Skype/ MS Team etc.

Besides day-to-day routine activities, following are some of the major milestones achieved while equipping the three campuses of CSIR-NML and two residential dispensaries with the requisite IT infrastructure during 2022-2023:

(a) Upgradation of existing server in terms of hardware & software.

(b) Planning, estimation & installation of IT facility required by users at various renovated sites of CSIR-NML.

(c) Coordination and management of lab wide maintenance services of CSIR-NML's IT assets.

(d) Preventive maintenance of IT infrastructure installed across campuses of CSIR-NML.

(e) Provisioning of IT facilities in terms of network connections and utility services to new recruits.

(f) Development and maintenance of several in-house utility web applications.

(g) IT support to Human Resource Group (HRG) for performing various HR activities (interviews/ assessments/DPCs).

(h) Conduction of Video Conferencing for important meetings and various project review activities.

(i) Procurement and installation of Large Format Display (LFD) for various locations of NML.

(j) Resolution of various technical issues and upgradation and hardware maintenance related to CCTV.

(k) IT support for conduction of seminars, workshops & conferences at NML.

(l) Upkeep of turnstile based attendance system at CSIR-NML for employees and pensioners.

(m) Verification of data and printing of employee identity cards.

(n) Technical maintenance and upkeep of Aadhaar Enabled Biometric Attendance System (AEBAS).

New Facilities / Infrastructure Created in the Reporting Year :

a) 155Mbps Internet leased line from BSNL

b) 100 Mbps Internet & NKN connectivity from NIC via PGCIL

c) Three nos of private leased line from main laboratory to pilot plant areas.

d) 328 Nos of Landline connections from BSNL with teleconferencing facilities.

e) 2 Nos VC facility supporting HD Video and content

f) Website NMLINDIA.ORG for the organization.

Team - KRIT

New Facilities

Potentiostat / Galvanostat System Electrochemical Workstation

Make : IVIUM Technologies, Netherlands; Model – Vertex

The Vertex potentiostat/galvanostat equipped with FRA/EIS was purchased for study of applied electrochemistry in the areas of corrosion monitoring and coatings. The equipment has an applied voltage range of ±10 V and current range of ±600 mA ±10nA. The equipment has the facility to measure Open Circuit Potential, Linear Scan Voltammetry, Cyclic Voltammetry Chronoamperometry, Zero Resistance Ammeter (ZRA), Galvanic Corrosion, Cyclic Polarization, Linear Polarization, Tafel, Electrochemical Noise, Potentiostatic, Potentiodynamic, Galvanostatic, Galvanodynamic, Constant Current, Constant Potential, EIS, Galvanostatic EIS, Mott – Schottky measurements.

100kVA Furnace Transformer

The existing power supply (50 kVA fixed voltage transformer) and accessories connected to EAF have been inadequate for several high-temperature smelting work. A new power supply (3-phase 100 kVA variable transformer with an advanced control system) was necessary for precise control on smelting of copper slag in EAF. The modification helped to collect data on melting behaviour and energy consumption as function of charge mix, time, furnace load etc.

Electric Forklift

Model : ACE AF20E

Current & Future Usages:

- Loading & unloading goods
- Line feeding
- Stacking
- Goods transport within campus

General features:

Mode of operation : Battery

Load Capacity : 2 T

Lifting height : 3000 mm

Fork size : 1070 mm x 100 mm x 40 mm

Tilting angles : 6° ~ 12°

Wheels : 2/2 solid

Battery rating : 48V/440Ah

Mast type : 3-stages

Overall height fork lowered = 2060 mm

Overall height (Overhead guard) = 2150

Single Channel Potentiostat / Galvanostat System with 20 A Booster

Single Channel Potentiostat/Galvanostat System with 20 A Booster. Single Channel Potentiostat/ Galvanostat System i.e., the VersaSTAT 4 having the max current capability to ±2A. High current boosters up to 20A for battery, fuel cell, or electroplating applications. Excellent current measurement resolution for corrosion, coatings, and microelectrode analysis. An internal frequency response analyser option for impedance analysis over the frequency range 10 µHz to 1 MHz Versa Studio software is included with all Versa STAT 4 systems for Voltammetry techniques like : Cyclic Voltammetry, Chrono-techniques and Pulse Voltammetry methods. Corrosion techniques including the most common ASTM standards such as Linear Polarization Resistance (LPR, ASTM G59), Tafel (ASTM G5), Cyclic Polarization (ASTM G61), etc. Impedance added to provide Electrochemical Impedance Spectroscopy techniques response for corrosion, coatings, electro catalysis and fuel cell.

Fabrication of an Industrial Grade Sensing Device

The device, an industrial grade sensing device, comprises of probes/sensors, the sensing device and interfacing & display unit. The EC sensor/ probe is an encircling coil connected in differential configuration, fabricated on a nylon -6 former. The entire assembly has been encapsulated in aluminium alloy housing. The sensing device consists mainly the central processing electronic unit that performs three basic operations. The RF signal energizes the sensing coil and induces an eddy current in the part to be inspected. When a change in fill-factor occurs in the test piece, the coil impedance experiences a change. It processes the responses due to the induced eddy current. The processing unit of the system includes a number of sub functions that include impedance matching network, modulation/demodulation unit, subsequent filtering, offset-gain control network and final amplifier unit. The final output is measured and recorded by PC unit through data acquisition (DAQ) card. The development program and interfacing protocols work on LabVIEW platform. Embedded system of the whole unit is designed by integrating sensor, central processing electronics and the controlling software through interfacing protocols.

Horizon Software (Metal) includes Dongle and Firmware for H25KS UTM

Software Controls Universal Tasting Machine (H25KS)

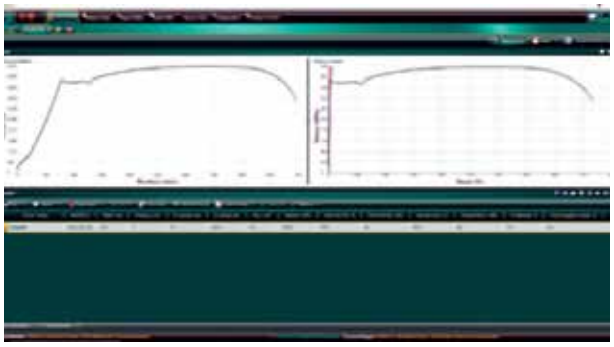
Manufacturer : Tinius Olsen, UK

Key features

- Full PC networking integration and backup across a PC network using industry standard SQL database structure.
- Multiple licensing of Horizon for multiple installations to review methods, results and reports away from the testing machine, lab or plant.

- Multi-level user password capability.
- Recall function enables users to add key data perhaps not available, or missed, prior to the test.
- Built in Team Viewer licenses enabling TO engineers to log in directly, upon request, and provide on-machine technical support.
- Live results during test; there is no limit to the number of results displayed and these do not have to be used in the test report.
- With sufficient PC power and bandwidth, multiple testing machines can be run from a single PC.
- Users can use pre-written international standards methods as templates to modify and build their own test methods.

Materials Testing, Analysis and Reporting Software



Software representing stress-strain curve

Eddy Current Sensing Technique for the Measurement of Coating Thickness

The setup is developed based on an excitation signal from the Eddy Current Device and then amplified using **High-Speed Bipolar Amplifier nF HSA42012**. The amplified excitation signal is fed to the sensor probe to measure coating thickness. The deviations in voltage based on the coating thickness are measured through the Sensing probe, developed in-house, using the **NI PXIe-1071** data acquisition system with the controller. The whole software is running on the **NI PXIe-1071** for the analysis of the output signals.

De- Dusting System for Beneficiation Unit Capacity of Bag Filter ID Fan : 1700m3/hr

De-dusting system for the beneficiation unit's Bag Filter ID Fan, meticulously designed and implemented at CSIR-NML, exemplifies a commitment to environmental excellence, equipment longevity, and uncompromising air quality standards. Through its efficient collaboration between the bag filter and ID Fan, this system stands as an essential component for impactful research practices in the area of metallurgical and materials science.

4HI/2HI Rolling Mill Laboratory Model

The 4HI/2HI Rolling Mill Laboratory Model at CSIR-NML seamlessly integrating into the laboratory's research ecosystem. Its versatile applications in material development, process optimization, and education underscore its value as a key asset in advancing the understanding and application of rolling processes within the metallurgical industry. With precision control systems and tailored capabilities, this laboratory model contributes significantly metallurgical research at CSIR-NML.

Phased Array Ultrasonic System

The Phased Array Ultrasonic System emerges as a technological cornerstone, aligning with the laboratory's commitment to excellence. Through its adaptive beamforming capabilities and high-resolution imaging, this system contributes significantly to ensuring the safety, reliability, and efficiency of various laboratory applications. It stands as a cutting-edge technology for advancing research and development in materials science and metallurgy.

Fabrication of an Electrochemical cell for the Deposition of Manganese Metal

The electrochemical cell designed for manganese metal deposition aligns with the laboratory's stringent standards in material selection, assembly, and operational management, this electrochemical cell emerges as a valuable and reliable tool for producing high-quality manganese coatings, contributing to advancements in various industrial applications.

Laboratory Scale Inert Gas Atomizer for Producing High Purity Spherical Metal/Alloy Powders

CSIR-NML Purchase Order No & Date :

NML-FG/MTE-KGK/40-19/7-2021 Dt. 28.07.2021

Supplier : M/s Precious Alloys Pvt Ltd., Mumbai

Manufacturer : M/s Blue Power, Germany

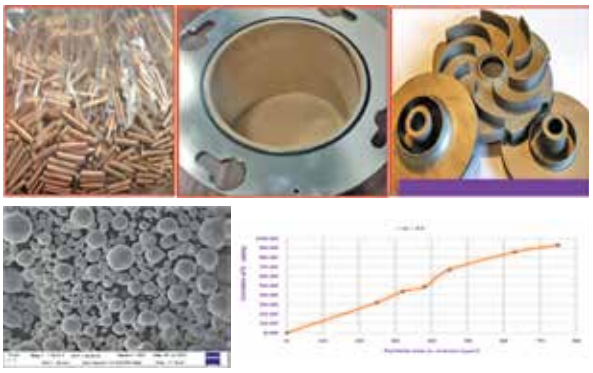
Model : AUG1000

The AUG1000 Inert Gas Atomizer (IGA) Features:

- Gas atomisation involves, breaking up of a molten metal stream using high-pressure inert gas & is an effective method of producing fine spherical metal powders.
- Capable of producing both (i) pure metal powders of Gold (Au), Iron (Fe), Nickel (Ni), Copper (Cu) etc. and (ii) wide range of alloy powders based on Fe, Ni, Co, Au etc.
- Includes melting furnace based on induction heating.
- The melt capacity is 1.0 litre melt with bottom pouring mechanism and close coupled nozzle.
- Provisions to control the particle size, and the typical d_{50} of the produced powders in a batch, found to be about 40±10 µm, where d_{50} is mass median diameter.
- Includes view ports in both melting furnace and atomization chamber. Another port in atomization chamber is fitted with CCD camera.

Laboratory scale Inert Gas Atomizer (AUG 1000) after installation and commissioning

(Inset : (A) Ceramic crucible setup (B) Graphite crucible setup (C) Atomization in process (D) Gold alloy powder



Typical characteristics of the $CuSn_6$ powder produced during the trial run using
AUG1000 inert gas atomizer after installation at CSIR-NML

(A) CuSn6 feed stock (B) Powder in receiver (C) Typical 3D printed pump components (D) SEM image of the powder showing globular particles (E) Size distribution on sieving

Research Planning and Business Development

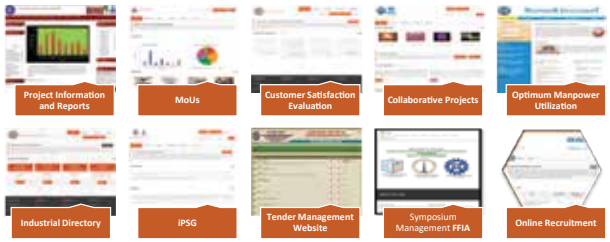
The Research Planning and Business Development (RPBD) Division is engaged in the management of R&D Projects of the laboratory as well as a range of other essential functions for the laboratory. The division interactions with both internal and external stakeholders to fulfill its various functions. Its primary areas of work include:

Research Management, Business Development & Client Interfacing

Role of RPBD is a crucial throughout all stages of research and development project execution, as illustrated above. The Division functions, as the primary point of contact for prospective clients and sponsors seeking solutions for their research and development (R&D) needs. It plays a pivotal role in initiating and fostering relationships between clients and the relevant technical experts. This includes conducting negotiations with potential clients to establish collaborative agreements, covering financial and intellectual property aspects. During the reporting period, the Division was instrumental in making 25 new clients for the Laboratory viz. *Krishak Bharati, Sani electronics, Sandur Manganese & Iron Ore, Welspun Corporation Limited andFrakka Barrage Limited; negotiated 26 new contracts/agreements during this period and signed 24 national and internal contracts/agreements with academia as well as industries viz. Colour Chromes Pvt Ltd., OP Jindal University, Surgiwear Ltd., Shahjahanpur, ReCy Energy Pvt Ltd, Pune, Saint-Gobain India Private Limited, Chennai, Log9Materials, Bengaluru, INDIA GOVERNMENT MINT, HYDERABAD, Vardhman Auto Recycling, New Delhi, IIT, Patna, Diva Envitec Pvt. Ltd., Mumbai, IIT-ISM, Dhanbad, NTPC Limited (NTPC), New Delhi, Raj Borax Private Limited, Mumbai, Jamipol, Jamshedpur, Vedanta Pvt. Ltd., Steel Authority Of India Limited-Bokaro Steel Plant, Bokaro, Enter Engineering Pte. Ltd, Singapore, Ashvini Magnets Pvt. Ltd., University of Stavanger, Norway, Tata Steel, Jamshedpur, BHEL, and Advanced Metals.* 105 additional projects were subjected to evaluation to ensure their alignment CSIR guidelines. The division also generated 1035 invoices to clients for payments. The Division also remained instrumental to collect customer satisfaction and evaluations of more than 15 completed projects (through online platform), resulting in an average CSE Index score of 4.7 out of 5.0. The division also engages in the procurement procedures of different sponsors, therefore acquiring new projects. During the reporting period, the Division issued 45 bids, resulting in the Lab being awarded 36 projects. Several successful bids were submitted to prominent organizations such as *Tata Steel, DMRL, Indian Navy, Geological Survey of India, DRDO, Ministry of Science and Technology, SAIL, Ministry of Steel, BARC, ISRO, JSW Steel Ltd, and Kerala Minerals Metals Ltd.*

Information Systems & Databases

The division develops and maintains many web-based information systems and associated databases internally, with the aim of promoting digital inclusion and enhancing the overall efficiency of the laboratory. The e-information systems and databases facilitate management decision-making by supporting various e-processes. These databases include information on several aspects including projects, manpower, external cash flow, intellectual property, agreements, and more. RPBD is responsible for the preparation and dissemination of a diverse range of reports to both internal and external stakeholders on a regular basis throughout the year. Some of the significant documents are the Key Performance Indicator (KPI) Document, the PMO Portal Data, the Research Utilization Data, the Monthly Reports, the Quarterly Reports, the Annual Plan Document, and the Replies to PMO & Parliament Queries, among others.



Institutional Publications

CSIR-NML disseminates monthly newsletters via RPBD, which highlight the significant activities & achievements of the organization. The division is responsible for coordinating the preparation of the Annual Report of the laboratory. In addition, the division also publishes the RC Agenda, Technology Handbook, Director's Desk, and Equipment Brochure.

IP Services

RPBD group offers IP search and analysis services to both external customers and internal users, with a particular focus on those engaged in the creation of new technologies or processes. The extent and proficiency of the department in these domains. During the 2022-23 period, the division offered a range of services in the field of Minerals, Materials, and Metals. These services included IP search and analysis, Evaluation FTO space, Patent Landscaping, Patent Portfolio Analysis, Patent Mapping, Patent Citation Analysis, White Space Mapping, and Competitive Intelligence.

The group possesses pertinent expertise in delivering competitive intelligence services through various means, including Competitor Tracking and Profiling, Comparative Technology Evaluation,

Market Assessment Studies, Strategic Grouping and Collaboration, Patent SWOT Analysis, Patent Claim Analysis, and Market Segmentation Analysis.

Scientific & Technical Services

RPBD coordinates provision of S&T Service to customers. Testing as per standards are carried out for various organizations every year. Last year 611 customers were provided testing services.

Technology Marketing

The CSIR-NML has a diverse range of technologies and products that are poised for commercialization, with some of them already been successfully introduced into the market. The publication of the second edition of the "Technology Handbook" encompasses a comprehensive compilation of over 60 technologies currently available from CSIR-NML. The Division periodically organizes industrial/ business meetings and presentations with the aim of raising awareness among industries in different sectors about the technologies that are now accessible.

Intellectual Property Facilitation Center (IPFC)

IP Facilitation Centre of CSIR-NML, which is established in the year 2020. The center was founded under the aegis of Ministry of MSME, Govt. of India with an objective of "Building Awareness on Intellectual Property Rights (IPR)" for the MSMEs. The ambitious project has a budget of 100 Lakhs with an objective to bring awareness about IP and exploit IP for the MSMEs competitive business advantage. It's a project of national importance which would create a surge in IP based start-up eco-system in the country and eventually it leads to knowledge based thriving economy. The center is fully equipped with all the necessary amenities, infrastructure and manpower competencies to provide IP related services to MSMEs in a big way. Since Its inception, IPFC center has organized several webinars to bring awareness about IP and the importance of IP protection for a competitive business sustainability. As a part of this program, NML-IPFC organized 19 webinars and 02 seminars so far wherein around 1900 people were benefitted in the matters of IP. The center has already started providing IP related services like patentability, patinformatics, patent landscaping analysis, copyrights registration services, trademark & design registrations, and other techno legal advisory services. So far the center registered 18 trademarks, filed 05 patens, 03 industrial designs registered, and 01 copyright registered.

Team-RPBD

Empire State Building - New York

- Most iconic and amazing, the Empire State Building, was constructed in 1931.
- The building's steel frame weighs 57,000 tonnes, while the Art Deco exterior is composed of 200,000 cubic feet of limestone and granite, 10 million bricks and 730 tonnes of aluminium and stainless steel.

Sources: wikipedia

Administration

The Administration provides a variety of support services for conducting R&D in the laboratory. The division has aligned itself to realize the vision of CSIR-NML and facilitates the overall system towards meeting the set goals and targets. The division has significant roles to play in every facet of the career development of the staff as well as providing sustained support right from their recruitments to superannuation, and often, even after superannuation. The Administration connects all the staff and facilitates in fulfilling various vital needs of the employees, like, academics, career, housing and health in the following manner:

- Formulate and implement the policies concerning administrative procedure for smooth functioning of the Institute.
- Provide advice to the functional bodies (committees/ functional groups) within the organization.
- Maintain liaison with CSIR Headquarters on matters related to administration/vigilance/ legal.
- Provide healthy working conditions and atmosphere to Institute by correct interpretation as well as implementation of governing rules and regulations.
- The Administrative Head of the Laboratory advises the Director for decisions on administrative matters.
- Implement instructions of the Director/CSIR on various matters.

The division is presently headed by the Administrative Officer, who is over all In-charge of the activities and supported by the Section Officers, and a group of ASOs, SSAs, JSAs and other supporting staff. The division also coordinates the work of the Health care centers, security services and Rajbhasa cell. In the recent past, the Administration has undergone a major shift in terms of work culture, towards implementing paperless processes through e-Office. An improved work culture and decentralized leadership at all levels has been introduced to bring the desired changes. A sustained effort has been initiated to inculcate the passion to ensure faster service delivery system to match with the expectations of CSIR-Enterprise Transformation initiatives.

Team - Administration

Luis Bridge - Porto

- Spanning 172 metres.
- Constructed from iron and granite, the bridge weighs a total of 3,045 tonnes.

Sources: wikipedia

Engineering

The Engineering Division caters and co-ordinates the engineering needs, both R&D and infrastructural, of the laboratory, Large Scale Testing Facilities & Residential Complexes. Majority of the needs are non-repetitive in nature, though some are of routine type. The division has two groups called Works Services and Maintenance (WSM) group and Project Planning and Engineering (PPE) Group. WSM group include Civil Engineering Unit, Electrical Engineering Unit and Air-Conditioning Unit, while PPE group consists, central workshop and new projects unit. The type of activities performed by the Division include: Design and Development of prototypes, Project Engineering, Engineering Consultancy, Infrastructural Development, R & D activities of the core areas of the laboratory, Up-keeping of premises, In-house maintenance, Workshop facilities and support services.

Project Planning and Engineering Group :

The activities of the group in brief, divided into following categories:

1. Prototype/Product design and development
2. Research and consultancy
3. Setting up and operation of critical infrastructure
4. Finite Element and CFD Modeling
5. Maintenance and up-keeping of R&D equipment
6. Central workshop
7. Skill development
8. Technology up-scaling and detailed Engineering Packages (BEP/ DPR)
9. Pilot plant operation and maintenance

Prototype/ Product Design and Development :

In the reported period, the division has contributed to the requirements of several projects. Design and development of barrel electroplating system for coating Mg-based biodegradable implants is a major inhouse prototypes designed and developed during the period.

Research and Consultancy :

In the reported period, the division has undertaken the following major research projects as follows:

1. Numerical modelling of heat transfer and fluid flow in Selective Laser Melting (SLM) of SS316L.
2. Design and development of an in-house barrel electroplating system for coating Mg-based biodegradable implants
3. Near net shape 3D manufacturing of Inconel 718 by optimizing controlled parameters of wire arc additive manufacturing with Cold metal

Setting up and operation of critical infrastructure : In the reported period the division has been working on the following areas for critical infrastructure development:

1. Facility maintenance for 24×7 controlled atmosphere testing conditions for the Creep Laboratory.
2. Setting up of infrastructural requirements for the successful installation of following major procurements during the period: Rolling Mill and Inert Gas Atomiser.
3. Operations of 493KWP solar power plant for catering the electrical load requirement of Laboratory, due to which a saving of Rs.1,50,000/- per month in the running expenditure is observed.

Finite Element and CFD Modeling :

The division is actively contributing in process modeling activities. We are gaining expertise in Particle Image Velocimetry (PIV) technique, which can be used for studying insights of fluid flow systems and for validation purpose. Following are the major contributions :

1. Optimization of FBG sensors requirement for locating the critical zone of blow pipe by numerical simulation and ANN.
2. Numerical modelling of heat transfer and fluid flow in Selective Laser Melting (SLM) of SS316L.
3. Temperature mapping of GTG gas collector for assisting annealing cycle and furnace design.

Basic Engineering Packages:

The group has been involved in Preparation of Detailed Project Report(DPR) for the NMLS retort technology for magnesium metal production and for the upscaling of an energy efficient process for the recovery of metal value from spent NdFeB magnets

Pilot Plant Operation and Maintenance:

1. Construction of energy efficient brass melting furnaces in various clusters of Bengal, Jharkhand and Odisha, and demonstration to artisans to construct themselves.
2. Support in carrying out pilot scale campaigns.
3. Support in revival of critical R&D equipment's.

Maintenance and Up-keeping of Equipment:

The division has limited manpower but actively involved in in-house maintenance support to high value equipment of the laboratory. This will save a lot of AMC costs and will reduce breakdown time of the equipment's. During the reporting period the Surface grinder and Lathe Machine were serviced.

Skill Development:

Every year the division provides training to graduate and technician apprentices. In addition, training in the area of welding and carpentry is provided under CSIR skill initiatives.

Central Workshop:

Central Workshop receives jobs from various divisions, for specimen preparation of different materials, fitting, machining & fabrication of prototypes and repairing of miscellaneous jobs. All these jobs are completed in time to the satisfaction of the indenters. Major facilities available in the workshop are: CNC Lathe, Universal Milling, Shaper, Radial drill, Pillar Drill, Double column band saw, Shearing, Pipe bending M/C, TIG/ MIG welding, EDM wire cut machine. Major achievements made during the period are:

1. Job value of the services during the period 2022-23 is Rs. 46 Lakh. (upto January,31st 2023)
2. No. of job-sheets served is 624 in FY 2022-23.
3. Average time to complete a job also has come down with emphasis to complete the given job in less than a week of its requisition.
4. Upgradation of workshop facilities by utilization of Robotic MIG and CMM.
5. New Forklift has been procured for material handling purposes in workshop and for entire laboratory.

Works Services and Maintenance Group:

This group has diverse responsibility to upkeep infrastructure, create new infrastructure and renovation of facilities in 7 campuses (Main laboratory, 2 pilot plants, 4 residential campuses) of CSIR-NML. These services include civil engineering, electrical engineering and refrigeration & air conditioning, lifts, water supply etc. The work accomplished by the group can be categorized in 3 major categories namely- New infrastructure, renovation jobs and routine maintenance jobs. List of major works undertaken are enumerated below.

New Infrastructure:

The infrastructure management team has successfully completed new facilities creation jobs as per the requirements of the laboratory. In addition, we take annual Maintenance & Overhauling of infrastructure & maintenance jobs. Some of the new facilities developed are as following:

New thermal Laborataory

New rolling mill foundation

New security office under construction, Agrico Housing Complex

Renovation Jobs:

The infrastructure management team has successfully completed new facilities creation jobs as per the requirements of the laboratory. In addition, we take annual Maintenance & Overhauling of infrastructure & maintenance jobs. Some of the new facilities developed are as following:

Road carpeting and concrete pavement in residential complex

Renovation of Melting Bay

Routine Maintenance:

Maintenance of L.T Breakers

Team - Engineering

Cloud Gate - Chicago

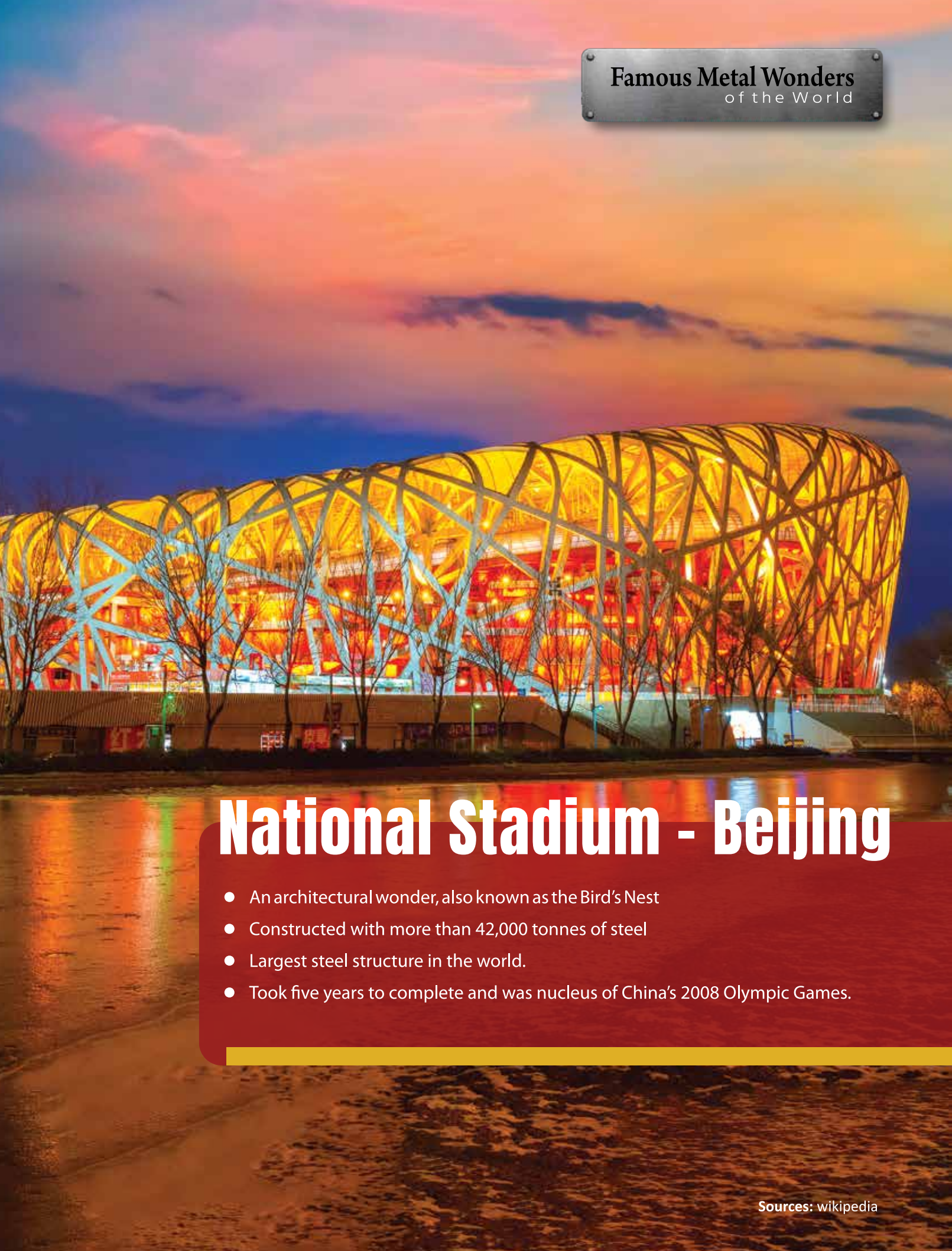
- Nicknamed 'the bean' because of its shape. Its design and was inspired by liquid mercury. Indian-born British artist designed it.
- Construction comprises of 168 stainless steel plates welded together and highly polished so that there are no visible seams. It measures 33 by 66 by 42 feet (10 by 20 by 13 m), and weighs 110 tonnes.

Sources: wikipedia

Stores & Purchase Division

CSIR-NML's Stores & Purchase Division is a committed team of dedicated officials who are primarily responsible for procurement of goods & services including imports from foreign countries. The team works as a support system to cater to the Research and Development (R&D) needs and also to meet the long term strategic goals of this Institute and also the team strive to keep the system of R&D and other supporting services running in smooth condition by taking care of procurement activities related to materials / services in time and within the ambit of public procurement.

Team - Stores & Purchase



National Stadium - Beijing

- An architectural wonder, also known as the Bird's Nest
- Constructed with more than 42,000 tonnes of steel
- Largest steel structure in the world.
- Took five years to complete and was nucleus of China's 2008 Olympic Games.

Sources: wikipedia

Finance & Accounts

Finance & Accounts Division of CSIR-NML is actively engaged in planning, organizing, directing and controlling the financial activities of the Lab including accounting of all the financial transactions of the year as per GFR and CSIR guidelines. This division provides a central accounting and financial information to Director, NML, CSIR Headquarters and other stakeholders through the management information system.

Following are the major activities of the Finance & Accounts Division.

- Preparation of Budget Estimate and Revised Estimate for CSIR-NML and submitting the same to CSIR for allocation of funds.
- To ensure that there are adequate funds available to acquire the resources needed to help the organization to achieve its objectives.
- To ensure cost control while facilitating adequate spending within laid down guidelines and procedures in the matter.
- To ensure adequate cash flow and proper management of funds through transfer of funds from CSIR.
- To provide appropriate financial information relating to different heads of accounts and projects to the Director, Project Leaders and other decision makers so that informed judgments and decisions are made. Posting of monthly progressive expenditure in NML intranet to keep all employees informed about fund position.
- To prepare financial documents such as Receipts and Payments account and Balance Sheet of the organization on a given date for submission to CSIR and decision makers including submission to CAG (Audit) for certification of accounts.
- Preparation and Submission of Utilization Certificate to sponsors of the projects as and when required.
- Pre-audit of all the bills before making final payment to avoid any irregularity or deviation from the financial Rules.
- Processing promptly all payment payable through Treasury Single Account (TSA) at RBI in PFMS system of the Government of India.
- Promptly, accurately and efficiently recording all the receipts and payments in the relevant ledgers and books of accounts.
- Closing of GPF/CPF accounts, remittance of funds to NSDL relating to National Pension Scheme and Professional tax, income tax, etc. within due date to appropriate authority.
- Accounting, processing and ensuring timely filing of various GST returns and payment of GST due to the Government.
- To provide progressive reports on monthly expenditure, OB, Bank reconciliation, Audit Paras, etc. to maintain transparency.

Performance Highlights for the Financial Year 2022-23

1. Utilized Budget Grant allocated by CSIR- Rs.7254.253 lakhs + Rs.5143.063 lakhs (pension)
2. Utilization from Laboratory Reserve- Rs.214.763 lakhs
3. Generation of interest by investment of surplus funds- Rs.634.268 lakhs
4. Generation of Lab Reserve - Rs.1239.375 lakhs.

5. Bank reconciliation of the Cash Book completed up to 31st March, 2023.
6. GPF Account as on 31-03-2023 has been reconciled, finalized and closed.
7. During the year new cases of 35 pension and 24 family pension cases have been completed with issuing of PPO and pension papers on time.
8. NML finance successfully switched over to PFMS system for payments out of Govt. grant, where payments are directly made to vendors by RBI under Single Treasury Account system.
9. Several CAG Audit para have been settled.
10. Accounts Division has been renovated for better ambience.
11. Provision of QR Code for online money receipt in the NML official Account.

Team - Finance & Accounts

Awards & Recognition

National/International Awards/Recognitions

TATA INNOVISTA Award 2022

As THE MOST INNOVATIVE PARTNER for the "Intelligent Billet Caster"

Team : Dr. Sarmistha Sagar, Chief Scientist, Dr. Tarun Kumar Das, Sr. Principal Scientist, Dr. Arpita Ghosh, Principal Scientist

MRSI Medal Lectures 2022

The award was conferred to eminent researchers for delivering MRSI Lecture.

Dr. Asit Baran Panda,
Principal Scientist

2nd prize

Presentation on topic of "**Development of Hydrogen CRMs in Steel (PIN)**" in 6th PTP/RMP Conclave 2022 during 25th - 26th August 2022, Bengaluru organized by NABL, QCI.

Dr. A. K. Upadhyay,
Principal Technical Officer & QM, CRM Unit

Recognition to CSIR-NML Scientists and their Mentorship

A web-article recognizing the role of CSIR-NML mentoring in shaping the career of a Nigerian researcher.
Link: https://twas.org/article/boosting-steel-industry-nigeria

Skoch Order of Merit 2023

e-Recruitment System

Team: Dr. Beena Kumari, Principal Scientist, Mr. Sudip Kundu, Principal Scientist and Mr. Kumar Rahul, Administrative Officer

Recognition and Felicitation of CSIR-NML Women Staff, NML on International Women's Day Celebrations 2023 in Various Forums for their Contributions in Different Fields of Work

Field of Work : Entrepreneurship & Skill Development

Felicitated and graced the chief guest in the function organized by CSIR-CMERI, Durgapur

Dr. Mita Tarafder, Chief Scientist

Field of Work : NDT

Felicitated and participated as one of the panelist's in a panel discussion organized by at LPSC, ISRO

Dr. Sarmistha Sagar, Chief Scientist

Field of Work : ICT Development and Digital Transformation

Felicitated in the function organized by CSIR-CIMFR, Dhanbad

Dr. Beena Kumari, Principal Scientist

Field of Work : Analytical Chemistry

Felicitated in the function organized by CSIR-CIMFR, Dhanbad

Mrs. Rupa Das Biswas, Sr. Technical Officer

Fellowships

INAE Fellowship 2022

Prestigious fellowship for the year 2022.

Dr. Sandip Ghosh Chowdhury, Chief Scientist

CSIR-NML Foundation Day Awards (26th November 2022)

V.A. Altekar Award for Best Technology developed and transferred,

Technology : "Fiber Optic Based Break Out Prevention Technology for Continuous Billet Caster"

Dr Tarun Kumar Das, Sr. Principal Scientist, Mr. Chandan Dutta, PA, Mr.Alok Kumar, PA and Dr. Sarmishtha Palit Sagar, Chief Scientist

B.R. Nijhawan Award for the Best Technical Paper published from laboratory, was awarded to the paper "Evolution of microstructure and deformation behavior in Al-Ni added medium- Mn Steel process through intercritical/ cold rolling and annealing".

Dr. Biraj Kumar Sahoo, Scientist, Dr. Vikas Chandra Srivastava, Chief Scientist, Dr. Avanish Kumar Chandan, Sr. Scientist, Dr. Sandip Ghosh Chowdhury, Chief Scientist

Professor Shilowbhadra Banerjee Award for the Best in-house project completed, was given to for the project "Preperation and Certification of Hydrogen Standard (CRM) in steel".

Dr. Ashok K

Dr. A K Upadhayay

Dr. A K Mohanty

Dr. K. Ashok, Scientist, Dr. Arvind Kumar Upadhyay, Principal Technical Officer, and Dr. Ashok Kumar Mohanty, Sr. Principal Scientist

Prof. S.P. Mehrotra Award for the Best Colloquium Speaker in 2022 was jointly shared

Mr. M. Ananda Rao, Principal Scientist and Dr. Rajen Kundu, Scientist

Prof. P. Ramachandra Rao Award for the Best Employees

Category : Technical

Mr. Dhani Ram Mahato, GrII/2 and Mr. Manoj Kumar Toppo , GrII/2

Prof. P. Ramachandra Rao Award for the Best Employees

Category : Non-Technical

Mr. Amod Kumar, ASO (G)-Admin

Mr. Md. Nayeem Ansari, ASO(G)-Admin

Meritorious Student Award-2022

Awards for scoring 90% or above marks in the Board Examinations (ICSE/CBSE/Jharkhand Board) in class 10th and 12th in the year, 2022.

Mr. Ayush Kumar
Mr. Chandresh Kumar, Section Officer
Class 10th , 96.00%

Miss Abhipsa Mishra
Dr. D. Mishra,
Senior Principal Scientist
Class 10th, 93.50%

Miss Stuti Das
Mr. Byomkesh Das,
Chief Scientist
Class 12th, 98.75%

Mr. Ankit Sahoo
Dr. K. L. Sahoo, Chief Scientist
class 10th, 98.75%

Miss Aditi Upadhaya
Dr. A. K. Upadhyay, Principal Technical Officer
class 10th, 98.25%

Miss Arpita Sahu
Dr. S. K. Sahu, Senior Principal Scientist
class 10th, 96.00%

Mr. Deepanshu Sau
Dr. D. D. Sau, Principal Scientist
class 12th 97.25%

Award for Scoring 100% Marks in any Subject in the 10th and 12th Class Examination held during the Year, 2022.

Mr. Anikt Sahoo
Dr. K. L. Sahoo, Chief Scientist
10th Mathematics

Miss Stuti Das
Mr. Byomkesh Das, Chief Scientist
12th Mathematics

Mr. Deepanshu Sau
Dr. D. C. Sau, Principal Scientist
12th Computer Science

Admission In Institutions of National Repute Through Competitive Examination Held during the Year, 2021 & 2022.

Mr. Ivan Jacob Thomas
Dr.(Ms.) Ansu J. Kailath, Senior Principal Scientist
2021 IIEST, Shibpur

Mr. Deepanshu Sau
Dr. D. C. Sau, Principal Scientist
2022
IIT, BHU

National / International / Committee Membership/ Editorial Board Membership

Dr. Sanjay Kumar, Chief Scientist	• Editorial Board Member of Transactions of Indian Ceramic Society for the third time, for 2023-25, a Tailor & Francis Journal with Impact Factor of 2.64 • Expert Advisory Committee Member for Technology Enabling Centre Program of DST, Ministry of Science & Technology from 29.04.2022. This program funds universities to establish Technology Enabling Centres at various part of country. • Screening Committee Member of prestigious National Technology Awards, 2023 given by Technology Development Board and DST, Ministry of Science & Technology from 06.02.2023. • Elected as Council Member of Indian Ceramic Society for the year 2023-24

 Dr. Trilochan Mishra, Chief Scientist	• Bureau of Indian Standards (BIS) for Inorganic Chemical Section Committee (CHD-1) • High level expert committee for environmental clearance of secondary metallurgical industries under Ministry of Environment, forest and climate change (MOEFCC) during Oct. 2021-Jan. 2022.
 Dr. Abhilash, Senior Principal Scientist	• Editorial Board Member, Mineral Processing and Extractive Metallurgy Review (Taylor Francis) • Editorial Board Member, Russian Journal of Nonferrous Metals (Springer) • Youth Editorial Committee Member, Journal of Central South University (Springer) • Review Editor, Frontiers in Chemical Engineering • Section Editor, Microbiology Insights (SAGE) • Academic Editor, International Journal of Analytical Chemistry (Hindwai) • Academic Editor, Journal of Chemistry (Hindwai)
 Dr. Pallab Bhattacharya, Senior Scientist	• Editorial Board Membership in Journal : Advances in Materials(AM) • Review Editor of Journal: Frontiers in Energy Research.
Dr. V Rajinikanth, Principal Scientist Dr. Sharma Paswan, Principal Scientist 	• MTD-6 Member, "The Pig Iron and Cast Iron Sectional Committee" in the panel as a convenor constituted for revision of standard Centrifugally Cast (Spun) Ductile Iron Pressure Pipes for Water, Gas and Sewage - Specification as per IS 8329.

High No. of Downloads of Research Publication

 Dr. Abhilash, Senior Principal Scientist Dr. Pratima Meshram, Principal Scientist	• Ata Akcil, Yahaya Alhaji Ibrahim, Pratima Meshram, Sandeep Panda, Abhilash; Hydrometallurgical recycling strategies for recovery of rare earth elements from consumer electronic scraps: a review • Pratima Meshram, Abhilash, Banshi Dhar Pandey; Advanced Review on Extraction of Nickel from Primary and Secondary Sources

High Impact Factor Journal Publication

 Dr. Abhilash, Senior Principal Scientist	Abhilash, Isiri Inamdar; Recycling of plastic wastes generated from COVID-19: A comprehensive illustration of type and properties of plastics with remedial options, Science of the Total Environment 838 (2022) 155895 Impact Factor- 10.753

Paper/Poster Awards

Receiver	Title	Description	Photo
Dr. Manis Kumar Jha, Sr. Principal Scientist	N.M.Sampat Award -2021	The award was conferred in the inaugural function of the national symposium on electrochemical science and technology (NSEST-2022) held in Indian Institute of Science Campus Bangalore, India organized by the Electrochemical society of India on (24 June 2022); Awarded Article: For the development of electro-leaching/ selective electro- leaching, electroplating, electro-winning of various non-ferrous, rare and precious metals from e-waste.	

Dr. Sanjay Prasad, Principal Scientist	Best Paper Award	Best Paper Award for the paper entitled "Zinc powder preparation for Zinc dross"; Presented in the technical session "Development of Materials and alloy for emerging applications" from 18th to 22nd April,2022.	

Invited Talks Delivered by Staff

Speaker	Topic/Event
Dr. Sandip Ghosh Chowdhury Chief Scientist	"Similar/Dissimilar Materials Welding of Automotive & Aerospace Sectors (WSM 2022)"; VIT Vellore; Indo-German Science and Technology Centre (IGSTC); 22 September 2022 to 24 September 2022.
Dr. Sanjay Kumar, Chief Scientist	"The Science of Making Artificial Stone"; Indian Ceramic Society, Jamshedpur Chapter; 19th November 2022.
Dr. Sarmishtha Palit Sagar, Chief scientist	NDT in AIMTEK-2022: One day Int. Conf. on Asset Integrity management"; 07th June 2022

Speaker	Topic/Event
 Dr. Ashis Kumar Panda, Senior Principal Scientist	"Rapidly Quenched Magnetic Materials for Sensor Applications"; K.L.University, Vijaywada; 21st February 2023
 Dr. Trilochan Mishra, Senior Principal Scientist	"Environmental Consciousness"; Atal Shodh Kendra, Kanpur; 6th June 2022
	5th International Symposium on hydrogen energy and Energy Technologies (HEET) seminar, Osaka, Japan; 18th -19th November 2022.
	"Material science and Nano Science"; SciWide; 29th – 30th July 2022.
 Dr. Sanjay Agarwal, Sr. Principal Scientist	• "Chromium partition studies in Al2O3-MgO-SiO2-CaO-FeO-Cr2O3 slag system for ferrochrome production", at Manganese/ Chrome Ores, EMD, EMM & Ferro-Alloy Summit, 3 - 4th January 2023, Kolkata, India. • "Utilization of low grade sukinda chromite fines for ferro chrome production" at Technological Advancement in Ferroalloys & Opportunities for Growth, Organized by STEEL TECH, on 11th April 2022, Kolkata, India.
 Dr. Ashit Kumar Pramanick, Senior Principal Scientist	"Defect Characterization of Ga2O3 Single Crystals by TEM and AFM Techniques"; EMSI-2023; 8th -10th February 2023.

Speaker	Topic/Event
 Dr. Abhilash, Senior Principal Scientist	• Invited Lecture at TATA STEEL on 21st June 2022 (Topic: EXTRACTION OF CRITICAL METALS FROM STEEL WASTES) • Invited Lecture at PESIT, Bangalore on 11th November 2022 (Topic : Application of Microbiology in Chemical, Mining and Environment Areas) • Invited Lecture at Karim City College, Jamshedpur on 5th September 2022 (Topic : Innovative Approaches to Remediate Issues in Basic Science Research & Education An Adaptive Competence Development Approach)
Dr. Premkumar Murugaiyan, Senior Scientist	"Development of High Induction Fe-Soft magnetic Nanocomposite alloys: Alloy design to Industrialization"; Central University of South Bihar; 20th March 2023
 Dr. Ajita Kumari, Scientist	International Womens Day 2022 Webinar, Organised by IIME Hyderabad Chapter; 08th March 2022
 Dr. Vinod Belwanshi Scientist	"Micro/Nanoelectronics Devices, Circuits and Systems (MNDCS) 2023"; National Institute of Technology, Silchar; 29-31 January 2023.

Books & Book Chapters

<table>
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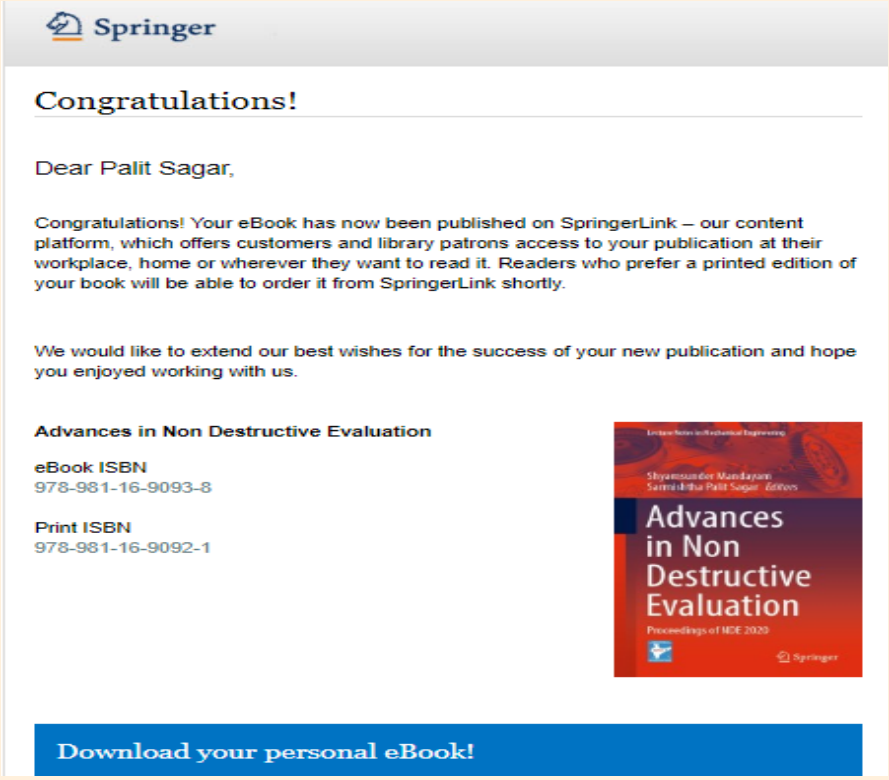
Dr. Sarmistha Sagar, Chief Scientist</td>
<td>Editor of e-Book

Co-edited an e-Book entitled as “Advances in Non Destructive Evaluation” Proceedings of NDE 2020.



Springer

Congratulations!

Dear Palit Sagar,

Congratulations! Your eBook has now been published on SpringerLink – our content platform, which offers customers and library patrons access to your publication at their workplace, home or wherever they want to read it. Readers who prefer a printed edition of your book will be able to order it from SpringerLink shortly.

We would like to extend our best wishes for the success of your new publication and hope you enjoyed working with us.

Advances in Non Destructive Evaluation

eBook ISBN
978-981-16-9093-8

Print ISBN
978-981-16-9092-1

Download your personal eBook!</td>
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Dr. Pratima Meshram, Principal Scientist

Dr. Abhilash, Sr. Principal Scientist</td>
<td>Material Recycling : Unearthing Metals from Anthropogenic and Industrial Resources. In: Shrivastava, A., Arora, A., Srivastava, C., Dhawan, N., Shekhar Singh, S. (eds) New Horizons in Metallurgy, Materials and Manufacturing. Indian Institute of Metals Series. Springer, Singapore. https://doi.org/10.1007/978-981-19-5570-9_5, pp. 69-89.</td>
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CSIR-NML Foundation Day Essay Competition

Somnath Das
Hindi (First)

Amit Prakash
Hindi (Second)

Rukhshana Parween
Hindi (Third)

Shilpa Bawkar
English (First)

Dr. Saswati
English (Second)

Sukalpan Nandi
English (Third)

CSIR-NML Foundation Day Quiz Competition

FIRST PRIZE	SECOND PRIZE
RR Srivastava and Roshan Kumar	**Vikas Kumar and Minati Sahu**

Vigilance Awareness Week Essay Competition

विषय : भ्रष्टाचार को रोकने के लिए सांस्कृतिक उपाय

Topic : Cultural remedy for preventing corruption

Roshan Kumar
(First)

Amit Prakash
(Second)

Abhishek Kumar Singh
(Third)

Vigilance Awareness Week Poster Competition

विषय : आज का सामाजिक परिवेश का भ्रष्टाचार में योगदान

Topic : Role of present social environment in corruption escalation

Rachit Ghosh (First)

Abhishek Kumar Singh (Second)

Pankaj Kumar (Third)

Vigilance Awareness Week Elocution Competition

विषय : भारत को भ्रष्टाचार मुक्त बनाने में सोशल मीडिया की भूमिका

Topic : Role of social media in making India corruption free

Roshan Kumar (First)

Shekhar Sanga (Second)

Hindi Week Dictation Competition for non-Hindi Speakers

C.R. Chakraborty (First)

Tapan Kumar Shankar (Second)

Mudila Dhanunjaya Rao (Third)

Suchitra Bhatt (Consolation)

Hindi Week Essay-Writing Competition for Hindi speakers

Rohit Mudi (First)

Amit Prakash (Second)

Somnath Das (Third)

Ajit Gangwar (Consolation)

Hindi Week Essay-Writing Competition for non-Hindi speakers

Tapan Kumar Shankar (First)

C.R. Chakraborty (Second)

Suchitra Bhatt (Third)

Rachit Ghosh (Consolation)

Hindi Week Hindi Noting and Drafting Competition for Hindi Speakers

Sudhir Kumar (First)

Rohit Mudi (Second)

Amit Prakash (Third)

Pankaj Kumar (Consolation)

Hindi Week Hindi Noting and Drafting Competition for non-Hindi Speakers

Rachit Ghosh (First)

C.R. Chakraborty (Second)

Tapan Kumar Shankar (Third)

Suchitra Bhatt (Consolation)

Hindi Week Poetry Recitation Competition for Hindi Speakers

Prem Vishwakarma (First)

Roshan Kumar (Second)

D. Bhaskar (Third)

Amit Prakash (Consolation)

Hindi Week Poetry Recitation Competition for non-Hindi Speakers

Tapan Kumar Shankar (First)

Sarita Kandeyang (Second)

Pinky Patra (Third)

Suchitra Bhatt (Consolation)

Special Appreciation Letter and Cash Award to the Personnel who Worked the most in the Hindi Language during the Year 2021-22.

Parmarth Suman

Sudhir Kumar

C.R. Chakraborty

Md. Naeem Ansari

Santosh Kumar Rai

Nandlal Paswan

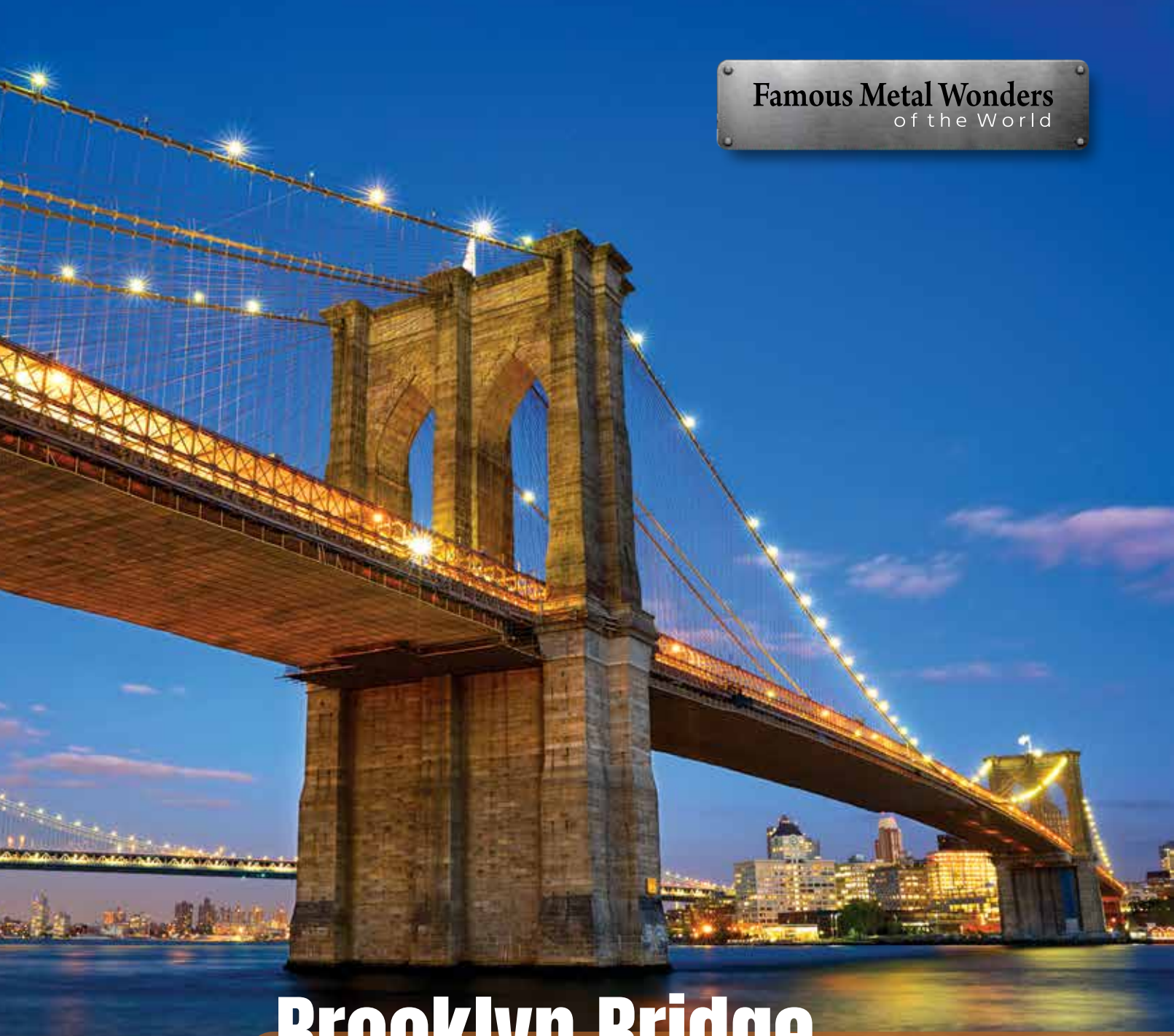
Anil Kumar

Jyoti Kumar

Ravi Ranjan Kumar

Rohit Mudi

G. Dharma Rao



Brooklyn Bridge

- It was the very first steel-wire suspension bridge built in 1869.
- The steel is so thick and construction so challenging, it took a decade to complete. It was also the longest suspension bridge in the world at the time of its opening, with a main span of 1,595.5 feet (486.3 m) and a deck 127 ft (38.7 m) above mean high water.

Sources: wikipedia

Special Days & Events

Cultural Night-n- Grand Feast (3rd April, 2022)

A number of cultural programs viz. Dance, Songs and Skit were organized in which the staff and staff children participated.

Visit of Reliance Industries Delegates (15th April, 2023)

Delegates from Reliance Industries visited various R&D facilities of CSIR-NML for future R&D collaboration.

Town Official Language Committee Meeting (25th & 27th April 2022)

Swachhata Pakhwada-2022 Celebrations (9th -13th May 2022)

A number of events like cleaning of all residential and office campuses, competitions for staff and staff children were organized as part of the celebrations like Sit & Draw, Essay writing and Extempore. The closing ceremony was graced by Mrs. Debarati Chattoraj and Mr. Sanjay Choudhury, Blood Bank, Jamshedpur as Chief guest and Distinguished guest respectively

National Technology Day Celebrations (11th May 2022)

The occasion was celebrated on virtual platform. The technological development of the laboratory was showcased and the success stories about reaching from laboratory to market, for the recently commercialized technologies were also presented during the ceremony.

International Day of Yoga-2022(21st June, 2022)

International Day of Yoga was celebrated at all campuses of CSIR-NML. A lecture was organized on the occasion. Mr. Rajeev Nair, Coach, Cricket, Tata Sports Complex, Tata Steel, Jamshedpur and Director Indian Institutte of Yoga and Management, Haryana delivered a lecture on “Importance of Yoga for a healthy life”.

Covid-19 Vaccination Drive @CSIR NML (1st-31st August, 2022)

Independence Day Celebrations 2022

The flag hoisting program was held at all official and residential premises of CSIR-NML. Various events for staff, staff children and staff families were organized to mark the event like poetry competition, competitions for ladies, drawing competition, football match, marathon and cultural events. The winners of various competitions were also awarded during the main function.

CSIR-Jigyasa Program- Virtual Lab Integration (18th August 2022)

NML visit by students of SSVM School Chandil

10th Prof. S. N. Sinha Memorial Materials and Metallurgy Quiz (SNSM3Q-2022)(23rd August, 2022)

The Indian Institute of Metals (IIM), Jamshedpur Chapter along with CSIR-NML organized the event titled "Professor S.N. Sinha Memorial Materials and Metallurgy Quiz (SNSM3Q-2022)". The primary purpose of this event was to create awareness about the role of materials science and metallurgy in industrial and technological developments amongst Standard XI and XII students of schools in and around Jamshedpur.

Inauguration of Technology Park for Women and Innovation Cell at NIAMT, Ranchi

Central Education Minister Honorable Madam Annapurna Devi was the chief guest. The centers have been opened jointly by CSIR-NML and NIAMT under the DST project on Women Technology Park.

एनआईएमटी - वीमेन टेक्नोलॉजी पार्क व इनोवेशन सेल का उद्घाटन

महिलाओं के लिए हर वर्ष दो नए शॉर्ट टर्म ट्रेनिंग प्रोग्राम शुरू होंगे

तीन वर्ष में 6 कोर्स के जरिए दी जाएगी महिलाओं को ट्रेनिंग

एनआईएमटी-एनएमएल मिल देंगे कौशल शिक्षा

अन्नपूर्णा ने कहा, महिलाएं ट्रेनिंग से आर्थिक रूप से आत्मनिर्भर बनेंगी

ऑफिसहुन या ऑनलाइन अलाई करने की सुविधा

महिला उद्यमिता को बढ़ावा देगा वीमेन टेक्नोलॉजी पार्क

स्टाफ रिपोर्टर • रांची

वह होगा खास

Healthcare Lecture (8th September 2022)

A lecture on "Breast Cancer: Self Examination & Early Detection" by Dr. Natasha Das, Cofounder and Director of Hazlo Consultancy Pvt. Ltd. was delivered at CSIR-NML in hybrid mode.

Contract Bridge Pairs Championship (11th September 2022)

Vishwa Hindi Diwas 2022 (14th September 2022)

Hindi Lectures were organized on the occassion of "Vishwa Hindi Diwas".

Hindi Week Celebrations-2022 (1st-7th September 2022)

Theme : Importance of Hindi language in the development of the nation.

A number of programs and events were organized during the program like Essay Competition, Poetry Recitation, Hindi Drama and Noting Drafting Competition.

CSIR Foundation Day Celebrations (26th September, 2022)

A number of events were organized to mark the 81st CSIR Foundation Day. The main function was celebrated at the laboratory having Prof. Tanusri Saha-Dasgupta, Director Satyendra Nath Bose National Centre for Basic Sciences as the chief guest. Dr. Indranil Chattoraj, Director-NML and Mr. Rajkumar Droach, Sr. CoFA were amongst the dignitaries present on dais. The chief guest delivered the CSIR Foundation Day Lecture along with presenting awards to the meritorious staff children and staff completing 25 years of service in the lab. The dedicated services provided by the superannuated staff to the laboratory, during last two years, were also recognized and appreciated. The CSIR-NML Annual Report 2021-22 was also released by the dignitaries, on the occasion.

Visit of Shri Chetan Prakash Jain, Financial Advisor, CSIR (28th September 2022)

Visit of Delegation from CSIRO, Australia

Vigilance Awareness Week 2022 (31st October - 6th November 2022)

The occasion was celebrated with many programs as essay, elocution and poster competitions on related topics. A lecture on "Corrosion free India for a developed nation" was also delivered by Mr. Binay Kumar Kar, Ex. Sr. COA, CSIR-IICB.

Ayurvedic Medical camp and lecture (14th October, 2022)

To commemorate the 7th Ayurveda Day, an Ayurvedic Medical Camp and free distribution of medicines was organized. The speaker of the lecture was Dr. Balaji Potbhare, R.O(Ay), Nodal Oflicer and the topic was "Ayurveda for mental well-being".

Fit India Freedom Run 3.0 (29th October, 2022)

The event was organized by the laboratory under the banner of Fit India Movement. Staff members and their families participated in a large number.

CSIR-NML Foundation Day Celebrations (26th November, 2022)

CSIR-National Metallurgical Laboratory celebrated its 73rd foundation day on 26th of November, Saturday. The main function started with the lamp lighting ceremony by the dignitaries on the dais. CSIR-NML song was also played on the auspicious occasion. Professor T N Singh, Director, IIT Patna graced the occasion as the chief guest. He delivered the Foundation Day Lecture on the topic E-Waste Recycling. A number of awards were customarily presented by the chief guest to the staff for their outstanding contribution in technical and non-technical areas as well as to the meritorious staff children for their various achievements in the year 2021. The awards included V.A. Altekar award for the best technology licensed or commercialized, B.R. Nijhawan Award for the best paper published, Prof. S.P. Mehrotra award for the best colloquium speaker and Prof. Shilowbhadra Banerjee award for the best in-house project completed during the year 2021, Prof. P. Ramachandra Rao award for the best employee in Technical/ Non-Technical Category during the year 2021 and several meritorious awards to NML staff children in various categories. The constitution day pledge was undertaken by the NML Staff and Guests on the day."

On the occasion, CSIR-NML signed MoUs with Industry and Academic institutions to carry out collaborative research in futuristic R&D areas and solving current & future industrial R&D problems. MoUs for academic collaboration were signed with IIT Patna and IIT (ISM) Dhanbad for enhancing joint student mentoring and undertaking joint R&D projects of mutual interest. This collaboration aimed to organize joint seminars/conferences/ workshops as well as to provide better exposure and access to available state-of-the-art equipment to the students to pursue their higher studies. This would also fulfil the Skill India objectives of Government of India. Industry partners including SAIL (Bokaro), NTPC, Vedanta Pvt Ltd, Jamipol (Jamshedpur) and Diva Envitech, Pune also signed MoUs with CSIR-NML to collaborate in various fields of mutual interest, to find novel solutions to the industrial problems and to develop technologies. CSIR-NML joined hands with NTPC to enable studies related to the residual life assessment of important parts of the boiler and turbines in power plants. Vedanta Pvt Ltd and CSIR-NML have agreed upon to work together for the development and scaling up of

the laboratory level technologies to industrial level. While the agreement with SAIL focused on developing technologies, which decrease the carbon footprint and greenhouse gas emission from steel plants. These collaborations will also ensure that research on sustainable technologies are also focused. The successful collaboration of CSIR-NML with academic and industrial partners is the need of the hour and will play a major role in the development of the nation.

General Collaboration with IIT, Patna

General Agreement with NTPC Limited (NTPC), New Delhi.

Collaboration for R&D in Mutual Interest Areas (Umbrella) with Vedanta Pvt. Ltd.

General Agreement with Steel Authority of India Limited-Bokaro Steel Plant, Bokaro.

General Agreement with IIT-ISM, Dhanbad.

R&D in the Areas of Mutual Interest With Diva Envitec Pvt. Ltd., Mumbai.

General R&D Collaboration with Jamipol, Jamshedpur

Republic Day Celebrations 2022

Visit of DG-CSIR (03rd March 2023)

Visit of Dr. N. Kalaiselvi, DG,CSIR and Secretary, DSIR .

Women's Day Celebrations @ CSIR-NML

The occasion was celebrated with many programs. A medical test camp was organized for the Janitorial and other Contractual female staff at the lab. In the main function distinguished ladies from various fields were felicitated and a Fun and Food fair was organized for staff and staff-families.

Technology Transfer and Memorandum of Understanding Signing Events (17th May 2022)

Transfer of Technology for Flawguard: A device for real time defect detection of high end wires. (//todo date)

Transfer of Know-How for the Recovery of Li, Ni, Mn, Co from spent Lithium-ion Batteries (Know-How Transfer) to ReCy Energy Pvt Ltd, Pune. (25th May 2022)

Development of optimized methodology for hot rolled TWIP steel plates (10mm thickness) (Sponsored) for Surgiwear Ltd., Shahjahanpur. (13th May 2022)

Collaboration for R&D in the areas of recycling with Vardhman Auto Recycling, New Delhi on 16th August 2022.

Webinars/Seminars/Conferences/Workshops

Webinar on "ROLE OF IPR IN INNOVATION ECOSYSTEM" (26th April 2022)

The Webinar was organized by CSIR-NML, IP Facilitation Center, Jamshedpur in association with CTTC-WIPO-TISC CENTER, BHUBANESWAR as a part of celebrations of the "World Intellectual Property Day".

Webinar on "Great Metallurgical Legacy of India through Ages" (26th May 2022)

"Azadi ka Amrit Mahotsav" was celebrated in association with Vigyan Bharti, Jharkhand Chapter. A number of experts on the subject participated in the event, to name a few Dr. Indranil Chattoraj, Director, CSIR-NML, Prof. Indranil Manna, Vice-Chancellor, BIT-Mesra, Ranchi, Prof. S. Basu, Director IMMT Bhaubaneshwar, and Dr. N. Ishwara Prasad, Director-DMSRDE.

Workshop on Matlab application (13th December 2022)

A workshop on MatLab applications by the representative from MathWorks was organized at CSIR-NML.

Workshop on "Materials for Energy and Sustainability" (20th January 2023)

The National Academy of Sciences (NASI), Jharkhand Chapter in association with CSIR-National Metallurgical Laboratory (CSIR-NML), Jamshedpur organized a one-day "Workshop on Materials for Energy and Sustainability" at CSIR-NML. The event has been envisaged to deliberate on the various frontiers of material types, property, structure, and applications in energy generation, storage and sustainability; and others.

International Conference on "Corrosion and Coating (i3C)" (7th-8th December 2022)

Indian Institute of Metals (IIM) Jamshedpur Chapter, in association with Tata Steel Ltd, CSIR-National Metallurgical Laboratory and NIT Jamshedpur organized the conference at CSIR-NML. Around 250 participants were present in the conference.

Trainings Organized

Corporate Skill Training Program (9th -13th May 2022)

"Exposure training on metallic pipes (ETMP)". A total of 10 Graduate Trainees attended the program.

Societal Skill training program (17th May - 16th June 2022)

Internship training on innovation productivity prototype making (IPPM 2022). A total of 46 Diploma students attended the program.

Corporate Skill training program (23rd - 26th May 2022)

Minerals & Coal Characterization (MMC 2022). A total of 6 Graduate Trainees attended the program.

Societal Skill training program (28th June - 01st July 2022)

Training on "Animation Video Making". A total of 32 participants attended the program.

06th June 2022- 05th July 2022

Internship Training on Innovative Product Prototype Making (IPPM 2022) Batch II for Graduate. A total of 146 participants attended the program

14th June 2022- 30th July 2022

Industrial R & D Training on Materials and Metallurgical Engineering (ITMME2022) for Undergraduate. A total of 70 participants attended the program

Popular lecture series

A lecture on decontamination of drinking water was organized on 25th August 2022 by CSIR-NML.

Trainings Organized by CSIR-NML

Jigyasa 2.0 (Integrated Skill Development):

The Integrated Skill Initiative Program, Jigyasa 2.0 - (Computer 3D Printing product development (C3PD)/ Handmade Paper Products) under project DST Women Technology Park was held from 10-Sep, 2022 to 02-Feb, 2023 and 14-Nov, 2022 to 13-Jan,2022 for 10th students (number of trainees = 60).

Jigyasa (Skill Development)

The Internship/ Summer Training was held under the Project "CSIR-Integrated Skill Initiative" from 1st March 2023 to 30th April, 2023 for B.Tech students.

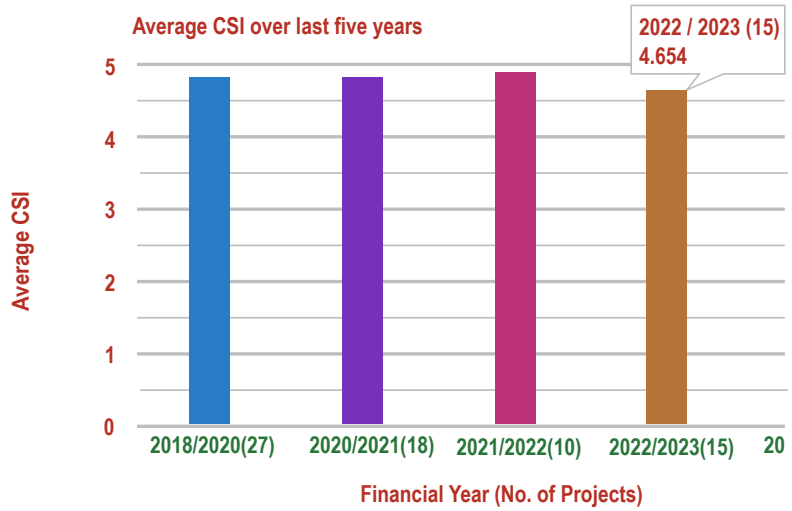
Jigyasa 2.0 (Integrated Skill Development)

The Integrated Skill Initiative Program, Jigyasa 2.0 - (Hands on experiment on water splitting for green hydrogen production / Innovative Product prototype making) was held from 28-Dec,2022 to 27-Jan,2023 and 04-Jan,2023 to 03-Feb,2023 for (B.Sc / B.Tech) students (number of trainees = 25).

Jigyasa 2.0 (Integrated Skill Development):

Jigyasa 2.0 Programme: Virtual Lab Integration - One Day NML Visit by (S.E. RLY Mixed High School, St. Jhoshep High School, Buddha Academy School students) was held on (10-Jan / 12-Jan / 18-Jan,2023) (number of trainees = 154).

Customer Satisfaction Evaluation & Feedbacks



Good support from PL;

Very Good;

Very satisfied with the overall output, Good work done, just delayed due to COVID situation.

Excellent team work Special thanks to Dr. Abhilash and team.

-Tata Steel Ltd. (SSP 1244, SSP 1291, SSP 1225, SSP 1176)

The testing live pictures and other videos shall be shared with report for better understanding of procedures and equipment availability very supportive team

-Arcelor Mittal Design and Engineering Centre Private Ltd. (SSP 1295)

Very Good

-Uttam Value Steels Ltd. (SSP 1324)

Excellent NML stands to its mark.

-Godawari Power and Ispat Ltd. (SSP 1331)

The R&D results reported have met expectations of the Company

-Sandur Manganese & Iron Ore (SSP 1330)

The project was executed in a very professional manner.

- ECOLAB (SSP 1289)

We are happy with the tests being carried out in NML and hope to carry out more in future It will be better, if we can carry out tests for protective coating as per ISO 12944-6-2018 and ISO 20340.

- Vision Craft Industries India Pvt. Ltd. (SSP 1239)

The project to recover valuables from waste PCB in an organized and environment friendly manner is commendable. We are overall satisfied with the process.

-M/s. Metaroe Recycler Private Ltd. (SSP 1273)

Excellent

-MOIL Ltd. (SSP 1180 & SSP 1179)

It was an excellent experience with Dr. Jha and his team. The technology transfer went smoothly. Every aspect of the technology was explained to us in details to help us commercialize this technology with confidence. We are certain that we will sign new MoUs, for other technologies.

-Recyclib Private Limited (SSP 1309)

The overall experience was very good. We are already running one more project with this team and are expecting to have more collaborations in coming future. Great work team NML!! Special thanks to Dr. K. D. Mehta jee and Dr. Ranjeet !! Great support. Thanks and Regards Piyush

- ECOLAB (SSP 1276)

Everything satisfactory only due to some issues there was delay in few sample reports.

-SGS India Pvt Ltd (SSP 1166)

Fortune 1000 and ET 500 Clients (2022-2023)

TATA STEEL

GEOLOGICAL SURVEY OF INDIA

DRDO

Coal India Limited
A Maharatna Company

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MINISTRY OF SCIENCE AND TECHNOLOGY

INDIAN RAILWAYS

इस्पात मंत्रालय
MINISTRY OF STEEL

सेल SAIL

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MAHAGENCO
Maharashtra State Power Generation Co. Ltd.

KMML
The Kerala Minerals & Metals Ltd.

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ATOMS IN THE SERVICE OF THE NATION

GMDC
FUELING THE GROWTH

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MoU signed between CSIR-NML and Recyclib Pvt. Ltd.. Delhi for e-waste recycling technology

JHARKHAND'S OWN ENGLISH DAILY

THE AVENUE MAIL

CSIR-NML inks 7 MoUs with industry and academia on 73rd foundation day

Five day Corporate Training Programme by CSIR-NML gets underway

Recyclib inks MoU with NML for e-waste recycling tech transfer

Mail News Service

Jamshedpur, Feb 28: Recyclib Private Limited, New Delhi signed an MoU with CSIR-NML for recycling technology of electronic waste.

The MoU will facilitate technology transfer of recycling of lithium ion batteries (LIBs) to recover metal or salts of Li, Co, Mn, Ni, Cu, Al, graphite and valuable plastics.

Technological know-how is a chemical design to recover Li, Co, Mn, Ni, Cu, Al, plastics and graphite from black cathodes material of spent LIBs. Developed process flow-sheet to recover Li, Co, Mn, Cu, Ni as metals salts and graphite from spent LIBs will be fine tuned by the samples supplied by the PARTY. The party will commercialize the technology as per the mutualized Know-How of CSIR-NML.

It is well known in past, CSIR-NML has transferred a number of technologies to a national mineral industries and research organizations. M/s Recyclib Pvt. Ltd., Delhi will process the LIBs and extract the non-ferrous metals viz Li, Co, Mn, Cu, Al, Ni, etc. and a part of that they will recycle all the materials present in it based on zero waste concepts.

On this auspicious occasion, Dr. Sudhan O Chatterji, Director CSIR-NML, Dr. Manoj Kumar Jha, Project Leader, e-waste recycling activities, Dr. Sanjay Kumar, Head MER, and a group of researchers Dr. Pankaj Kumar Choubey, Dr. Rabita Pandey, Mr. Om Shankar Dinkar, Ms Bakshima Parveen and from the RPHD side, Dr. S. K. Pal, Head, RPHD and Dr. Barun Kumar, were altogether present. Dr P.N. Mishra actively participated to bridge the NML with the media for advertisement and dissemination of e-waste recycling technology to the society.

Mohit Garg, Director, M/S Recyclib Pvt. Ltd. Company, Delhi has entered into a technology transfer MoU with CSIR-NML, Jamshedpur concerning the improvement of LIBs recycling in the present scenario. The recovered metals will fulfill the demand-supply gap of Li, Co, Mn, Ni, Cu, etc. Statement of Mohit Garg, "Pan-very pleased to be a part of CSIR-NML by taking the LIBs recycling technology to serve the nation by making pollution free society as well as conserve the natural resources for generations to come".

The NML director said, "In the recent past, NML has transferred a number of technologies to Indian companies and hope in future we can transfer more to make India an e-waste free society".

On this occasion, Dr. Sanjay Kumar, Head MER division expressed his disappointment and said, "NML will transfer more technologies in near future"(IW-an

गोवा के विद्यार्थियों ने किया एनएमएल विजिट

एनएमएल की तकनीक से बनेगा ई-वेस्ट रिसाइक्लिंग प्लांट

MNPS students visit NML, gain firsthand experience of research environ

एनएमएल में मनाया गया अंतर्राष्ट्रीय महिला दिवस

CSIR-NML initiates two day training on welding and non-destructive evaluation of joint quality

एनएमएल और रीसाय एनर्जी के बीच हुआ करार

खराब मोबाइल से सोना-चांदी निकालने की तकनीक जानी

CSIR-NML MoU with Recy Energy Pvt Ltd for recycling scrap, used LIB

एनएमएल व रीसाय एनर्जी प्राइवेट लिमिटेड के बीच एमओयू

Five day Corporate Training Programme by CSIR-NML gets underway

एनएमएल में रिसाइक्लिंग के साथ किया ई-वेस्ट रिसाइक्लिंग पर काम

A Workshop on VIDEO conf... by CSIR-National Metallurgical Laboratory, Jamshedpur

एनएमएल एवं एनएसआई ने राष्ट्रीय विज्ञान दिवस समारोह मनाया, शिक्षक पुरस्कृत

एनएमएल म मनाया गया अतर्राष्ट्रीय महिला दिवस

Acknowledgment

We sincerely thank all who have extended their generous support, advice and help, in the preparation of the Annual Report 2022-2023. The effort of each and every person who has contributed in the making of this report is hereby acknowledged. We are grateful for the timely submission of data and for the support provided by the scientific and technical staff, Heads of various Divisions, Administration, Finance and Accounts and Stores & Purchase. We are gratified by all your efforts to go beyond your individual problems at hand and work towards achieving the broader, organizational goal to prepare and release this report on time. You have made our job easier and results more effective. Last but not the least, we are grateful to M/s. Kailash Printers for the timely publishing of this good quality Report.

Giving us feedback, keeping in touch :

We want to hear from you, whether it is a constructive suggestion or a critical observation or any other feedback that you have about this Report.

Please contact us at +91-657 2345209/ director@nmlindia.org

Or stop in at CSIR-National Metallurgical Laboratory,
Jamshedpur, Jharkhand, India-831007.

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सीएसआईआर
CSIR
भारत का नवाचार इंजन
The Innovation Engine of India

CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, India

Phone : 91-657-2345028 /2345000-001, Fax : 91-657-2345213

e-mail : director@nmlindia.org, Website : www.nmlindia.org

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वार्षिक प्रतिवेदन
Annual Report
2022-23

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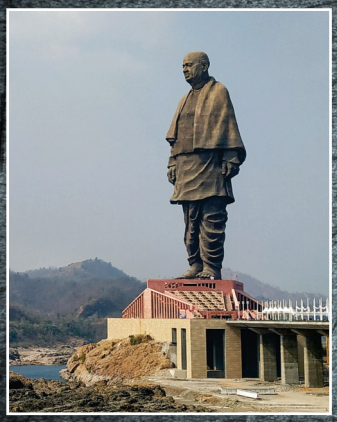
CSIR
भारत का नवाचार इंजन
The Innovation Engine of India

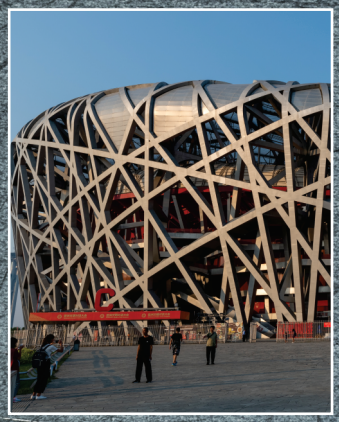
CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, India

Famous Metal Wonders *of the World*

Several splendid constructions in the world have been built from metals such as steel, iron and copper in entirety or a crucial part of it. These have became famous tourist attractions as well. This book treasures some of the most iconic bridges, buildings, statues, and monuments across the globe.





Sources: wikipedia

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"I was very impressed in my visit to NML which was my first visit to Jamshedpur itself. On a very short interaction, I got a glimpse of the very active activities of NML. I have planned for the next visit along with my colleagues to set up collaboration".

Tanusri Saha-Dasgupta

28/09/2022

CSIR-National Metallurgical Laboratory

The Inception

The foundation stone for National Metallurgical Laboratory was laid by Hon'ble Sri C. Rajagopalachari on 21st November, 1946. It was formally inaugurated and dedicated to the nation on 26th November, 1950 by Pandit Jawaharlal Nehru "in a spirit of hope and in a spirit of faith in the future'. The laboratory was an element of Sir Shanti Swaroop Bhatnagar's vision of providing India with a network of research institutions for taking the country ahead in science and technology. CSIR-NML played a significant role in the industrial revolution of India starting from 1950 especially in the areas of mineral processing, iron and steel making, ferroalloys and extraction of non-ferrous metals, notably magnesium. Asia's largest creep testing facility was also set up at CSIR-NML in the early 1970s and even today it ranks as the second largest creep testing lab in Asia.

".....But when I come to Jamshedpur it is not the past of India that comes up before me but some vision of the future comes before my eyes."

"I do not wish any worker to come to these laboratories merely with the aim of earning his living. What I wish is that our young men and women who come here should have a zeal for working out problems, which would have great consequence. That would give vitality to these Institutes. They should realize that service to science is real service to India - no, even to the whole world - science has no frontiers".

...Pandit Jawaharlal Nehru

Glorious Past

CSIR-National Metallurgical Laboratory (CSIR-NML) is a premier Indian research organisation dedicated to various facets of Minerals, Metals and Materials -science, technology, industrial services and human resource development. Since inception, CSIR-NML has diversified its research areas ranging from extractive metallurgy, alloy development and import substitution, refractory material, development, corrosion studies, mathematical and physical modeling of metallurgical processes, mineral research, advanced materials and materials tailoring, integrity evaluation of critical industrial components, surface engineering and cleaner and sustainable metals production. The Laboratory has made notable contributions in the areas of mineral beneficiation and agglomeration, ferrous and nonferrous metallurgy, alloy development and processing, materials science & engineering and, resource conservation & environment. A historical accounts of past achievements (1950-2010) of CSIR-NML is painted in the Diamond Jubilee commemorative volume 'la vintage metallurgie: 60 years of marriage of science to industry' (http://eprints.nmlindia.org/4360/).

Present Focus

Research & Development

CSIR-NML continues to play a vital role in the quest of the country towards scientific and technological leadership and providing scientific solutions to the industries in the areas of minerals, metals and materials. CSIR-NML is also carrying out major activities for creating awareness among the common masses on issues relating to health, environment, rural technology and sustainable development. With a strong and committed staff having a wide spectrum of expertise and modern facilities, CSIR-NML has completed 70 glorious years of existence and still endeavours to move ahead to meet the challenges of the global economy and reach greater heights. The Laboratory has kept pace with changing research scenarios and needs of the country. In the last few years, greater emphasis is given to industry-sponsored research and, alignment with government program; namely, Make in India, Innovate in India, Strategic sector needs, Swatch Bharat, Societal and skill India, etc. The activities of the Laboratory touch upon several major sectors relevant to the growth of India, including iron and steel, power and energy, oil and gas, automotive, railways, strategic, societal, and others.

CSIR-NML envisions becoming a self-reliant, self-sufficient R&D laboratory by providing feasible and sustainable solutions to the industries in the areas of metals, minerals and materials. The laboratory strives to recreate its niche in the areas relevant for empowering the evolving India via catering to the needs of modern India.

Our Vision Statement

"To become a global leader and an internationally benchmarked laboratory in mineral and metallurgical research and development. To become a self-sustained technology centre in minerals, metals and materials."

Research Council (RC)

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Vice Chancellor,
Birla Institute of Technology, Mesra
Ranchi, Jharkhand

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Tata Steel, Kolkata

Dr. Indranil Chattoraj
Former Director
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Materials Science,
IIT Bombay

Dr. G. Madhusudan Reddy
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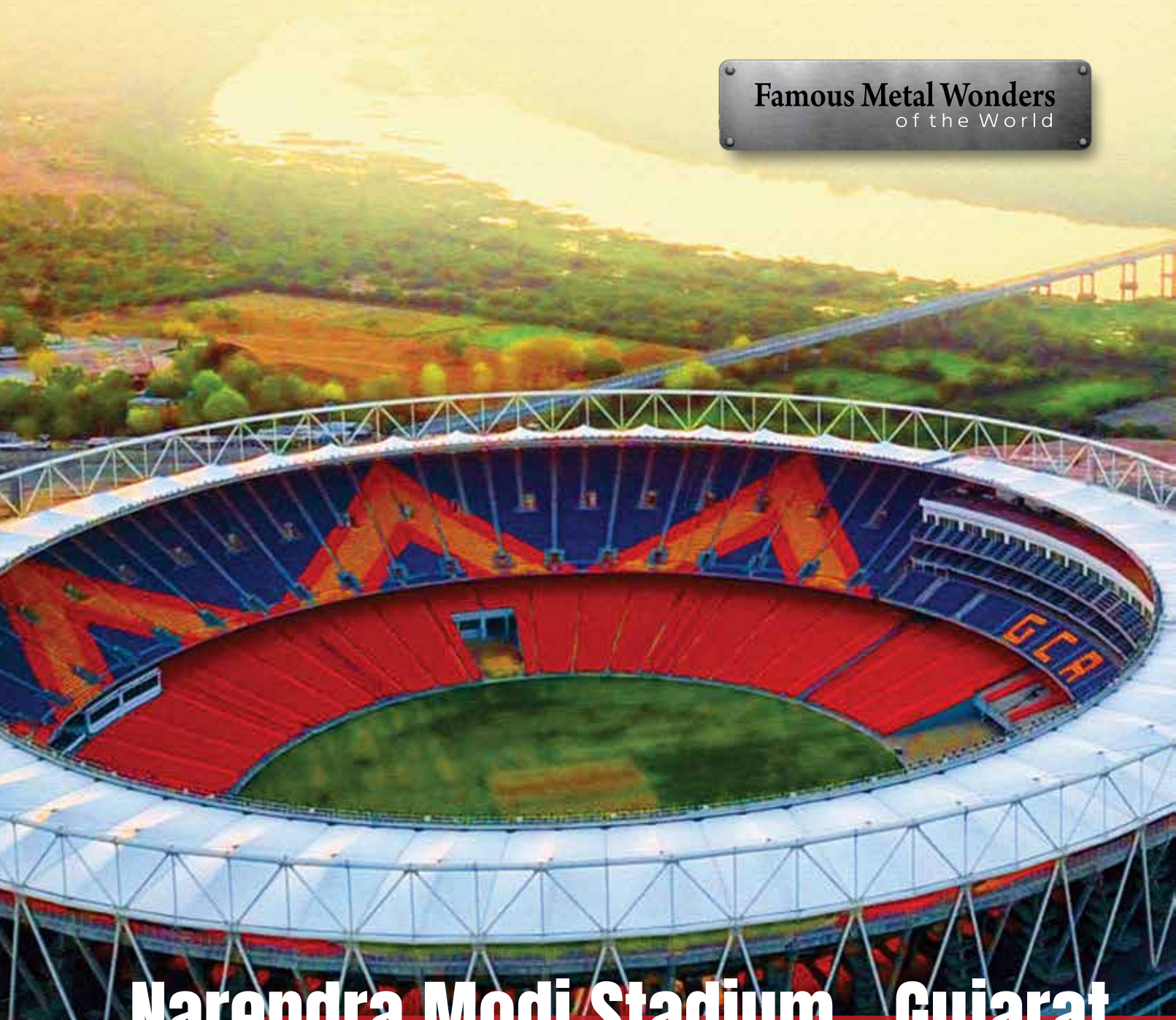
Defence Metallurgical Research Laboratory
Hyderabad

Prof. Jyotsna Dutta Majumdar
Department of Metallurgical and Materials
Engineering,
IIT Kharagpur



Narendra Modi Stadium - Gujarat

- Largest International Cricket Stadium in the world.
- Seating capacity of 132,000 spectators.
- Constructed with 11,000 tons of steel rebars.
- The 13th edition Cricket World Cup 2023, final was played between host nation India and Australia recently at the stadium.

Sources: wikipedia

Foreword

CSIR-NML, a constituent of CSIR laboratories, focuses on excellence, relevance, and sustainability aspects of Research and Development. Thanks to the foresight and vision of its earlier directors and mentors, the laboratory has maintained a consistent momentum of research excellence and relevance. This trend continued in the past year, contributing significantly to the intents of CSIR-NML. The laboratory pursues R&D through various avenues such as contract & grant-in-aid research, technology development & transfer, consultancy and S&T services. The laboratory makes every effort for creating intellectual property (IP) and undertaking collaborative research.

The outputs and outcomes during the year were satisfying. The external cash flow (ECF) generated crossed a total of Rs. 26 Crores in the reporting year, which remained slightly short from our set target of Rs. 30 Crores. This shortfall happened due to non-realization of expected funds for a few major projects. We were able to generate Rs. 22. 74 Crores of industries funds which remained marginally lesser than the set target of 24.0 Crores. Still, it was very encouraging to see that around 76% of our ECF was generated from the industrial sources only. This reflected upon our excellence in delivering industrial solutions. Further, with respect to the generation of intellectual property, 12 Patents and 01 Copyright were filed by our researchers in the reporting period. On the technology front, due to stringent policies in place, none of the developed technologies could complete achieve the desired readiness level (TRL), to be declared as a fully developed and transferrable Technology. In the reporting year, one technology (Know-How for the Recovery of Li, Ni, Mn, Co from spent Lithium-ion Batteries) was transferred to M/s. ReCy Energy Pvt. Ltd., Pune. This success is attributed to the diligence, dedication, and industry expertise of our scientists in both the R&D Division and R&D support divisions. On the front of knowledge generation, the cumulative SCI publications (1986 onwards) from CSIR-NML has increased from 72017 to 77633 registering an increase of about 8%. During last fiscal year, 124 papers were published in SCI journals and 25 were published in Non-SCI journals. The institutional H-index also increased to higher than 120. Two of our technologies were commercialized during the reporting period: 1) Pilot scale flotation column of 200 tpd was installed at Bhelatand Coal Preparation Plant of M/s Tata Steel Limited and 2) Know-how for the recovery of Co, Li, Mn, Cu, Ni, Al, graphite and saleable plastics from waste LIBs was commercialized by M/s. Recyclib Pvt. Ltd., New Delhi. Few of our

flagship projects in the reporting period are: Effective Utilization of Middlings of Coking Coal Washery for Recovery of Carbon Values, Processing of high Ash & high Sulphur containing Lignite Coal from Gujarat, Corrosion behavior of different rail steels in varied environments, Extraction of critical metals form used Li-ion Batteries: A Mission Mode Project under CSIR Bulk Chemicals Mission. For the strategic sector, Space and Navy, we are working upon: Effect of Processing Parameters on Cryo Impact Properties of Cast Alloys, Electronic Packages for Ultrasonic Flow Meter for On-Board Propellant Gauging of Spacecraft, Metallurgical investigation to explore the damage mechanism of worn out quill shaft of aero engine, Destructive test/analysis for establishing life estimation matrix (LEM) boiler tubes.

We created an Intellectual Property Facilitation Centre in 2020 for facilitating the entrepreneurs and MSME for their IPR awareness and filling as well as to support commercialization of NML technologies. Till date, through the centre, 19 webinars, 02 seminars, IPR awareness and training of 1900 people have been organized. So far, 18 trademarks, 03 industrial designs, 05 patents, and 01 copyright have been registered and filed.

Connecting society at all levels and generating scientific awareness in society has always remained a priority for the organization. In this connection, the laboratory participated in a number of programs like: School-NML Interaction Program(SNIP) and Jigyasa. Under the GOI's mission "Skill India", the CSIR-Integrated Skill Initiative program has endeavored to train people in different areas. In the reporting period, more than 300 people were trained in metals, metallurgy, manufacturing, waste utilization, soft skills, and entrepreneurship. Under the DST project "Women Technology Park (WTP)". We have undertaken project on developing Detailed project report (DPR) on common facility centre for silver cluster of West Bengal. Based upon the inputs of Industrial Development Officer (IDO) of District Industry Centre (DIC), artisans, site survey, and discussion with vendors at their site, the intended Detailed Project Report (DPR) has been prepared which contains the basic details of the cluster, benchmark survey, proposed business model, machinery required, bill of quantity for civil estimation, commercial viability and demand and scope for diversification.

I on behalf of my colleagues, wish to express sincere thanks to our valued clients, members of the Research Council, and many other friends and mentors for their ongoing support and guidance.

Director, CSIR-NML

Performance Targets Achieved in 2022 - 2023

	Objectives	Planned	Achieved
1.	Total External Cash Flow (ECF)*	30.0 Crores	26.02 Crores
2.	Industrial ECF (a part of ECF)	24.0 Crores	22.74 Crores
3.	Customer Satisfaction Index	4.9 (Max 5)	4.7
4.	SCI Publications	125	124
5.	Patents	25	12
6.	Copyrights	5	01
7.	Technologies Developed	5	Nil
8.	Technologies Transferred#	5	01

*Cash flow generated from sponsored projects of industrial, PSU and government agencies.

Technology Transferred :

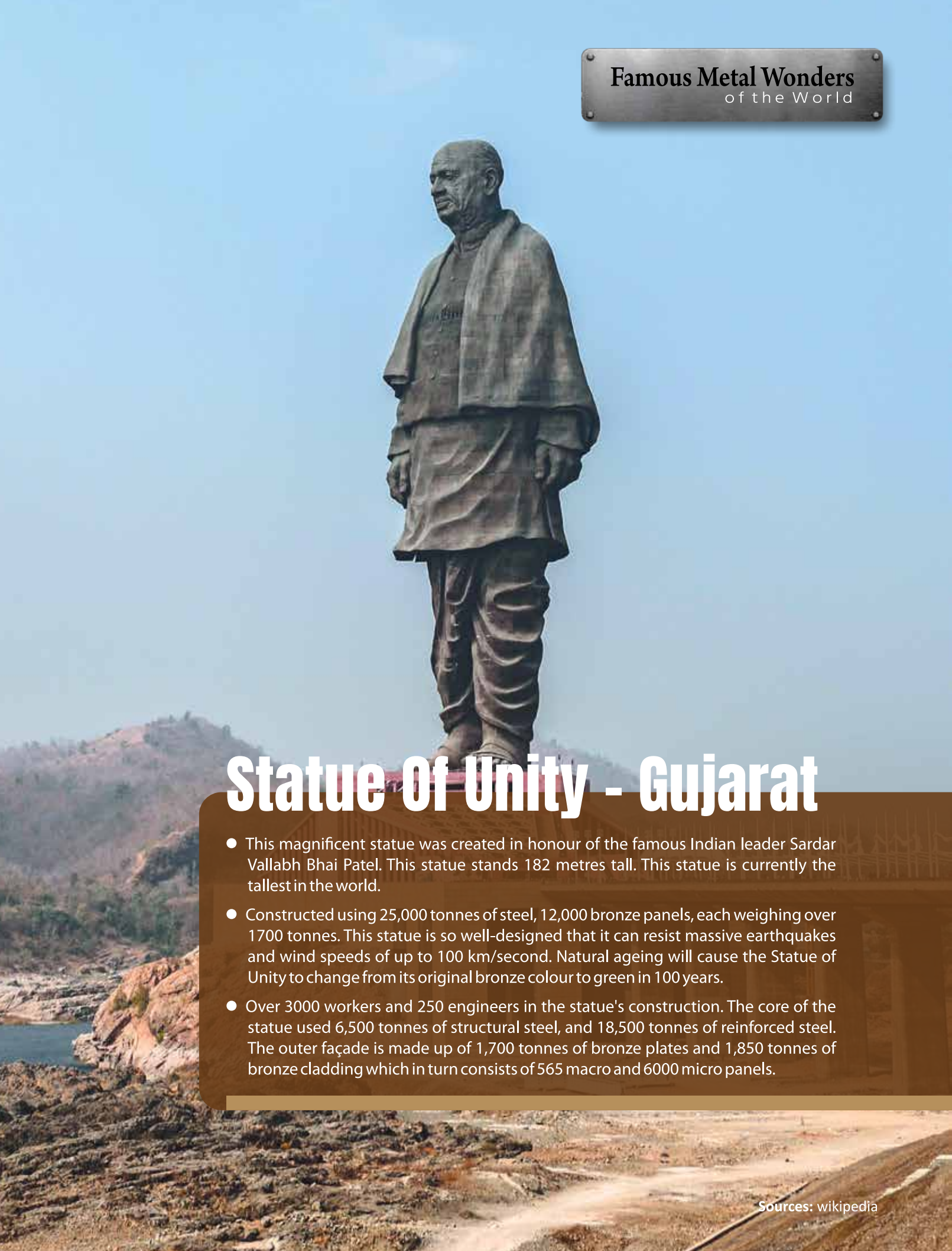
1. Know-How for the Recovery of Li, Ni, Mn, Co from spent Lithium-ion Batteries to M/s. ReCy Energy Pvt Ltd, Pune.

Major Technological & Scientific Targets Planned and Achieved in 2022-2023

Planned for 2022-2023	Achieved in 2022-2023
1. Benchmarking of zinc coated magnesium alloy as bio-implant	Desired corrosion rate (~0.25 mm/year) in simulated body fluid (SBF) achieved. Zn coated Mg alloy samples survived in SBF for 05 months.
2. Scale up of Ti_3AlC_2 (MAX) with purity ≥95% with our indigenous process to 100g scale	Process is scaled up to 200g scale and ready for transfer.
3. Magneto-Impedance Array sensor based device	Magneto-impedance (MI) Array Sensing Device using Nanostructured Material (MagRays)
4. Multi-channel coating weight measurement sensing device	Developed 5-channel system and performance evaluated at one of the renowned Wire mills
5. Scale-up of sol-pre-coating based universal HDPS process for AHSS	Universal Hot Dip Galvanizing Coating Process was successfully developed with optimized continuous process parameters compatible to CGL line using HDPS on Standard Size DP 980 Steel Sheet Specimen of size 12 cm width X 22 cm length X 0.8 mm Thickness

Planned for 2022-2023	Achieved in 2022-2023
6. Production of ferrochrome at pilot scale using 500 KVA submerged arc furnace	• Around 40 tons of ferrochrome has been produced using 500 KVA submerged arc furnace.
7. Technology transfers in the area of E-waste management	• MoU has been signed for the technology transfer in the area of E-waste.
8. Production of magnesium metal (kg scale) using Pidgeon process	• 2 Kg magnesium metal of >98% purity has been produced using modified Pidgeon process.
9. Benchmark data generation for HCF and LCF of Ni base alloys	• HCF data evaluation of Ni base alloys are in progress
10. Piloting Armour steel development, aiming for 2GPa strength and minimum fracture toughness of 50MPam$^{1/2}$ (Min)	• Armour steel with 2 GPa UTS and fracture toughness of 75MPa.m1/2 have developed at lab scale
11. Piloting coal with oily bubble flotation	• Oil-coated bubble flotation eliminate the addition of a collector to the aqueous phase. • Optimized results were obtained with an ash content of clean coal as 13.07 % with a yield of 44.99% from a feed ash of 27.4% for seam 7 coal. • Seam 5 coal study is under progress.
12. Processing of hydrocyclone underflow of grinding circuit towards recovery of silver through advance gravity separator	• Silver content in the sample was enriched from 200 ppm to 1000 ppm with a recovery of 36% using advanced gravity separation techniques.
13. Pelletization of iron ore concentrate using organic binder	• Performance of organic binder developed by NALCO Water Ltd for pelletization was evaluated through the laboratory scale experiments.
14. Effective utilization of middling and fines of coking coal washery for recovery of carbon values	• Process flowsheet has been developed for recovery of carbon values from middlings of the coking coal washeries by spiraling followed by column flotation. Project is in progress.

Planned for 2022-2023	Achieved in 2022-2023
15. Study on Performance Improvement of Coking coal washery through modelling and simulation	• Steady state model has been developed and validated for the Moonidih coal washery. Project is in progress.
16. Coal core analysis and beneficiation ▪ Coal beneficiation through oil agglomeration: Development of process to reduce mineral matter in coking and non-coking coal through oil agglomeration in 1 kg scale. ▪ Referee sample analysis of Coal challenged by different coal industries ▪ Preparation of coke from non-coking and semi-coking coal: Technology for preparation of coke from semi-coking and non-coking coals will be developed in 7 kg scale.	• Achieved and Completed
17. Certified reference materials (CRM) production and proliferation	• Achieved and Developed 5 nos. of new CRMs
18. Online chemical treatment of rebar to improve corrosion resistance	*Plant trail with TATA Steel and JSW Steel is ongoing*

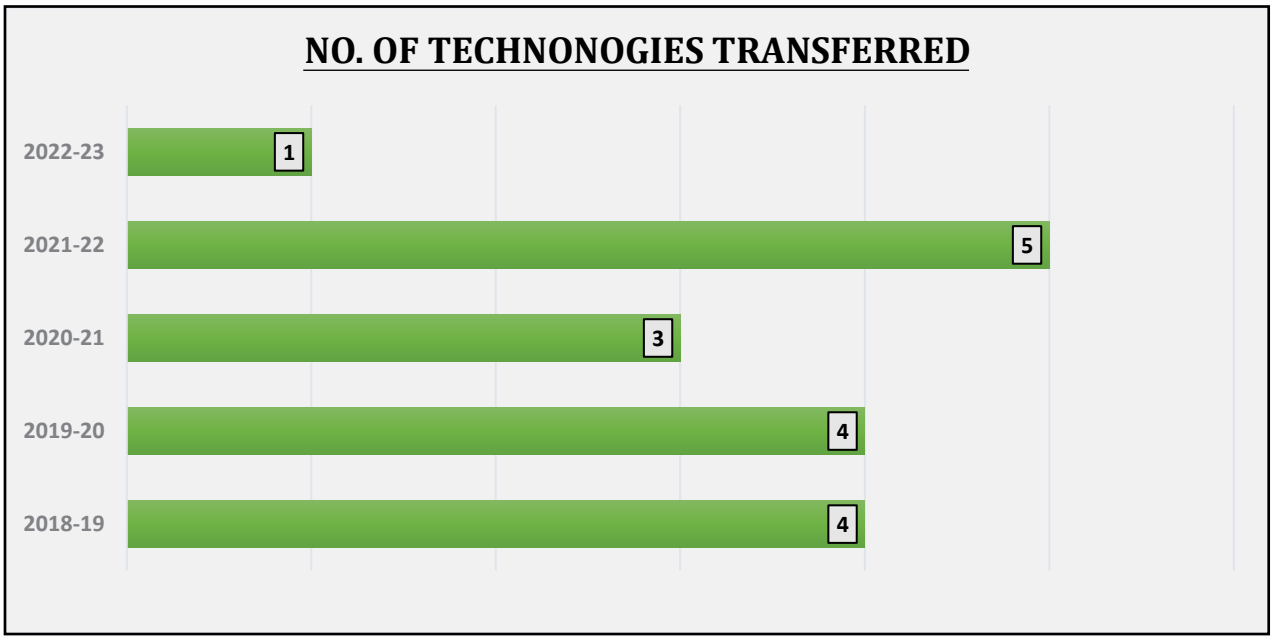


Statue Of Unity - Gujarat

- This magnificent statue was created in honour of the famous Indian leader Sardar Vallabh Bhai Patel. This statue stands 182 metres tall. This statue is currently the tallest in the world.
- Constructed using 25,000 tonnes of steel, 12,000 bronze panels, each weighing over 1700 tonnes. This statue is so well-designed that it can resist massive earthquakes and wind speeds of up to 100 km/second. Natural ageing will cause the Statue of Unity to change from its original bronze colour to green in 100 years.
- Over 3000 workers and 250 engineers in the statue's construction. The core of the statue used 6,500 tonnes of structural steel, and 18,500 tonnes of reinforced steel. The outer façade is made up of 1,700 tonnes of bronze plates and 1,850 tonnes of bronze cladding which in turn consists of 565 macro and 6000 micro panels.

Sources: wikipedia

R&D Output


NO. OF TECHNONOGIES TRANSFERRED
2022-23
1
2021-22
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2020-21
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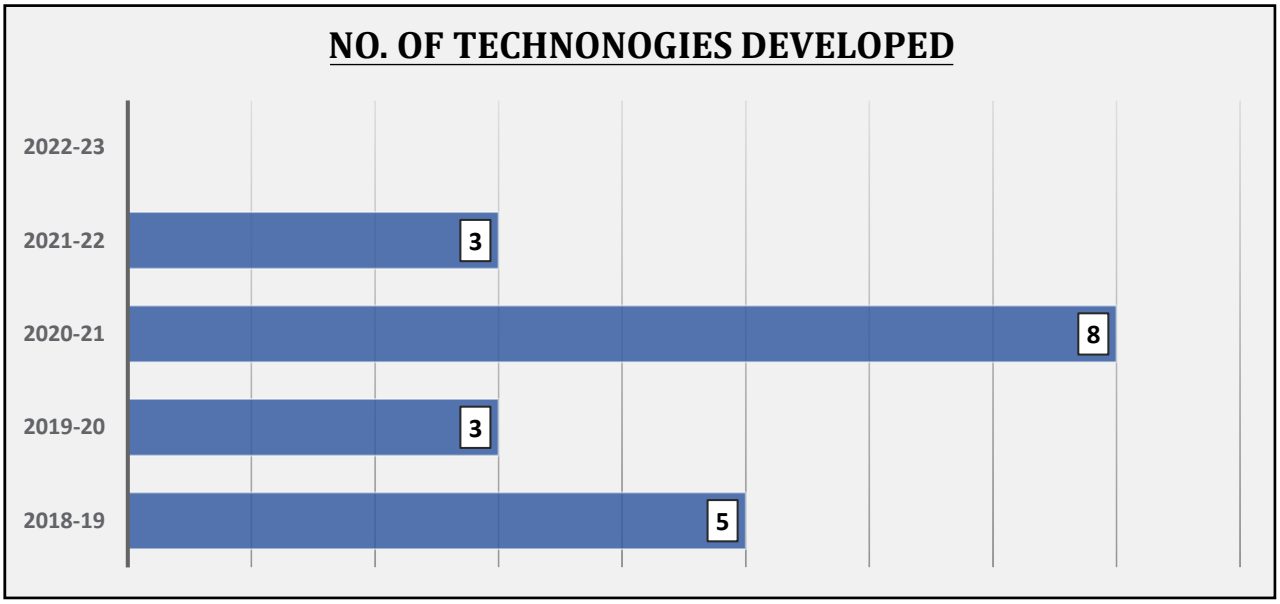
2019-20
4
2018-19
4


NO. OF TECHNONOGIES DEVELOPED
2022-23
2021-22
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2020-21
8
2019-20
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2018-19
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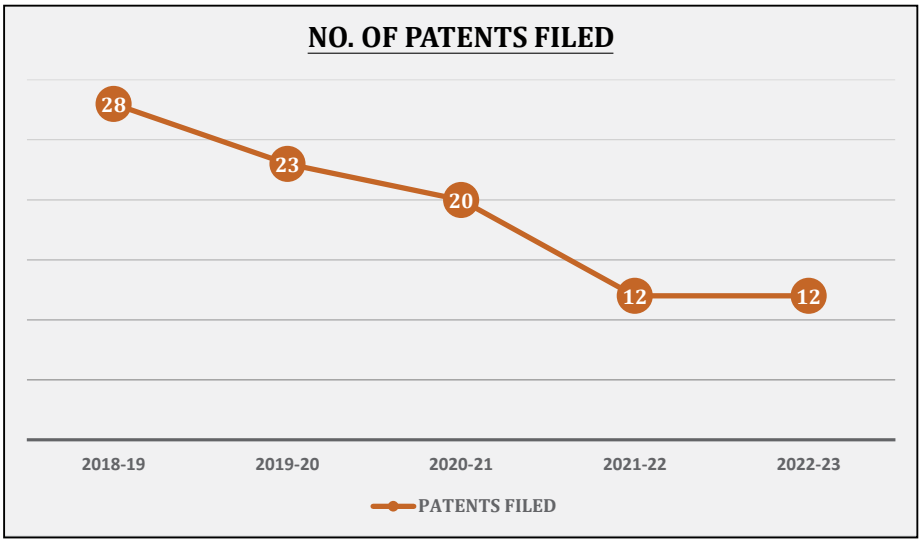
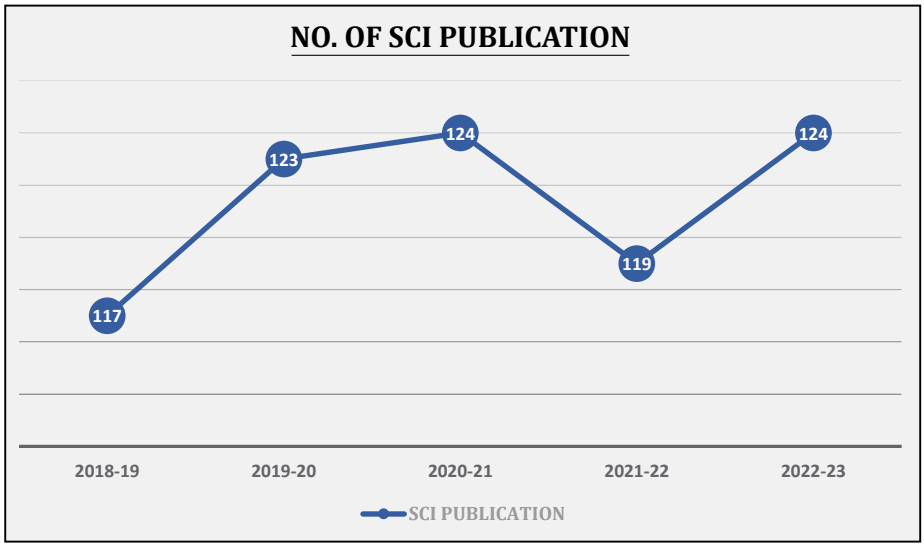
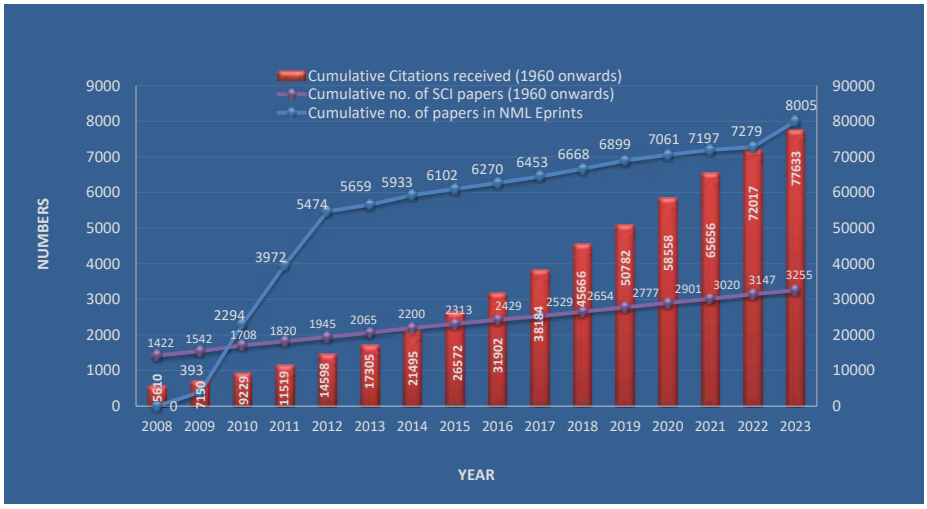






Source : Web of Science / Google Scholar as on 29.09.2023

Impact Making Technologies

Column Flotation Technology

CSIR - National Metallurgical Laboratory (CSIR-NML) has been in the forefront in indigenizing the **'Column Flotation Technology'** for processing lean grade and fine-grained ores for more than three decades. Laboratory scale (74mm diameter) and Pilot plant scale (500mm diameter) flotation columns were designed, fabricated and field tested at various private and public sector mineral processing industries located across the country. Development of column flotation technology achieved **Technology Readiness Level - 9**, implying that it is ready for successful deployment at commercial scale. The USP of CSIR - NML is providing a **'One-stop solution for installation and commissioning of commercial scale flotation columns'** by collaborating and partnering with an EPC company, M/s McNally Sayaji Engineering Co. Limited, Bengaluru and reagents manufacturers and suppliers, M/s Somu Organo-Chem Private Limited, Bengaluru. So far, **5 laboratory scale, 1 pilot plant scale and 8 commercial scale flotation columns were commissioned.**

The column flotation technology is a new mineral beneficiation method developed on strong scientific principles for processing of fine, low-grade ores and minerals. The merits of the technology includes improved metallurgical performance in terms of grade and recovery, effective cleaning of froths, small foot print, low capital investment, less operational and maintenance costs with user-friendly controls. Improved metallurgical performance is due to: (i) Less entrainment and entrapment of gangue in the froth, (ii) Independent control of operating variables, (iii) Froth washing provision and (iv) Control over bubble size – effective in fines collection. The Reduced operating & capital costs is due to: (a) No moving parts & Lower energy consumption, (b) Lower reagent consumption, (c) Substantial reduction in floor area – vertical configuration and (d) One stage of column flotation generally replaces multi-stage conventional flotation.

Column flotation is commercially used all over the world due to its salient features such as better hydrodynamic conditions and froth washing mechanisms that exist in the flotation column which enhances both recovery and grade, compared to conventional cells.

Extensive laboratory scale studies were carried out at CSIR-NML Madras Centre on feed to sillimanite flotation circuit to arrive at the required reagents' dosages, optimum grade, and recovery of sillimanite and design parameters of flotation column installed at M/s KMML.

M/s McNally Sayaji Engineering Limited, Bengaluru, CSIR-NML's engineering partner, executed the supply of all equipment and instruments, fabrication, erection, and integration of all sub-systems consisting of air compressor, air dehumidifier, column shells and conditioners etc.

Technology Package

(i) Flotation reagent development in collaboration with M/s Somu Organo Chem Pvt. Ltd., Bengaluru,

(ii) Flotation column design, engineering, erection, commissioning, stabilization and training in collaboration with M/s McNally Sayaji Engineering Limited., Bengaluru.

Figure 1: Flotation column

Impact on Society

Detailed Project Report (DPR) on Common Facility Centre for Silver Cluster

India is one of the world's largest silver markets, with a very traditional core in a diverse market. In the sculptures and the paintings can be seen the wide range of jewelry worn by king and commoner. It is the traditional cultural heritage of Indian society. The artisans are still following an age-old traditional process for making ornaments. Lack of innovation and modernization paves the way to a variety of problems ranging from raw material to the marketing of products. However, under the changing socio-economic environment, Government and non-government organizations are instrumental in assisting the sector. In order to this, Directorate of MSME, Government of West Bengal is coming forward to help the silver clusters. The artisans of this cluster form a co-operative society named "Jafarnagar Astha Silver Ornaments Artisan's Welfare Foundation".

Based on the inputs from General Manager (GM)/ Industrial Development Officer (IDO) of District Industry Centre (DIC), artisans, site survey, and discussion with vendors at their site as well as at CSIR-NML the intended Detailed Project Report (DPR) has been prepared which contains the basic details of the cluster, benchmark survey, proposed business model, machinery required, bill of quantity for civil estimation, commercial viability and demand and scope for diversification. Infra-facilities proposed for CFC to house the equipment and their accessories which also includes office building, operator's accommodation, boundary.

Figure: Silver thali and ornaments developed at cluster

Skill Development Program:

The Council of Scientific and Industrial Research (CSIR) aligning with the government of India on the "Skill India" mission launched the 'CSIR-Integrated Skill Initiative' program. Under the umbrella of skill India, all CSIR laboratories have taken up various skill training programs under different domains. The purpose of the CSIR-Integrated skill initiative is to generate quality human resources at various levels by providing and upgrading skills in all the possible fields at various levels beginning with school dropouts to Farmers to ITI diploma holders to graduates. From 2017 to 2022, CSIR-NML received fund around Rs. 150 Lakhs from CSIR under 'CSIR-Integrated Skill Training' to provide skill training ranging from basic training for rural youths, summer/winter internship for undergraduate students, M. Tech/Ph.D. dissertation guidance for post-graduate students, apprenticeship training for ITI/Diploma/Graduate engineers and specialized training

for professionals from industries. These training programs vary from a few days to a year in duration. The focus is to develop skills in the area of metals, metallurgy, manufacturing, waste utilization, soft skills, and entrepreneurship development. In FY 2022 – 2023, CSIR-NML trained 691 participants, through corporate training programmes, societal training program, and Others training program. CSIR-NML Conducted 3 corporate training program named Metallography Techniques, Minerals & Coal Characterization (MMC 2022) and Exposure Training on Metallic Pipes for CIPET Officials - (Phase-III)15 Societal training program has been conducted by CSIR-NML i.e. Innovative Product prototype making, Hands on experiment on water splitting for green hydrogen production, NML visit by NIT Jamshedpur, NML visit by Students of Goa Engineering College, Fitter – Mechanical Assembly, Industrial training on materials & metallurgical engineering, Internship Training on Innovative Product Prototype Making (Batch IV), Internship Training on Innovative Product Prototype Making (Batch III), Animation Making Training, Industrial R & D Training on Materials and Metallurgical Engineering, Internship Training on Innovative Product Prototype Making (Batch II), Internship training on innovation productivity prototype making (Batch I), NML Visit by Kazi Nazrul University students. CSIR-NML conducted 4 Others Training Program like M.Tech/ PhD guidance, National Apprenticeship Training, Winter and Summer Internship program. Some of the future plan by CSIR-NML is to conduct Women centric training programs, Entrepreneurship focused training programs, NSDC accreditation for conducting NSDC training program and Trainings to empower rural person.

Metallography Techniques Training

Women Technology Park

CSIR-National Metallurgical Laboratory (NML) in association with the National Institute of Advanced Manufacturing Technology (NIAMT), Ranchi is implementing a Women Technology Park (WTP) sponsored by the Department of Science & Technology (DST). The title of the project is Women Technology Park (WTP) for capacity building and entrepreneurship development at Ranchi and East Singhbhum. The project is approved under the Science for Equity, Empowerment & Development (SEED) program of DST. The project cost is 52.6 lakhs.

The objective of the project is to train rural women in the areas of Waste Management and Carpentry for capacity building and entrepreneurship development. In FY 22-23, CSIR-NML trained 117 women participants in the area of Institutional Waste Management and carpentry. CSIR-NML successfully conducted the following training: Handmade Paper Making, Carpentry and Woodcraft with 3D Design Software, Computer, 3d Printing & Product Development (C3PD).

In the Institutional Waste Management training program, the participants were trained to utilize paper waste & electronic waste. They learned to make handmade paper using waste paper and also learned to make various products from waste paper like earrings, planter covers, bookmarks and key hangers. In addition, participants learned basic computer skills, art & craft skills, professional soft skills and marketing skills.

Along with the above-mentioned training program, under the DST-Women Technology Park project, CSIR-NML organized training on Mental Health, Women Empowerment, COVID-19, Media Literacy, and Professional skills.

Certificate Distribution Program

Art & craft Training

Handmade Paper Products training at Jamtara

Carpentry Training at CSIR-NML

Paper Plate Making

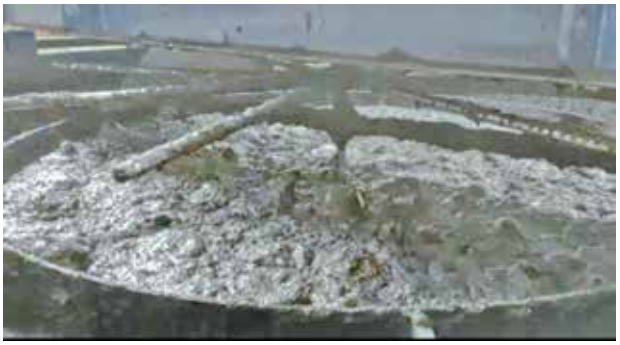
Technologies Commercialized

Column Flotation Technology

CSIR - National Metallurgical Laboratory (CSIR-NML) has been in the forefront in indigenizing the '**Column Flotation Technology**' for processing lean grade and fine-grained ores for more than three decades. Laboratory scale (74mm diameter) and Pilot plant scale (500mm diameter) flotation columns were designed, fabricated and field tested at various private and public sector mineral processing industries located across the country. Development of column flotation technology achieved **Technology Readiness Level - 9**, implying that it is ready for successful deployment at commercial scale. The USP of CSIR - NML is providing a '**One-stop solution for installation and commissioning of commercial scale flotation columns'** by collaborating and partnering with an EPC company, M/s McNally Sayaji Engineering Co. Limited, Bengaluru and reagents manufacturers and suppliers, M/s Somu Organo-Chem Private Limited, Bengaluru. So far, **5 laboratory scale, 1 pilot plant scale and 8 commercial scale flotation columns were commissioned**.

Recently, a commercial scale flotation column of 200 tpd was installed at Bhelatand Coal Preparation Plant of M/s Tata Steel Limited.

Commercial flotation column (200 tpd) at Bhelatand Coal Preparation Plant, M/s Tata Steel Limited



Recovery of fine coal in 200 tpd flotation column installed at M/s Tata Steel, Bhelatand Coal Processing Unit

Sillimanite concentrate recovery from 120 tpd flotation column at M/s Kerala Minerals & Metals Ltd. (KMML)

Recyclib Pvt. Ltd., New Delhi Commercialized the LIBs Recycling Plant Based on CSIR-NML Technology

A license was provided to M/s Recyclib Pvt. Ltd., New Delhi for the commercialization of CSIR-NML's Know-how for the recovery of Co, Li, Mn, Cu, Ni, Al, graphite and saleable plastics from waste LIBs. The recycling plant M/s Recyclib Pvt. Ltd. under the Directorship of Mr. Mohit Garg is ready for commercial production to recover Co, Li, Mn, Cu, Ni, Al and graphite as saleable product from waste LIBs. The plant has established good infrastructure and has latest equipments for the recycling of waste lithium-ion batteries (LIBs). All the equipments are properly installed and connected in a closed-loop for extraction and recovery of metals from waste LIBs. The newly commercialized recycling company is now operational for the production of saleable products of Cu, Ni, Co, Mn and Li from LIBs based on CSIR-NML technology.

Initially, the batteries are discharged in environmental friendly manner, further shredded using the scutter cutter and processed for the separation of black powder, plastics and metallic fractions using wet gravity separation techniques. The black powder obtained is processed for the leaching of metals using chemical processing in closed loop system. The obtained black powder is processed under the optimized condition in a leaching reactor as per the CSIR-NML know-how and optimized conditions. The leach liquor generated is filtered using filter press to separate the solution from the slurry whereas the leached residue (mainly graphite) is further treated and washed to make saleable graphite. The leach liquor is collected in a storage tank and further processed using advance separation techniques. From, the leach liquor the selective separation of Cu and Ni are made using solvent extraction techniques. The obtained purified solution is processed for the recovery of Co, Li and Mn using precipitation, evaporation and electrowinning technique. The recycling plant is successful in view of environmental concern and feasibility with physical processing, hydro- and electro-metallurgical set-up.

MoU signed between CSIR-NML and Recyclib Pvt. Ltd., Delhi for e-waste recycling technology

MoU Signed between CSIR-NML and M/s Recyclib Pvt. Ltd., New Delhi

Demonstration to M/s Recyclib Pvt. Ltd., New Delhi at CSIR-NML

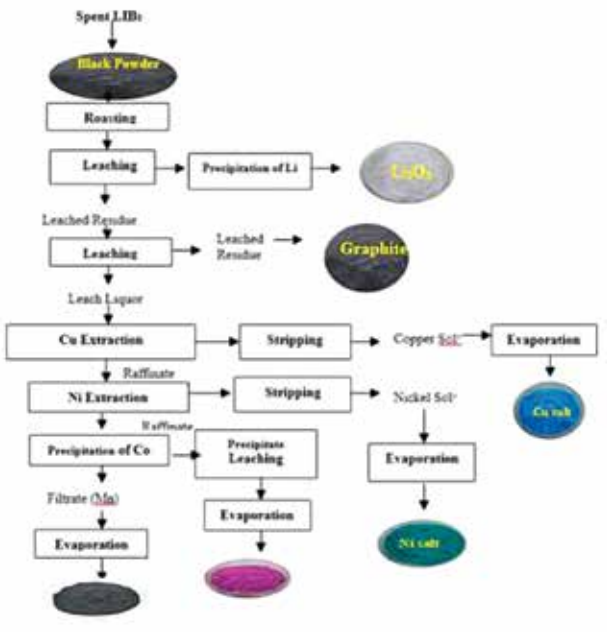
Closed-loop Know-How to recycle spent LitLihium-ion Batteries (LIBs) to produce value added products of Li, Co, Mn, Cu, Ni, saleable plastics and graphite (NILE Li-Cycle Pvt. Ltd., Hyderabad)

Front view of M/s Recyclib Pvt. Ltd., Kashipur, Uttrakhand

LitLihium-ion Batteries (LIBs) to Produce Value Added Products of Li, Co, Mn, Cu, Ni, Saleable Plastics and Graphite (NILE Li-Cycle Pvt. Ltd., Hyderabad)

CSIR-NML transferred Know-how for the recovery of Li, Co, Mn, Cu, Ni, saleable plastics and graphite from waste LIBs to M/s NILE Li-Cycle Pvt. Ltd., Hyderabad. The recycling plant M/s NILE Li-Cycle Pvt. Ltd., Hyderabad under the Directorship of Mr. Kaliprasad is now operational for the production of saleable products of Li, Co, Mn, Cu, Ni, saleable plastics and graphite from LIBs based on CSIR-NML technology.

Initially, the discharged batteries are shredded using scutter cutter machine and processed for the separation of black powder, plastics and metallic fractions using wet gravity separation techniques. Subsequently, leaching of metals from the black powder is carried out by chemical processing in closed loop system in a leaching reactor as per the CSIR-NML technological know-how and optimized conditions. Filtration of the leach liquor is carried out using filter press for the separation of solution from the slurry whereas the leached residue (mainly graphite) is further treated and washed to make saleable graphite. The leach liquor is collected in a storage tank and further processed using advance separation techniques. The obtained purified solution is processed for the recovery of Co, Li, Cu, Ni and Mn using precipitation, evaporation and electrowinning technique.



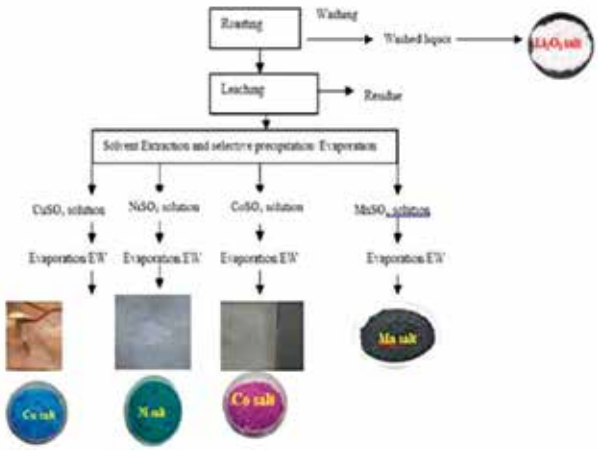
Complete process flow-sheet for the recovery of Li, Co, Mn, Cu, Ni, saleable plastics and Graphite from waste lithium batteries.

Know-How for the Recovery of Co, Li and Mn From Lithium-Ion Batteries (LIBs) with Fine Tuning (Metaore Recycler Pvt. Ltd., Kolkata)

CSIR-NML transferred Know-how to recover Co, Li and Mn from Lithium-Ion Batteries (LIBs) with fine tuning to M/s Metaore Recycler Pvt. Ltd., Kolkata. In this regard, demonstration, training & license were provided to M/s Metaore Recycler Pvt. Ltd., Kolkata.

The recycling plant M/s Metaore Recycler Pvt. Ltd. under the Directorship of Mr. Sourabh Rungta is now operational for the production of saleable products of Co, Li and Mn from Lithium-Ion Batteries based on CSIR-NML technology. The plant has established good infrastructure and has latest equipments for the recycling of waste LIBs. All the equipments are properly installed and connected in a closed-loop for extraction and recovery of metals from waste LIBs.

Initially, the batteries are discharged in environmental friendly manner, further shredded using scutter cutter and processed for the separation of black powder, plastics and metallic fractions using wet gravity separation techniques. The black powder obtained is processed for the leaching of metals using chemical processing in closed loop system. The obtained black powder is processed under the optimized condition in a leaching reactor as per the CSIR-NML technological know-how and optimized conditions. The leach liquor generated is filtered using filter press to separate the solution from the slurry whereas the leached residue (mainly graphite) is further treated and washed to make saleable graphite. The leach liquor is collected in a storage tank and further processed using advance separation techniques. From, the leach liquor the selective separation of Cu and Ni are made using solvent extraction techniques. The obtained purified solution is processed for the recovery of Co, Li and Mn using precipitation, evaporation and electrowinning techniques.



Complete process flow-sheet for the extraction of Co, Mn, Cu, Ni and Li from black powder of lithium-ion batteries (LIBs).

Know-How for the Extraction of Cu, Al and Au from Waste PCBs (Metaore Recycler Pvt. Ltd., Kolkata)

CSIR-NML transferred Know-How for the extraction of Cu, Al and Au from waste PCBs to M/s Metaore Recycler Pvt. Ltd., Kolkata. In this regard, demonstration, training & license were provided to M/s Metaore Recycler Pvt. Ltd., Kolkata. The plant has well established hydrometallurgical infrastructure and has latest equipments for the recycling of waste PCBs. All the equipments are properly installed and connected in a closed-loop for extraction and recovery of metals from waste PCBs.

Initially, the PCBs are dismantled and depopulated. Further, pre-treatment and beneficiation of the depopulated PCBs is carried out to separate, epoxies and metallic concentrate. Hydrometallurgical recovery of Cu from metallic concentrate of PCBs is carried under the optimized condition followed by recovery of gold from the small depopulated components. Aluminum is recovered from the heat exchanger mounted on the PCBs.

The technology is used for the commercial production as per the flow-sheet.

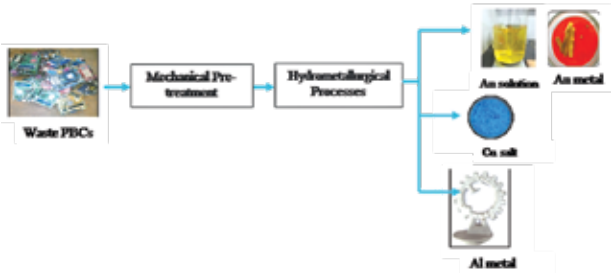
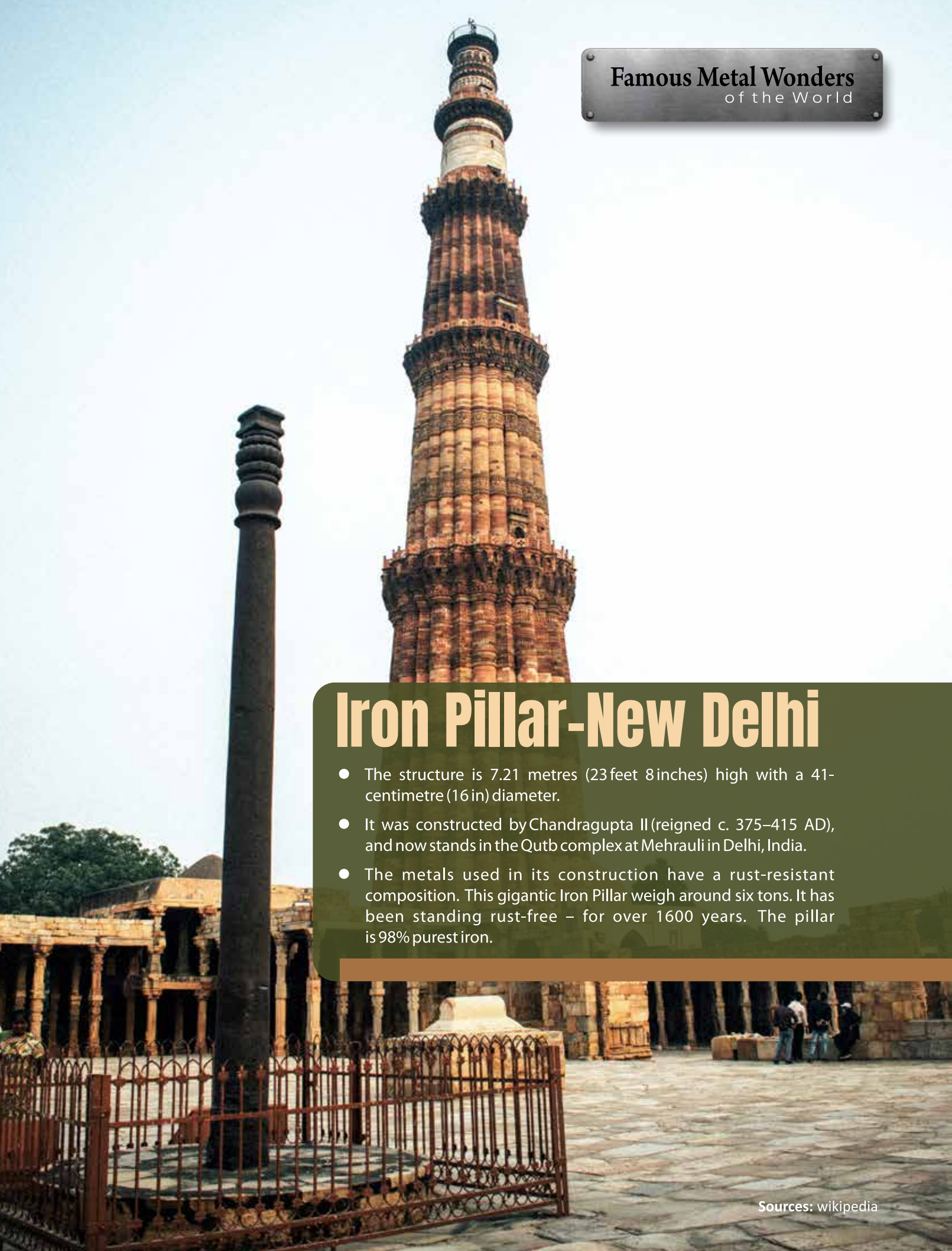


Figure 6: Process flow-sheet for the recovery of metals from waste PCBs



Iron Pillar-New Delhi

- The structure is 7.21 metres (23 feet 8 inches) high with a 41-centimetre (16 in) diameter.
- It was constructed by Chandragupta II (reigned c. 375–415 AD), and now stands in the Qutb complex at Mehrauli in Delhi, India.
- The metals used in its construction have a rust-resistant composition. This gigantic Iron Pillar weigh around six tons. It has been standing rust-free – for over 1600 years. The pillar is 98% purest iron.

Sources: wikipedia

Performance Targets Planned for 2023-2024

	Objectives	Planned
1.	External Cash Flow (ECF)	25.0 Crores
2.	Industrial ECF (a part of ECF)	12.0 Crores
3.	Customer Satisfaction Index	4.9 (Max 5)
4.	SCI Publications	125
5.	Patents	20
6.	Copyrights	5
7.	Technologies to be Developed	5
8.	Technologies to be Transferred	5

Major Technological & Scientific Targets Planned for 2023-2024

Applied & Analytical Chemistry

- A sponsored project from Coal India Limited on "Coking coal assessment through Artificial Intelligence".
- Self-healing coating for corrosion protection of structural steel.
- Benzoic acid reference material for calorimetry /or bomb calorimeter analysis.
- Salvaging Lithium mixed metal oxide and converting into value added product from spent Li-ion Battery.
- Development of alternate reagent for the elimination of mercury effect for reliable analysis of Hg in coal and coal fly ash samples.
- Development of 6063 grade Al disc standard (500Nos.)
- Development of two different grade Pb base disc CRMs (500Nos. of each grade).
- Development of four different grade Chromite ore CRMs (200Nos. of each grade).

Materials Evaluation

- Scaling up of armour steel to achieve TRL-7
- Powder production of superalloys for additive manufacturing

Metal Extraction & Recycling

- Green Steel Making in Induction Furnace/Electric Arc Furnace using Hydrogen based DRI
- To set up pilot scale battery dismantling setup.
- To develop lab scale process for the recycling of discarded solar panels.
- To initiate studies on use of MOF's in post combustion CO2 capture

Advanced Materials and Processes
• Commercialization of the MXene (Ti_3C_2) technology**.** • LTCC based eddy current sensor susceptible beyond 600 °C for real time creep damage monitoring in power plant components. • AI based smart alarm system for predicting critical zone of large industrial structure using embedded FBG sensors. • Integrity assessment of Iron Beams of Konarka Sun Temple. • Predictive model for weld quality assessment based on thermal imaging. • CEMILAC Certification and Patent for Electroplating of Binary Zn-Mn Alloy Coatings from Deep Eutectic Solvents-based Electrolytes (December 2023 onward) • Development of ferrochrome slag coating for continuous steel caster rolls • Development of antimony chalcogenide-based photoabsorber coatings for photovoltaic applications • Development of Zn-Al-Mg based hot dip coating for cold rolled steel sheet (RDCSI)
Minerals Processing
• Pilot scale trials with oily bubble flotation. ❖ Study of Oily Bubble effect on seam 5 coal
• Novel Collector Reagent performance evaluation during flotation of coal ❖ Pilot scale trials with novel reagent and conventional reagent. ❖ Performance evaluation in terms of ash rejection and yield achieved
• Beneficiation of coking coal by hybrid mode: dry and wet processing to reduce the ash forming impurities. (**Ministry of Steel, Two years**) ❖ Dry de-shaling of high ash coking coal to improve the quality of the feed material before wet processing ❖ Dry beneficiation at coarser size using Air fluidized vibrating deck separator (AVFD) to generate pre-concentrate before subjecting to wet methods. ❖ Wet processing of coking coal sample using Dense medium cyclone and Column flotation technique to achieve the targeted ash of 14-17% with maximum yield.
• Development of a process for the production of chromic oxide from chromite beneficiation plant tailing (CSIR funded). ❖ Detailed Characterization of chromite Tailing sample will be carried out. ❖ Bench Scale beneficiation studies in advance gravity concentrator will be done.
• Feasibility study on reduction roasting of high-iron bauxite ore ❖ Roasting followed by Magnetic separation was planned carried out. ❖ It was noted that alumina content enhanced from 26% to around 44% with a yield of 43%. However, iron content in product is high due to isomorphs substitution of Fe atom in alumina.

Flagship Projects

A. Coal Beneficiation

Effective Utilization of Middlings of Coking Coal Washery for Recovery of Carbon Values

Coking coal is a scarce commodity in India. The demand of coking coal in steel sector is increasing day by day due to the expansion of existing steel plants and addition of Greenfield projects in the country. Indian coking coals are characterized by high ash owing to their drift origin and sometimes has inferior coking properties. Therefore, to meet the desired grade of coking coal for blast furnace coke, imported coking coal are blended with the indigenous coal.

Indian coking coal washeries produce three types of products-clean coal, middling and reject. It is found that because of gradual depletion of the high grade raw coal, generation of middling is increasing day by day, while the yield of clean coal is decreasing in the washeries. The middlings generated from Coking coal washeries is about 35-40% with35-42% ash. It contains more than 3000 K Cal/Kg Gross calorific value. Presently this product is used for power plant. This middling could an excellent potential source of coking coal in view of conservation of this scarce coking coal reserve of the nation. Hence, there is a need to beneficiate the middling to enhance the recovery in order to conserve and sustain the scare resource of coking coal.

Objectives of the present research project are to address the characterization of middling and fine coal samples from coking coalwasheries, explore the possibility of recovering the washed coal at about 18%-19% ash from middlings of coking coal washeries by wet and dry process, and to develop process flowsheet for producing a product with 18% ash for enhancing the carbon recovery and reduction of surface moisture of washed products. Two coking coal washeries have been identified to collect the middling samples to carry out the study. From the study it was possible to achieve a product with 18-19% ash from 42-45% middling samplesby reducing the top size of 13mm to -1mm using spiral concentrator. Further work is underway to develop the process flowsheet.

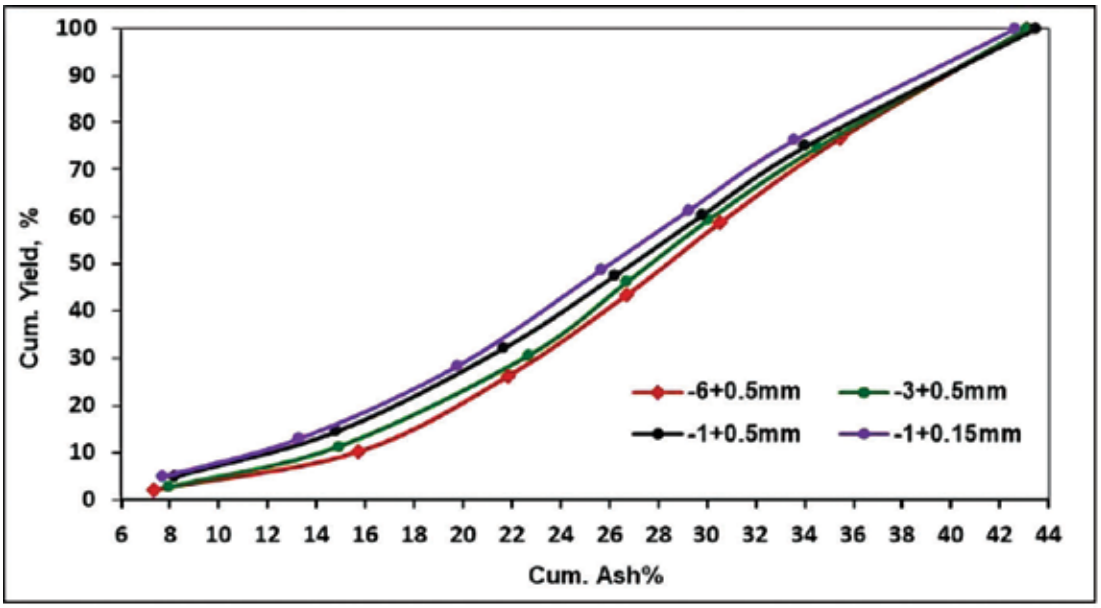


Figure 1: Washability study of middling sample at different top sizes.

Processing of High Ash & High Sulphur Containing Lignite Coal from Gujarat

Lignite coal is often referred to as brown coal. It is a soft brown combustible sedimentary rock that is formed from naturally compressed peat. It is the lowest grade coal having least concentration of carbon and high moisture content. Lignite contains low heating value. It is mainly used in electricity generation. However, small amounts are used in agriculture, as jet, in jewelry.

Lignite samplesfrom different seams of one of the biggest mines of Gujarat containing high sulphur and ash were studied to produce Lignite concentrate with ash below 17% and sulphur below 3%. Washability study of the composite lignite sample (Figure 2) was carried out to assessthe amenability to processing. It was found from washability study that 95% yield could be achieved at 17% ash level. Dry processing of composite lignitesample was studied by different techniques using dry high intensity magnetic separator (DHIMS), FGX-dry coal separator and Air Jig separator with different feed sizes. From the detail dry processing studies, five different process schemes evolving different techniques were developed. The Scheme evolved from theseparation of +50mm fraction by dry sieving followed by dry processing of -50mm fraction by FGX-1 separator results product yield of 84.8% with ash content of 17%.

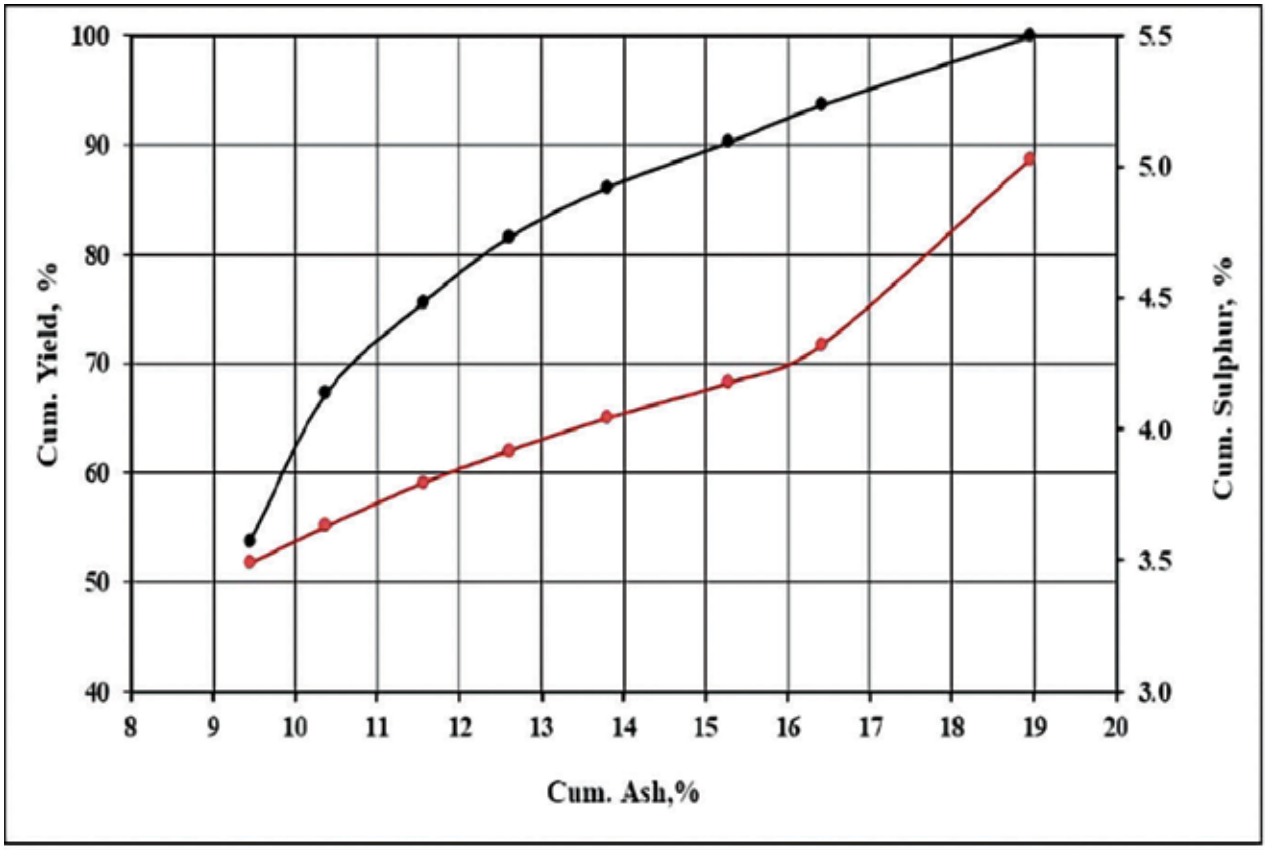


Figure 2: Washability curve of Composite Lignite sample.

B. Railways

Development of standard in collaboration with RDSO for procurement of center buffer coupler (CBC) for Indian Railways; evaluation and assessment of CBC manufactured by Indian vendors (Foundry) for supply to Indian Railway

Centre Buffer Couplers are used for joining freight cars of Indian Railways (Figure 3). Before 2009, the CBCs were imported and were expensive. The indigenized CBCs were supplied to Railways after 2009. However, there were many field failures resulting in revenue losses. During 2010-11, RDSO had approached CSIR-NML to have the root cause analysis of these CBC failures; suggest preventive measures and also help to develop a new standard for supply of healthy CBC to Railways.

Figure 3: (a) Centre Buffer Coupler (CBC) joining two rolling stocks; (b) Different parts of CBC (Yoke, Body, Knuckle)

RDSO in collaboration and consultation with CSIR-NML developed a **standard WD-70-BD** with the following objectives:

(i) Indigenization of Grade E castings used for manufacturing of Center Buffer Couplers (CBC);

(ii) Safety in rail transport;

(iii) Revenue saving

The standard WD-70-BD envisage that the CBC manufactured by foundry need to be evaluated at NML for soundness of casting, mechanical properties, microstructure etc. Presently, several manufactures in India have started manufacturing and supplying CBC to Railways and some vendors are under developmental stage. The contribution mentioned above helped in: Indigenous vendor development for Indian railways, saving in revenue losses resulting from parting of wagons, Safety in rail transport, Spin off projects led to ECF of about 400 Lakhs INR.

Metallurgical Failure Analysis of Railway Wheel Disc

A pre-mature failure of metro rail wheel was reported to CSIR-NML. An investigation was carried out to find out the root cause of wheel damage / failure. The as received wheel discs were shown in Figure 4. Visual examination revealed that one of the wheel discs contained fracture, along with delamination over the edge of tread, opposite to flange. Signature of degeneration also contained spalling at the centre of tread; cracks along the circumference and skidding near fracture of the same wheel are shown in Figure 5. The other part of the particular wheel and the counter wheel of the same assembly (condemned wheel) did not show any degeneration. Chemical composition of the alloy for railway wheel exhibited substantial variation in hydrogen content for both damaged and condemned wheels with respect to EN 13262 ER8 Cat2 standard. H_2 content in the damaged and service exposed condemned wheels was significantly higher with respect to the specification. Cr content in virgin wheel showed marginal deviation. Mechanical properties of the damaged railway wheel were marginally lower than that of the specification near fracture; however away from that particular location, the alloy satisfied the specification. Condemned wheel in this respect

revealed mechanical strength well above the specified limit. Microstructure of rim consisted of ferrite-pearlite aggregate. Partial spheroidization of cementite was observed near fracture. Sub-surface of the damaged location revealed the formation of martensite is shown in Figure 6 (a-b). Perhaps the phase transformation was triggered by rapid heating and cooling during sudden braking and spalling was occurred. Inclusions were present within the matrix of the wheel material; they were MnS and globular oxides for virgin and failed wheel, respectively. The inclusion rating by and large at par with specification, except a meagre variation in one type. Bulk hardness was consistent and satisfied standard for different locations of both damaged and condemned wheels, except the fracture location of damaged wheel. In that region the hardness was increased. The charpy impact energy at ambient temperature and -20 °C of the rim material of fractured wheel and condemned wheel was at par with the specification. The failure was initiated from the microcraking of martensite layer and severely accompanied by hydrogen diffusion to propel crack propagation over time. The hydrogen assisted crack propagation resulted in spalling of material. The spalled region was served as further crack initiation under rolling contact fatigue creating a signature of beach marks. Finally, the component was fractured in quasi-cleavage mode due to limited ductility of the alloy.

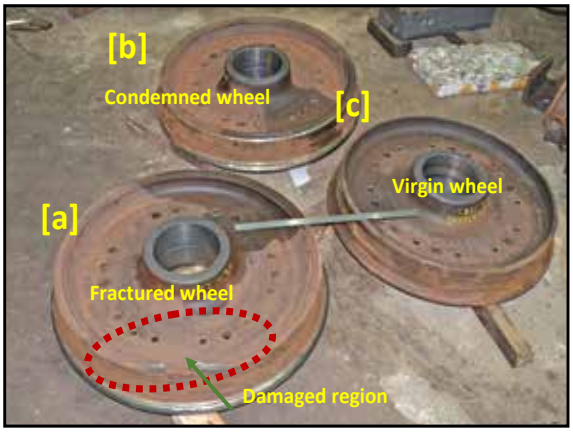


Figure 4. The photographs of as received wheel discs (a) Failed wheel, (b) Service exposed wheel and (c) virgin wheel.

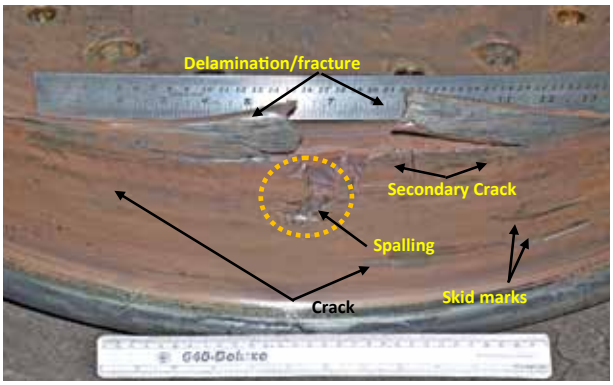


Figure 5: Photograph of damaged wheel showing overall fracture and other signature of different damages on wheel disc.

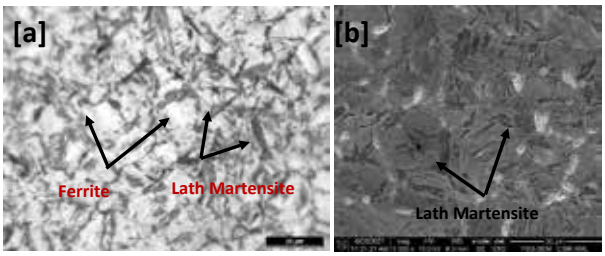


Figure 6. Microstructure showing martensite formation at spalled region due to spalling phenomenon (a) Optical micrographs (b) Scanning electron micrographs

Corrosion Behavior of Different Rail Steels in Varied Environments

The rail steels often seen to be susceptible to three types of corrosion namely atmospheric, microbial and stray current corrosion which result into reduced service life and premature replacement of rails. This study aims to evaluate the comparative corrosion performance comprehensively through standardized test exposures in weathering, saline and microbial environments of six different rail steels developed by SAIL, India. This investigation will facilitate Indian Railways in selection of appropriate rail grade for application in corrosion prone sections based on severity of atmospheric exposure and microbial corrosion. The objective of the present investigation is to study the corrosion behavior of six different grades of rail steel (*Plain carbon 90 UTS rail, Ni-Cu-Cr rail, Cu-Mo rail, High toughness corrosion resistant rails (HTCR-3 and HTCR-4 grades) and 1080 Cr)* in varied environments as mentioned below:

a) Evaluation of relative corrosion resistance of different rail steels through salt spray exposures in 5 % NaCl solution (as per standard ASTM B117).

b) Evaluation of relative corrosion resistance of different rail steels through cyclic humidity exposures in 1 % NaCl, 1 % $CaCl_2$ and 0.1% H_2SO_4 solution (as per standard ASTM G60-01).

c) Evaluation of relative corrosion resistance of different rail steels through spray exposures in synthetic urine solution with or without bacterial species.

Outcomes:

a) Initially, six different grades of rail steels were evaluated for their relative corrosion performance in 5% NaCl foggy environment through salt spray chamber at temp 35 ± 1°C. The time to first rust (yellowish) spot appearance was recorded around 65 min, 50 min, 45 min, 60 min, 70 min and 60 min for NCC, Cu-Mo, 1080Cr, 705, 699 and 90UTS steels, respectively. Further, the corrosion rate trends (in ascending order) were found to be as follow (pictorial depiction is provided.

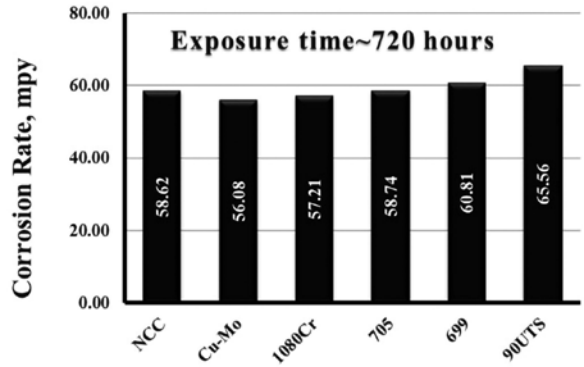


Figure 7. Cu-Mo < 1080Cr < NCC < 705 < 699 < 90UTS.

Corrosion rate of different grades of rail steels in 5% NaCl solutions, exposure time ~ 720 hours.

The localized corrosion (pitting, pit depth) trends were found to be as follows (3D view of topography is represented in ***Figure 1080Cr < NCC < 90UTS < 699 <Cu-Mo < 705,*** whereas uniform thickness loss trends (in ascending order) determined as follows; ***1080Cr < NCC < Cu-Mo < 90UTS < 699 < 705.***

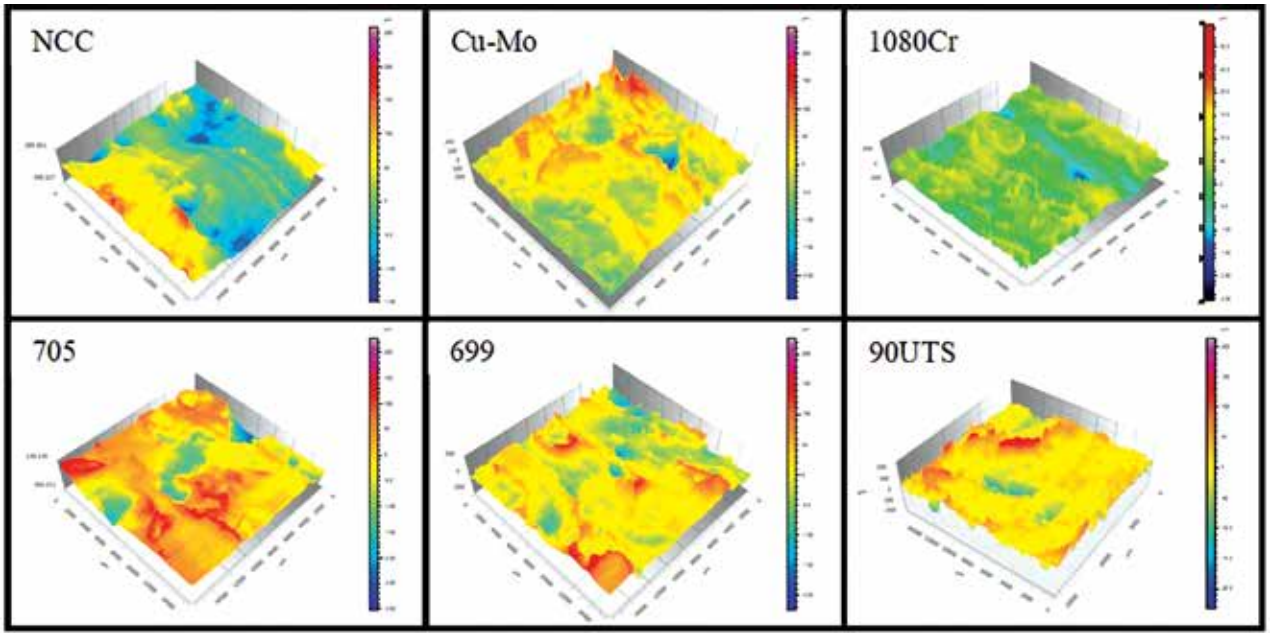


Figure 8. 3D topographical view of corroded surface (after cleaning) after 720 hour's exposure (as per ASTM B117) (Blue color indicates the depth-pit).

Initially, the steel Specimens were exposed to synthetic urine solutions containing no bacterial species at room temperature. The corrosion rate trends (in ascending order) in, were found to be as follow (pictorial depiction is provided in ***Figure NCC < 705 < Cu-Mo < 699 < 90UTS < 1080Cr***

The corrosion rates were found to be almost 10-12 times lower as compared to both salt spray and cyclic humidity environments. The area covered with rust was found to be ~ 29-41% and 42-54% after the completion of 480 and 720 h of exposure, respectively. The localized corrosion (pitting, pit depth) trends were found to be as follows (determined through 3D profilometry); ***NCC < Cu-Mo < 90 UTS < 1080Cr < 705 < 699,*** whereas there wasn't any measurable thickness difference after completion of the exposure duration for all the steels.

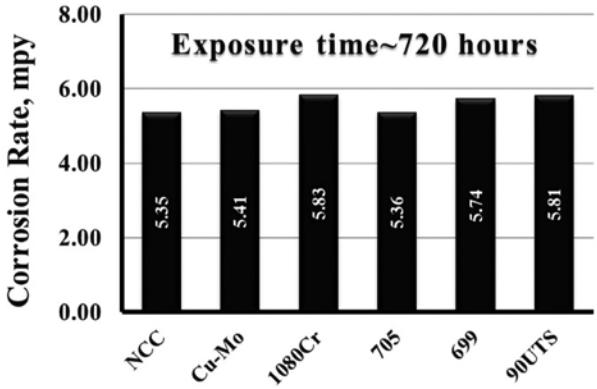


Figure 9. Corrosion rate of different grades of rail steels in synthetic urine solutions without bacterial species at room temperature, exposure time ~ 720 hours.

Further, the steel specimens were exposed to the synthetic urine solutions inoculated with microbial species through immersion method. The bacterial species were isolated and sub-cultured from the corroded rail specimens collected from in-service railway lines (Ranchi & Hatia Railway stations). The corrosion rate trends (in ascending order) in, were found to be as follow (pictorial depiction is provided in ***Figure***); ***NCC < 705 < Cu-Mo < 699 < 90UTS ~ 1080Cr.***

The corrosion rates found to increase by around three folds in presence of the bacterial species in the synthetic urine solutions. Thus, it is concluded that the corrosion of the rail specimens is guided by the bacterial species which further confirmed by the scanning electron microscope (SEM) which shows well grown bacterial colonies on the specimen surface.

The localized corrosion (pitting, pit depth) trends were found to be as follows (3D view of topography is represented in ***Figure***); ***NCC ~699 < Cu-Mo < 1080Cr < 705 ~90 UTS,*** whereas uniform thickness loss trends (in ascending order) determined as follows; ***NCC < Cu-Mo < 699 < 1080Cr < 705 < 90UTS***.

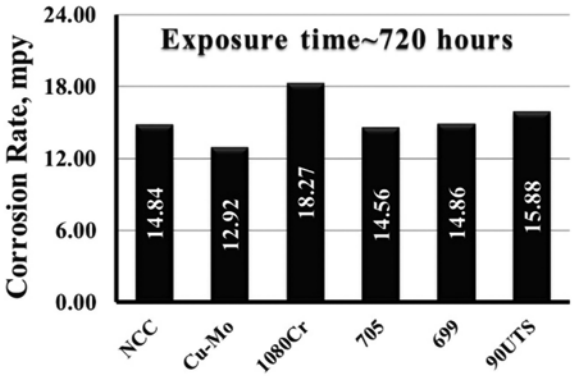


Figure 10. Corrosion rate of different grades of rail steels in synthetic urine solutions with bacterial species at room temperature, exposure time ~ 720 hours.

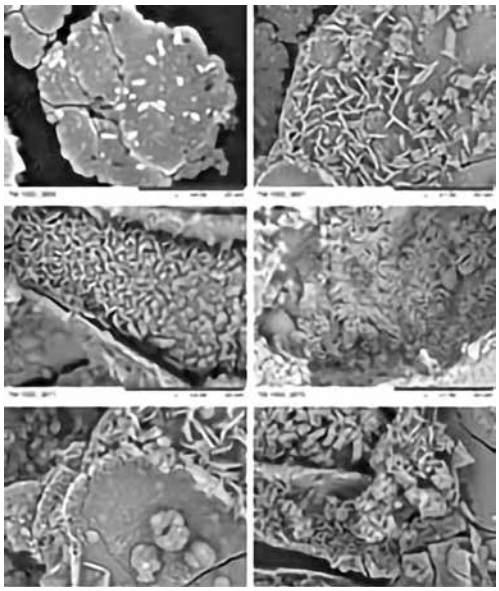


Figure 11. SEM micrographs of the corroded specimens showing the presence of the bacterial colonies on the steel surface; microbial corrosion.

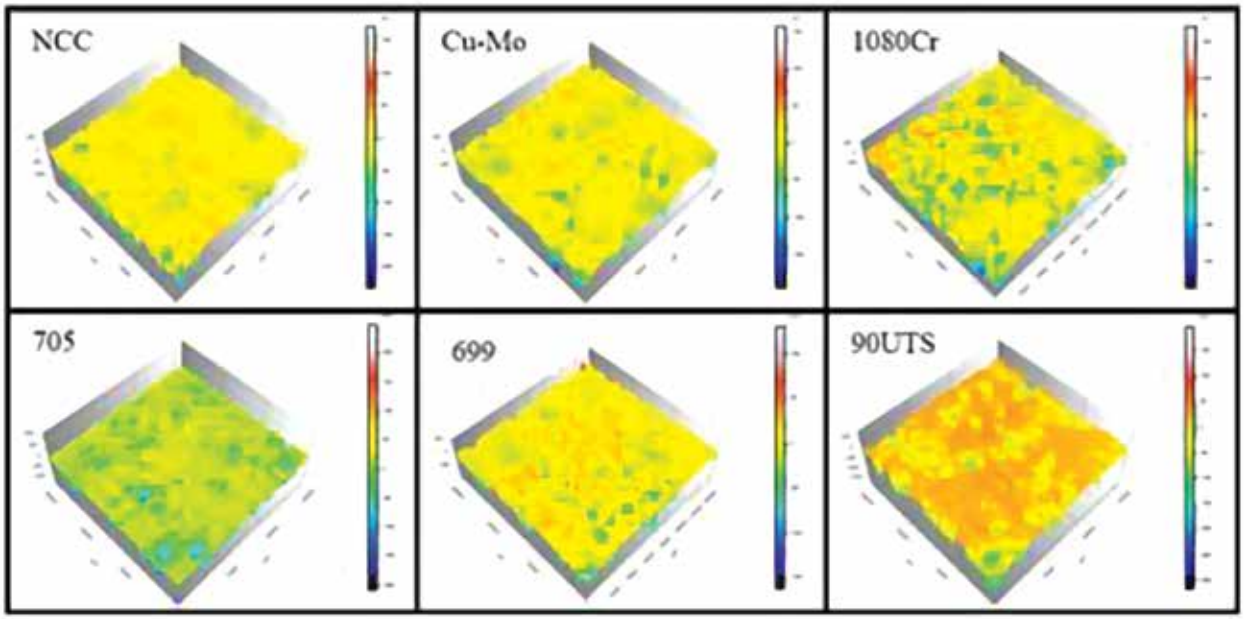
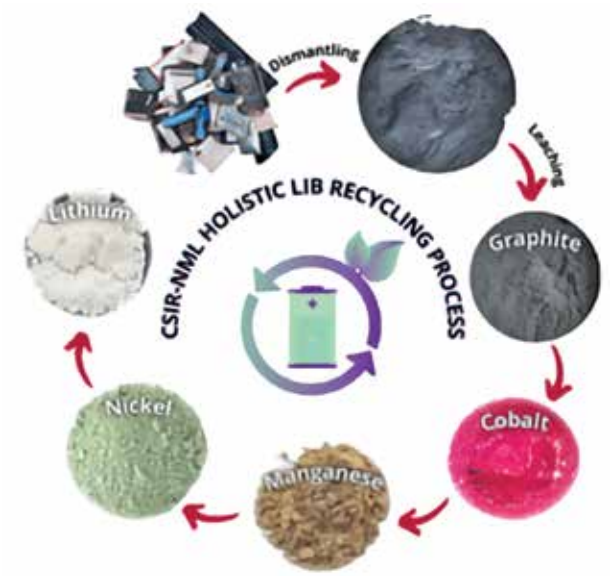


Figure 13. 3D topographical view of corroded surface (after cleaning) after 720 hour's exposure (cleaned as per ASTM G60-01) (Blue color indicates the depth-pit).

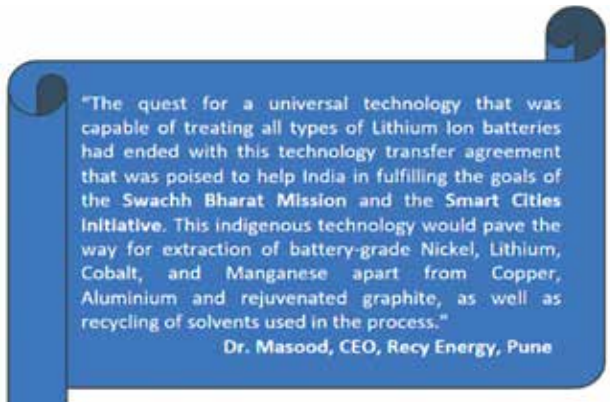
C. Flagship Projects (Extraction Li-Ion Batteries)



Extraction of critical metals form used Li-ion Batteries A Mission Mode Project under CSIR Bulk Chemicals Mission

CSIR-NML, Jamshedpur has developed CSIR's first holistic process that can tackle any type of Lithium based batteries, to extract and separate high pure salt products of Lithium, Nickel, Cobalt, Manganese, Aluminium, Copper, and Reusable Graphite. This process ensures the recovery and yield of Li, Co, Ni, Mn (>95%) with purity >min. 99.6% as carbonate/nitrate/chloride/sulfate/oxide/phosphates (eliminating iron, aluminium, copper) for direct new battery making. It is a blue print tailored patent filed process that can utilize any type of black mass, which provides recyclers a flexibility to buy/collect/use any type of lithium battery and use them to recover all metals or lithium selectively (Patent Appl. No. 202111040164 and 202111040165 dt. 16.09.2021). The process would result in utilization of huge reserves of spent lithium batteries generated in India, and recycling them to recover and supply indigenous metal precursors, which will bring the cost of batteries and in turn the cost of EVs.

The pilot plant is slated to be commissioned at CSIR-NML, Jamshedpur, which shall be first of kind Hire-Operate-Transfer (HOT) platform for MSMEs and Entrepreneurs in India. Currently, it has signed agreements with five Indian firms with whom technology transfer is on anvil, and more are in the queue.

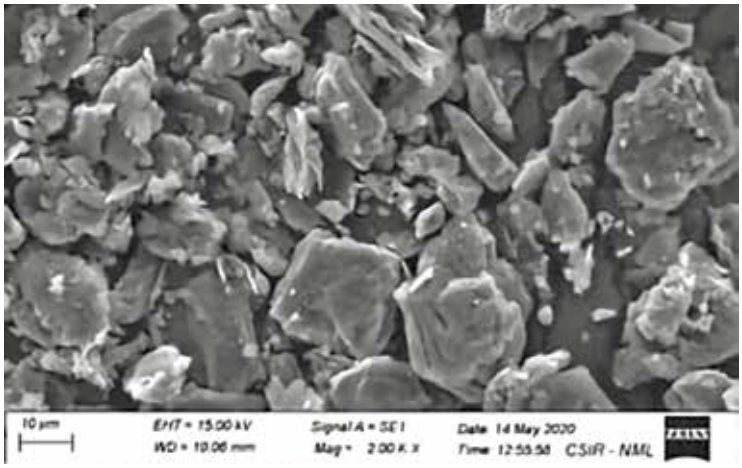


Technology Transfer agreement signed with M/s Recy Energy, Pune (25th May 2022)

https://government.economictimes.indiatimes.com/news/technology/national-metallurgical-lab-collaborates-with-pune-based-recy-energy-for-recycling-used-lithium-ion-batteries/91977577

Recycling of Graphite from Spent Lithium-Ion Batteries for High Energy Li-Ion Capacitors (In Association with IISER, Tirupati)

This project is operated in the close knit association of IISER-Tirupati, NML Jamshedpur and Industrial Partner. The project is based on the objectives of recovery and purification of graphite from spent LIB followed by production of high energy and power LIC (>150 Wh kg^{-1}).



The high pure graphite synthesised at CSIR-NML has been submitted to IISER, Tirupati for trials. The analysis of graphite shows >95% purity on chemical analysis basis and >99% on SEM mapping. The flake graphite shall be conditioned and used in the project deliverables.

Strategic Sector Projects

A. Space

Effect of Processing Parameters on Cryo Impact Properties of Cast Alloys

The project aims to investigate the phase evolution with different heat treatment conditions (quenching and tempering route) and their effect on cryo-impact properties of super-martensitic stainless steel grades. The output of the work would be the assessment of heat treatment parameter on cryo impact properties of existing alloy grade and the design of new alloy composition with its Quenching & Tempering parameter that would give desired mechanical properties.

The objectives of the work are as follows:

I. To assess the effect of heat treatment parameters on cryo-impact properties of as-cast alloy. The proposal aims to study:

- Factors affecting the stability of retained austenite
- Factors affecting the transformation of room temperature retained austenite to martensite at cryogenic temperature (77 K)

II. To design alloy an alloy composition and its Q&T parameter which would give 100 J impact energy at 77K, Room temperature properties: YS 800 MPa, UTS 1050 MPa and Elongation 14%.

A super-martensitic stainless steel having 6.5-8 wt.% Ni was designed with the help of thermodynamic and kinetic simulation in ThermoCalc software, and taken up for the study. A detailed thermodynamic analysis, prediction of Martensite start (M_s) temperature and prediction of retained austenite at room temperature and -196 °C were done. Thereon appropriate heat treatment schedules were designed and experiments were performed. Tensile property (at RT) and impact properties (at RT and -196 °C) testing was conducted, followed by microstructural characterization. The 250 °C tempered sample exhibited good tensile properties (YS: 843 MPa, UTS: 1077 MPa and % El.: 15%) meeting the targeted properties. Also, it exhibited superior cryo impact property of 74 J at -196 °C. The crystal orientation map and phase map of the sample is shown in the Figure 1 below. Transmission electron microscopy analysis indicated no significant partitioning of substitutional solute elements between martensite and austenite during tempering at 250 °C, however, the presence of fine precipitates (<5 nm) was observed in the sample. Further optimization of alloying content and heat treatment was carried out which led to significant improvement in properties: an excellent cryo Charpy impact toughness of ~90 J (at -196 °C) along with yield strength greater than 800 MPa was achieved in the alloy.

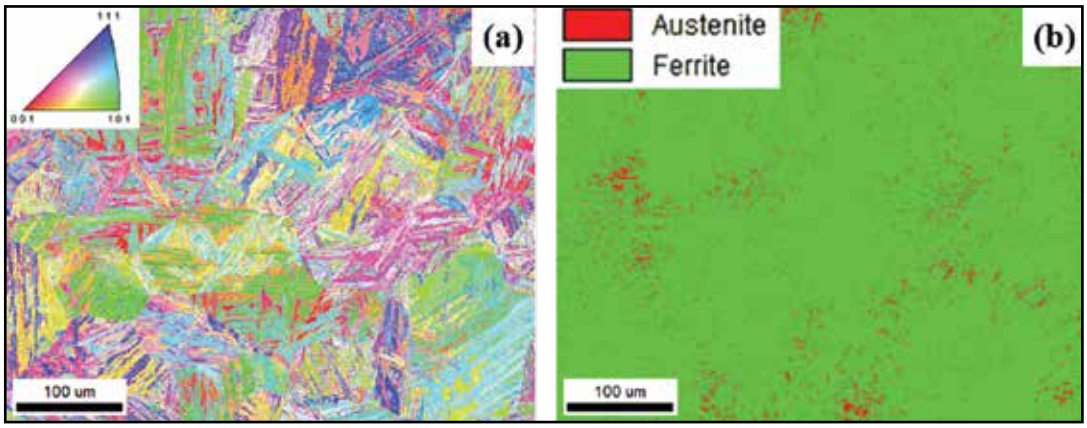


Figure 1: EBSD analysis of the 250 °C tempered sample (a) crystal orientation map and (b) phase map

Electronic Packages for Ultrasonic Flow Meter for On-Board Propellant Gauging of Spacecraft

Spacecraft propellant gauging is one of the important activities that allow estimating the amount of propellant available onboard in a spacecraft. The propellant availability dictates the life of the spacecraft; also the data related to the propellant availability determines the mission sequence and decisions. CSIR-NML along with the collaborator is in this project to fabricate four systems using flight qualified electronics for on-board propellant gauging of space craft based on CSIR-NML technology fluid flow rate detection through a narrow tube. Qualification tests of the devices for continuous and pulsating modes for further use in Indian spacecraft will be carried out on ground in space environment. The electronic package development involves pulser, receiver, onboard storage and signal processing so as to enable acquisition, analysis and delivery of data from spacecraft to the ground stations. After several rounds of project team meetings, design and components for the master module has been confirmed and the fabrication of the master module has been completed. Trials of the master module from 0.1 LPM to 6 LPM flow rate was successfully completed. Fabrication of flight qualified modules are in progress.

Generating Forming Limit Diagram (FLD) of welded and non-welded aluminum sheets using Nakajima Test

The sponsor approached CSIR-NML to develop forming limit diagram (FLD) of non-welded and welded aluminum sheets using Nakajima test. The aluminum sheet thickness for non-welded sheets are in the range of 1~2 mm, while welded sample thickness is 1 mm. Nakajima tests are carried out as per ISO 12004 -02-08 standard in universal sheet metal testing machine with varying blank width from 25 to 200 mm. Figure 2(a) shows the picture of Erichsen universal sheet metal testing machine available at CSIR-NML.

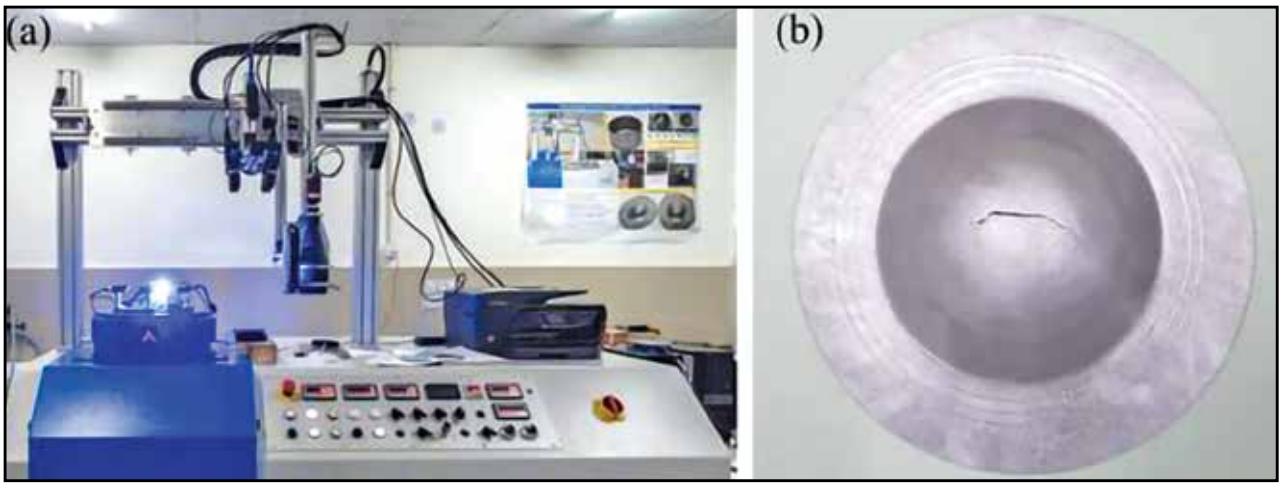


Figure 2: (a) Erichsen sheet metal testing machine, (b) grids generated on aluminium sheet

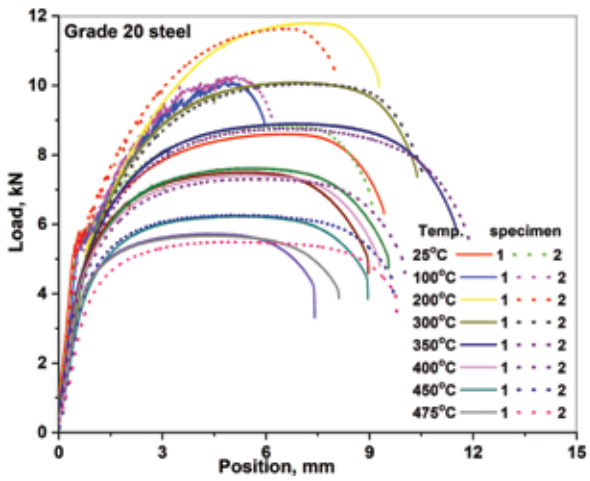
Figure 2 (b) shows a test specimen geometry called dog bone shape blank (waisted blanks with parallel shaft). The widths of the shaft are around 25, 50, 75, 100, 125 and 200 mm for uniform allocation of FLD from uniaxial to biaxial tension. Choice of appropriate grid spacing is essential for quality of the strain analysis. electro-chemical etching is employed to inscribe square grids of 1 mm in dimensions on the aluminum surface, as shown in Figure 2(b). After preparation of grid on the specimen surface, aluminium sheet with proper dimensions is placed in the machine to carry out the Nakajima test based on ISO 12004 standard. Four cameras integrated with the machine perform

in-process measurement of major and minor strains during deformation of the sheet. The drawing punch of 100 mm diameter is used for testing with punch velocity of 60 mm/min. After the test is over, the in-process captured images are analysed by AutoGrid® strain analyzing system to determine the strain paths and subsequently draw forming limit diagram.

B. Navy

Destructive Test / Analysis for Establishing Life Estimation Matrix (LEM) Boiler Tubes

Indian Navy (IN) operates several ships powered by boiler units. As part of regular maintenance efforts formarine boilers, **IN** needed destructive testing and analysis of test results for the sake of establishing life estimation matrix for boiler tubes. Accordingly, tests were carried out for mechanical properties of tensile strength, hardness, stress rupture strength along with microstructural conditions. Boiler tubes in the initial and service-exposed conditions were evaluated. Obtained results were used to establish the life estimation matrix in the initial and service exposed stages.



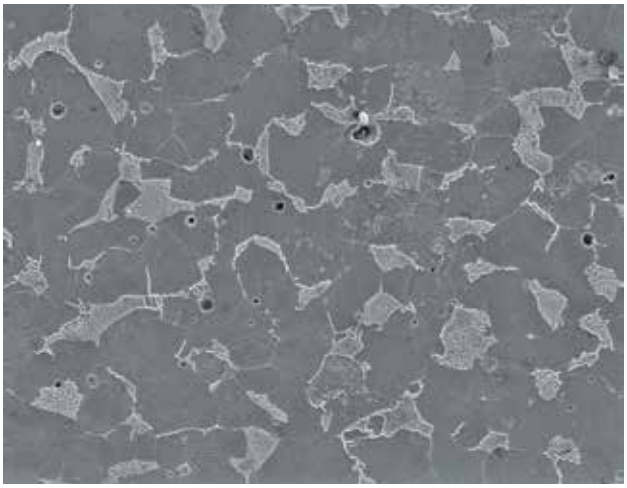


Figure 3: (a) Tensile curves of Grade 20 steel ; (b)Initial microstructure of Grade 20 steel

Metallurgical investigation to explore the damage mechanism of worn out quill shaft.

The Quill shaft of the main fuel Pump of the aero-engine, was worn out during service exposure (as shown in the **Figure** 4 below). To identify the root cause of material damage, the sponsor requested CSIR-NML, Jamshedpur, and accordingly, specimens were received for investigation. Macro observation revealed that the load-bearing surface of the teeth of the quill shaft i.e., on the gear-box side, was damaged. The bulk chemical composition of the virgin and damaged components exhibited deviation in carbide forming elements i.e., Cr and W with respect to the specification. The bulk hardness of the virgin and damaged components were close to each other. The microstructure of the components was tempered martensite containing discrete carbides at the lath boundary. Degradation of microstructure at the core was absent for the damaged component. The cross-sectional structural investigation showed extensive thinning of the teeth. Formation of layered deformed zone and plastic flow of material along the direction of rotation was evident. Surface examination of the damaged teeth (gear-box side) illustrated material flow lines, deformed zone along the surface of the teeth, overlapping of material near edges, and fragmentation of the material.

The investigation confirmed that the damage of gear tooth material occurred under excessive torsional load. The deformation of the gear teeth material gradually thinned down the

tooth alloy and caused extensive material flow near tooth edge. During service under excessive torsional stress, the material was fragmented. Excessive stress beyond the tolerance limit may either have generated from improper lubrication or due to mechanical misalignment.

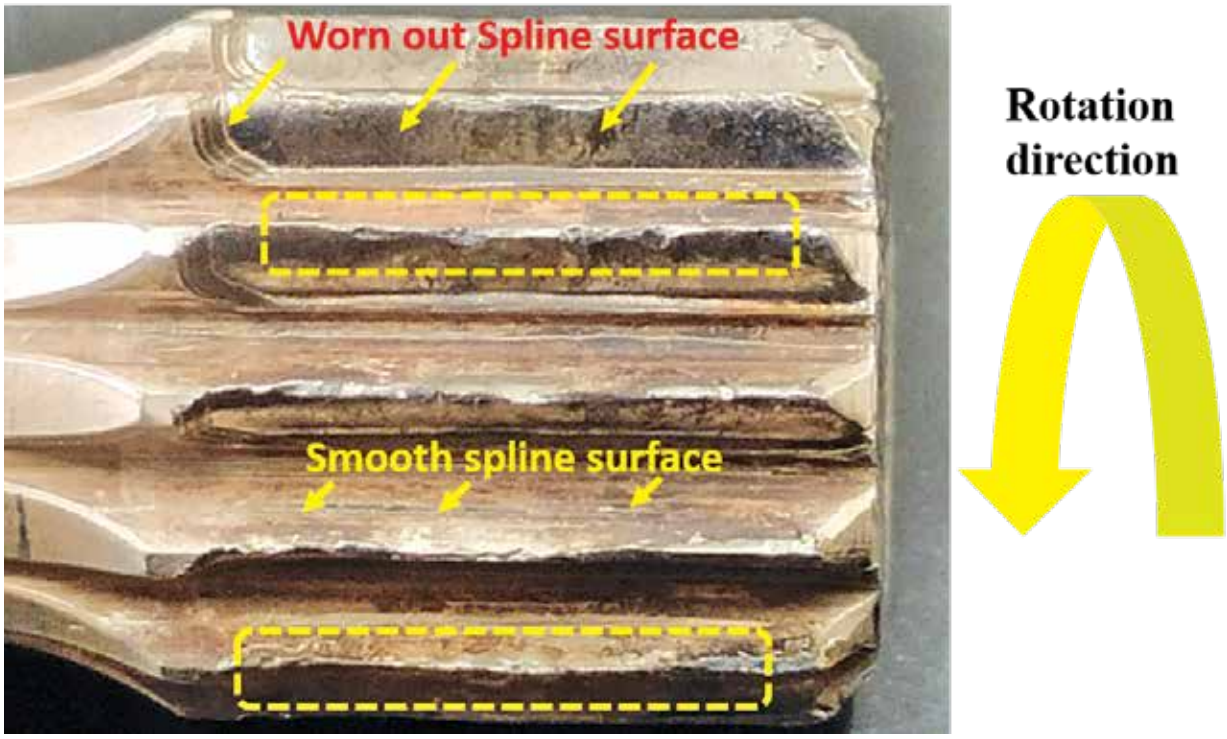


Figure 4: Photograph of the worn out quill shaft component

Analytical & Applied Chemistry

Analytical & Applied Chemistry (AAC) Division has been focusing on the basic and applied research in the areas of Analytical chemistry, Corrosion Inhibitors & Polymeric Coatings, Coal chemistry and Certified Reference Materials (CRMs). The Division is fully equipped with state of the art analytical instruments for analytical support to the ongoing R&D projects of CSIR-NML and provides analytical testing service to outside agencies. The Division is a NABL accredited laboratory for Chemical Testing as per ISO/IEC 17025:2017. Another important activity of the AAC division is to develop and serve Certified Reference Materials (CRMs) for metallurgical products like Ores, Coal, Steel, Ferro-alloys and other metal alloys. The Division has been developing and serving various CRMs in the areas of ores, minerals, coal, steel (powder, gaseous Pin, spectrographic and chip/turning standard) and Ferro alloys. AAC Division is a NABL accredited laboratory for reference materials producer (RMP) as per ISO/IEC 17034:2017. Some of the major achievements/activities of AAC Division in the reporting year are listed hereinafter:

Non-Coking Coal to Coke Making

The prime objective of various projects undertaken in this field of research is to induce swelling and thermoplastic properties in low grade non-coking coal through alteration of structural properties in non-coking coal. This alteration in structural properties has been induced by blending in both natural additives as well as those which are derived from coal. The coke making experiments were conducted on both non-coking and semi-coking coals with lower ash content acquired from different geographical locations. The resultant cokes were characterized using CSR/CRI (Figure 1) and petrographic characterization to ascertain the development of the desired plastic property, strength and mosaic structure.

Figure 1: CRI and CSR facilities to assess reactivity and strength of coke.

Our research team in AAC has successfully completed multiple projects in collaboration with industrial partners assessing the quality of coals of varied geographical origin for their coke making potential. In Indian scenario, successful development of a process to prepare coke by utilizing low grade coals is anticipated to have the following consequence:

- The huge reserved of India's low grade coal, could be utilized for both thermal power plants and metallurgical applications.
- The cost of importing coking coal will reduce significantly, making India self-reliant.

Oil Agglomeration to Beneficiate Indian High Ash Coals

Beneficiation of coal fines using oil agglomeration is known since long time owing to its efficiency and simplicity. The chemical complexity of Indian coals makes the utilization of this process, which is based on selective adsorption owing to difference in surface properties, even more challenging. Extensive research has been done on agglomeration of Indian coals focussing on the various kinds of cost-effective oils which could be employed for the process; however, they were primarily on coking coals. In order to gain an overview of the

behaviour of all the coal types, low grade coals needs equal attention like coking coals, owing to their abundance and application in thermal power plants. They are comparatively more challenging to agglomerate due to their unfavourable hydrophilic surface chemistry. Our research team has conducted extensive research on optimization of all the essential process parameters for oil agglomeration of both prime coking coals and low grade coals (ash content >35%). We have successfully completed two collaborative projects with Coal India Limited (CMPDIL and MCL) on beneficiation of both coking and non-coking coals. An indigenous set up has been developed (Figure 2) for the complete process which can potentially handle up to 2 kg of coal, resulting in demineralization of coals by 50-60% from the original ash content, with high organic recovery (70-80%).

Figure 2: Indigenous oil-agglomeration set up at AAC division.

Extraction of Rare Earth Elements from Coal Ash

Coal ash is the primary by-product of thermal power plants which is generated in huge amount annually. Unfortunately, majority of the waste being generated is being discarded into ash ponds. This apparent waste contains valuable elements, such as rare earth elements and trace elements, which could be potentially extracted. One of such valuables consists of lanthanides along with Sc and Y, collectively termed as rare earth elements (REE). In recent times, due to the ever-increasing demand of REE in every technological sector and restricted primary resource, research on extraction from secondary source such as coal ash has gained momentum. Till date, most of the leaching process has been optimized using mineral acids which are corrosive, destroys the matrix and lacks selectivity. Owing to the environmental concern, development of eco-friendly reagent as a leaching agent is the need of the hour towards designing of sustainable extraction process. Our research team has worked on multiple organic acids (tartaric acid, citric acid, lactic acid and methanesulphonic acid) as potential alternatives to corrosive mineral acids for leaching from coal ash. The optimization of the crucial process parameters such as leaching temperature, acid concentration, reaction duration and solid to liquid ratio along with the experimental challenges thereby has been studied. A bar graph enumerating the leaching potential of REEs from coal ash by various organic acids has been shown in Figure 3. The selectivity imparted by these eco-friendly acids along with the matrix retention ensures further utilization of the residue for construction material, which is typically the biggest use of the waste in the present scenario.

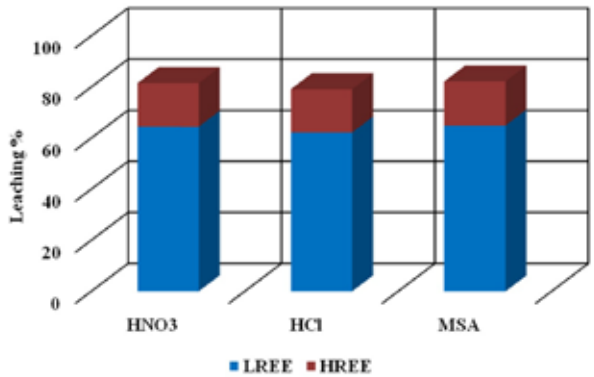


Figure 3: Comparison in leaching % of MSA with respect to mineral acids.

Quantification of REEs, Trace and Major Elements in Soil Sediment Samples

AAC Division has actively involved on the projects sponsored by Geological Survey of India for quantification of rare earth elements (REEs), trace elements, heavy metals (such as Hg) and major elements in soil sediment samples. The study involved development of methodology for

X-ray fluorescence (XRF) instrument analysis and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis including calibration, fusion and digestion methodology for quantitative analysis of various REEs, trace and major elements found in stream sediment samples (Figure 4). The quantified results are validated by NIST SRMs or NIST traceable CRMs.

Figure 4: Digestion and ICP-MS sample preparation of soil sediment samples.

Certified Reference Materials (CRMs)

Reference materials are of critical importance and indispensable for calibration of instrument, method validation, accuracy of analytical results, quality control and quality assurance of products and processes. AAC Division of CSIR-NML is involved in production and marketing of Certified Reference Materials (CRM) for last 50 years. CRM's of NML has created its own market value and has more than 600 Industrial customers across India. We target to develop new CRMs every year. In the FY 22-23, new CRMs for steel such as CRM 216 (0.6 % carbon Steel, turning form) has been developed in a batch size of 1540 bottles (100gm pack) and CRM 220A Stainless Steel, turning form has been developed in a batch size of 205 Bottles (100gm pack). Two nos. of gaseous CRMs such as CRM 204 & CRM 205 for Carbon & Sulfur in Steel PIN form have been developed in a batch size of 210 bottles (100 Pin pack) of each one. Spectrographic CRM 304A for Steel (0.17 % carbon Steel) in Disc form has also been developed in a batch size of 520 nos. All the above CRMs are prepared as per ISO 17034:2016 & Guide 35: 2017 and these are import substitute having notional value for NABL accredited CRMs in India. In addition to the above-mentioned reference materials, CRM Unit, AAC division has developed already 35 nos. of NABL accredited CRMs which are available in brochure uploaded in www.nmlindia.org.

Figure 5: Carbon and Sulfur Standard

Coal Characterization and Analysis

Quality assessment of the coals produced is a job of national importance. AAC Division is recognised as a Referee Laboratory for Coal Analysis. AAC division is actively involved in the coal characterization and analysis such as band by band analysis, seam overall analysis of coal sample received from various subsidiaries (CMPDIL, ECL, BCCL, CCL, SECL, NCL, MCL, WCL etc.) of Coal India Limited. AAC Division carry out quality assessment of both coking and non-coking coals through chemical characterization using its state-of-the-art coal characterization laboratory (Figure 5).

Figure 6: Coal characterization and analysis facility.

Indigenous Development of Benzoic Acid Reference Material for Calorimetry Analysis

Benzoic acid is used as a reference material (RM) for calorimetry analysis such as in bomb calorimeter instrument for calibration. This reference material is hugely used in our country for gross calorific value (GCV) analysis. However, till now there is no Indian manufacturer for producing such type of reference material for GCV analysis. In particular, we are importing this RM from foreign manufacturer. Therefore, indigenous benzoic acid reference material development is an urgent need to meet the demand of benzoic acid reference material production and contribute on the product development for import substitution.

Project Objectives :

- Synthesis and characterization of ultra-pure benzoic acid
- Homogeneity test and stability study of the synthesized material.
- Inter-laboratory comparisons of gross calorific value of the synthesized material
- Statistical analysis and assignment of GCV

In this ongoing project we have synthesized ultra-pure benzoic acid from commercially available raw material. Synthesized product was characterized by NMR spectroscopy, CHN analyzer and melting point measurement. Next, the product was palatalized and gross calorific value (GCV) was experimentally measured. The GCV was found within the range 6305 to 6325 cal/g. GCV value of NIST SRM 39j (Benzoic acid) is 6317.8 cal/g.

Figure 7: Preparation of Benzoic acid and benzoic acid tablet for gross calorific value analysis.

Envisaged deliverables

- ✓ Indigenous development of benzoic acid reference material for calorimetric analysis
- ✓ Production of 200 units, 50gm/unit benzoic acid reference material

Team-AAC

Advanced Materials and Processes

Advanced Materials and Processes (AMP) Division targets the development of advanced materials, processes and techniques for the improvement in performances of materials and components and the mitigation of environmental problems related to materials application in energy, space, oil & gas, iron & steel, biomedical and infrastructure. The division comprises three research verticals namely (i) Surface Engineering (SE), (ii) Functional Materials (FM) and (iii) Non-destructive Evaluation (NDE) Group. The division mainly focuses on (i) Development of advanced materials, coatings for energy, automotive, health, environment, etc., (ii) Development of sensors and devices for non-destructive evaluations and structural health monitoring. The mission of the division is to develop and translate end to end solution to the stake holders with advanced materials and processes under different technological sectors.

Structural Engineering into 3D Macroscopic Architecture with Hierarchical Porosity for Real Application of Energy Storage Devices

By following the objective of this project, several MXenes and carbon based electrode materials for both the energy storage systems like supercapacitor and lithium ion batteries (LIBs) with efficient energy storage performances were successfully developed. For example, a specifically designed 3D carambola shaped SnO_2 wrapped by carbon nanotubes as LIB anode materials which produces long cycling stability was developed and published this work in high impact journal i.e. Chemical Engineering Journal (**impact factor = 16.74**). In another work, a composite of Ti_3C_2 MXene and bi-metallic chalcogenide e.g. NiCoS to apply as supercapacitor electrode material was developed where both EDLC and pseudocapacitive contribution is promisingly controlled its energy storage performance. Ti_3C_2 MXene and conducting polymer e.g. PANI based composite has also been prepared to investigate the effects of a different form of conducting polymers attached to MXene surfaces. Recently, an article was published with **impact factor of 14.51**, where it was found that conventional annealing fails to dope phosphorous into Ti_3C_2 MXene because of the formation of unwanted phosphates. In this work, we proved that an optimized microwave assisted rapid heating method can successfully dope phosphorous into Ti_3C_2 MXene which improves the electrochemical properties further by many folds. We have also published a review article (**impact factor = 19.92**) exploring the integrated ice-frozen assembly techniques for developing various energy materials with suitable architectures. 01 book chapter has also been published in springer-nature, and 03 book chapters are in press. During this project, 03 M.Tech students submitted their thesis, 02 project assistants were trained, and 01 project student joined for his M.Sc. project work. 06 internship students were also trained. A prize was also being won in an image competition held in IIM-ATM 2021. Currently, focus is to demonstrate the practical application of fabricated supercapacitors. We have recently developed a process where waste biomasses were converted to high surface area carbon and metal oxide/phosphate based composites for fabricating symmetric and asymmetric types of supercapacitors and then the demonstration of its practical application by running LED board containing multiple LEDs and also small consumer's electrical instruments like oximeter and calculator. **Figures 1 and 2** are shown to demonstrate the practical use of the prepared supercapacitors from the waste coffee grounds by running one LED board and a pulse oximeter.

Figure 1 & Figure 2: Demonstration of the prepared supercapacitors from the waste coffee grounds

Process Development of High Quality Layered Transition Metal Carbides/Nitrides/ Carbonitrides (MAX)

In this project, an indigenous optimized pressureless sintering process for manufacturing Ti3AlC2 MAX phase having high purity of more than 95 % was successfully developed, as per the proposal. Theoretical calculations have been carried out and integrated with experimental techniques to improve the purity of the developed Ti3AlC2 MAX phase. The current scale of production is 50-80 g which needs to be improved for its successful commercialization. As the MAX phase is the only precursor to develop 2D MXene so, to confirm the suitability of the MAX in the production of 2D MXene, we have derived the Ti3C2 MXene from our developed Ti3AlC2 MAX phase and further explored its application toward clean energy storage system like supercapacitor. We have filed an Indian patent on the process developed for manufacturing Ti3AlC2 MAX phase and also published high-impact publications (**impact factor of 14.51 and 19.92**) on its MXene based energy storage systems. Further, in this project, the possibility of developing another type of MAX phase like Ti2AlC has also been explored, which is also in high demand for its unique electrical and mechanical properties. In the recent attempts, a good quality of 2-5 g of Ti2AlC MAX phase but with some TiC and Ti3Al impurities has been developed, and thus, further optimizations in terms of composition and ball milling and heating conditions are needed to increase the purity and scale of production. During this project, 1st prize in the poster session held in an international conference, and also trained 08 students including a project assistant, M.Tech, and intern students. For summarizing the whole achievements pictorially, please find the figure 3 below.

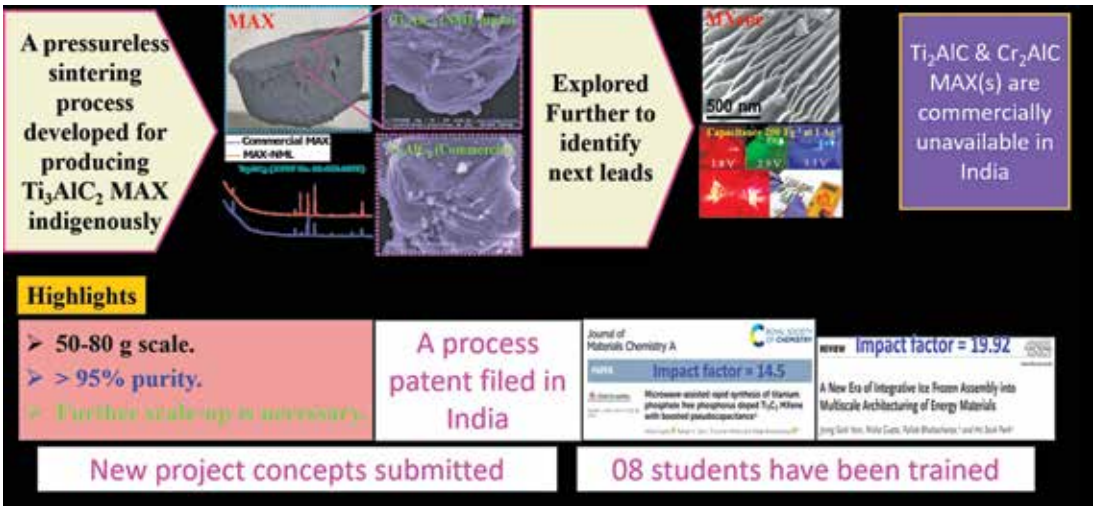


Figure 3 : Achievements in the project MLP3119

Development of Advanced Giant Magneto-Impedance (GMI) Based Sensor for Structural Health Monitoring of Engineering Structure with Enhanced Area Coverage

Magneto-impedance sensors are gaining ground in industrial applications due to enhanced sensitivity and portability of the device. These sensors typically contain amorphous / nanostructured soft magnetic microwires as the sensing element. The earlier developed Giant Magneto-impedance (GMI) sensor has only single sensor element which is a rapidly quenched amorphous microwire of diameter in the range of 80 to 120 micron. Therefore, the area of assessment was small. Thus, to increase the coverage area of evaluation, a project was proposed with the objective of developing a Giant Magneto-impedance based array sensor for detection of carburization in austenitic steels / components used in petrochemical refinery units. Based on CSIR-NML's laboratory experimentation and technical inputs, a device was fabricated and coined as "MagRays".

Achievements:

- **Patent :** An Indian patent filed with the title "A process for arrangement of amorphous / nanostructured microwires in an array for enhancement of signal response in a magneto-impedance sensor" (Appln no: 202111039713 dated 02-09-2021).
- **Device development :** Development of a Magneto-impedance (MI) Array Sensing Device using Nanostructured material. Device is coined as "MagRays".
- **Sensor material :** The sensor element used in the MagRays comprises of a nanostructured material in the form of microwire prepared using CSIR-NML's in-water quenching facility. In the developed device an array of such sensor microwires have been used for large area coverage.
- **Device performance :** Device showed satisfactory performance during laboratory tests on service exposed petrochemical refinery unit component (Johnson screens) and on defective weld.
- **Technology video :** A technology video prepared and uploaded as youtube video to get prospective clients for future applications. The youtube link is https://youtu.be/28mU03M27sk

Figure 4: Magneto-impedance Array Sensor (MagRays) measurement on a Johnson Screen

Figure 5 : Magneto-impedance Array Sensor (MagRays) measurement system

Replacement of Toxic Cadmium Coatings by Electrodeposited Al/Zn-Mn Coatings on High Strength Steels

The objective of the project is : (a) Development of binary Zn-Mn alloy and ternary Al/Zn-Mn alloy from ionic liquids preferably from an affordable, simple and stable ionic liquid, based on choline chloride (ChCl) type deep eutectic solvents (DES) by electrodeposition, approach, (b) Performance of coating should be similar or better than the Cd plating and improve the aircraft maintenance .

Achievements :

(i) As per commitments in the mission, identification of water and air stable ionic liquids & surface pre-treatment process has been established.

(ii) Development of Zn-Mn coatings from an affordable, simple and stable ionic liquid, based on choline chloride (ChCl) type deep eutectic solvents (DES) on high strength steel has been achieved. In addition, a separate aqueous bath was prepared for electrodeposition of Zn-Mn as a comparison material.

(iii) Bend test passed with No Flaking, Electrochemical corrosion tests analysis in distilled water as well as 3.5% NaCl solution, In distilled water : OCP (ZnMn) :- 0.958 V vs. SCE Ecorr (ZnMn) :- 0.965 V vs. SCE In 3.5% NaCl solution OCP (ZnMn) :- 1.05 V vs. SCE Ecorr (ZnMn) :- 1.07 V vs. SCE Ref. Corrosion Science 53 (2011) 1489-1497 (In 3.5% NaCl solution) Ecorr (Cd) :- 0.76 V vs. SCE Ecorr (Zn-Ni) :- 1.11 V vs. SCE

There are three tasks planned for upcoming quarters:

1. Salt-spray test and Hydrogen embrittlement (HE) test for as-coated ZnMn coupons
2. Optimization of Mn content in the coatings (ZnMn) and their correlation in the enhancement of corrosion resistance
3. Initiation of ternary alloy (Al/ZnMn) coatings on high strength steel and their electrochemical corrosion analysis

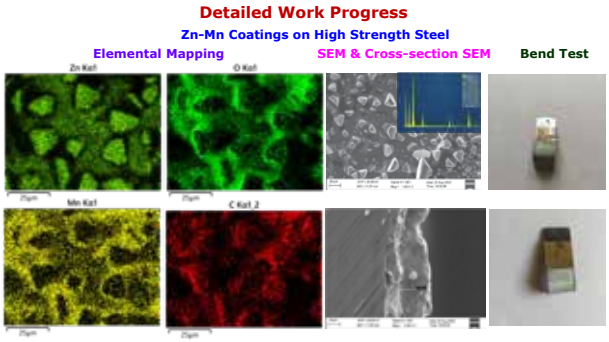


Figure 6: Elemental mapping, SEM & cross-section SEM, and bend test of as electrodeposited ZnMn coated sample on high strength steel sheet

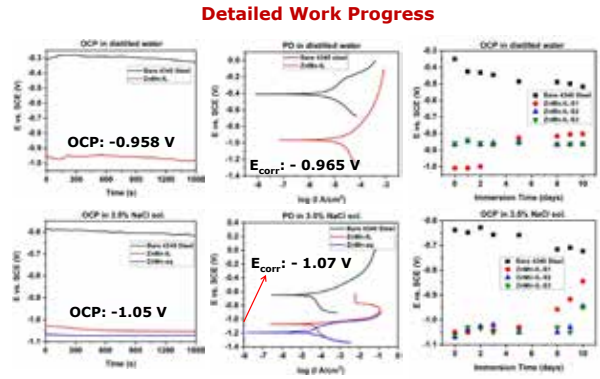


Figure 7: OCP, potentiodynamic polarization and long term immersion OCP studies in distilled water and 3.5% NaCl solution.

Development of Advanced NDE based Diagnosis and Prognosis Protocols for A-USC Power Plants

This project is one of the modules of the consortium project entitled "National Centre for Development of Advanced Materials and Manufacturing Processes for Clean Coal Technologies for Power Applications". The present module aims to address the following:

- NDE for the advanced manufacturing processes like laser and hybrid laser weld quality assessment of Ni-based super alloy.
- Comprehensive data base creation of various NDE parameters to spot onset of damage (Fatigue, Creep Fatigue etc).
- Development of sensor for in-situ structural

health monitoring of engineering components exposed to high temperature and stress.

This module addressed on the development of non-destructive techniques for the advanced manufacturing processes like laser and hybrid laser weld quality assessment of Ni-based super alloy. Hybrid laser-arc welding of nickel-base alloys can increase productivity and decrease costs during construction and repair of critical components in nuclear power plants. The keyhole formed under high laser intensity gives the hybrid welding technique the greater penetration depths compared to arc welding. To assess the quality of welds phased array ultrasonic and ultrasonic imaging were used to measure the level of porosity in terms of their size and locations of the pores inside the weld through proper signal analysis.

Another important objective of this project is multi-parameters NDE measurements of futuristic materials like ODS material. The goal is to develop an appropriate NDT technique for damage evaluation of such kind of components. Under this objective, ODS ferritic steel (Fe Al Cr Ti + Oxide dispersoids) developed at ARCI is characterized using Magnetic Hysterisis Loop (MHL), Ultrasonic(UT), Non-Linear Ultrasonic (NLU) and Eddy Current (EC) based NDE techniques. An Extruded ODS ferritic bent rod with irregular corrugated surface of length 560mm and average dia of 19mm was received from ARCI. As many as 05 specimens were prepared as per ASTM standard that were undergone creep-fatigue interaction tests at two different conditions in interruption mode and subsequently, NDE measurements were performed to generate data-base from the as-prepared till material rupture. The data generated from these measurements could be employed for remaining life assessment of components fabricated of ODS material and operating at high temperature and stress.

The other important aspect of this module is to develop sensor susceptible to high temperature >600°C for real time integrity assessment of power plant components. Assessing and monitoring of such degradation during operation at harsh industrial environment is hindered by non-availability of high temperature (HT) sensors. In this module sensor based on Low Temperature Co-fired Ceramic (LTCC) technology has been fabricated and used for real-time creep damage evaluation at 650°C / 305 MPa till the sample rupture (FIG 1). This will help to overcome the current limitation for real-time integrity assessment of components operating at temperature beyond certain limit and assessment of the extent of damage.

Figure 8: Real-time sensor output during Creep testing at 650°C / 305 MPa using fabricated LTCC-EC sensor

Development of an AI Based Smart Alarm System for Predicting Critical Temperature Zone of Large Industrial Structure

Industrial ducts and pipes carrying fluids at high temperature are refractory lined for protection. Failures of these structures is a catastrophic event causing loss of production and, more importantly, possible loss of life. Despite being refractory lined, these conduits are vulnerable to wear and thermal cracking. A crack in the refractory exposes the pipe to high temperature and thus the monitoring of the thermal condition of these structures is essential. Several examples of such structures exist in a steel plant (e.g. Blast Furnace, Down comer of Pellet Plant etc.). Appearance of a hot spot on the surface of such structure is an indicator of the onset of an unsafe condition. Monitoring hot spots of these structures can be done through thermal camera. Apart from being tedious, such an arrangement is

grossly inadequate as many areas of the structure would not be accessible. Embedded temperature sensors (thermocouples, FBGs etc.) are a viable alternative but embedded sensors sense temperature at discrete points and not all locations in a large structure can be so instrumented. Hence, there is a need to develop an understanding of the thermal conditions of the entire structure through only a few temperature measurements. Under this mission mode project, development of an AI based system that can give the entire thermal picture with acceptable accuracy (90%) based on the minimum number of sensing points was aimed. To develop the AI model, blow pipe of blast furnace was considered. Blast furnaces are an integral part of steel plants, used to produce pig iron from iron ore for subsequent processing into steel. Blowpipe is one of the important components of a blast furnace which transmits preheated air into the blast furnace through the tuyere. During the combustion process in the blast furnace, blowpipes deliver a hot blast of air at 1200 °C and 4 atm. pressure inside the blast furnace. There is a possibility of erosion of the refractory lining of the blowpipe which may result in catastrophe and loss in operations. Due to the erosion of the refractory, the temperature of the blowpipe surface is altered abruptly. Online monitoring of the entire blowpipe surface is essential which is not possible with thermography owing to the inaccessibility of the front portion of the blowpipe. So, there is a need for real-time temperature monitoring of the blowpipe utilizing suitable sensor arrangements considering the environmental constraints. Also, the entire blowpipe body cannot be supported by sensors. So, The Conjugate Heat Transfer (CHT) model of the blowpipe generated via the Finite Volume Method. Multiple hotspots or critical hot zones are created and solved numerically. Based on the CHT model, number of sensors to map the thermal profile of entire blow pipe was optimized to 20. Four arrays of Fibre Bragg Grating (FBG), used as the temperature sensor, each with 5 FBGs were embedded on the surface of a blowpipe. Using the 20 sensor input, an ANN based model was developed to predict the hot spot temperature and an alarm generation protocol was incorporated above the critical temperature. Instrumented Blowpipe is installed at the HBF of Tata Steel in November 2022. Continuous temperature data is getting acquired in the system and prediction of maximum temperature is simultaneously recorded from last 4 months. Figure 9 represents the data logging and hot spot predicting panel of the developed system.

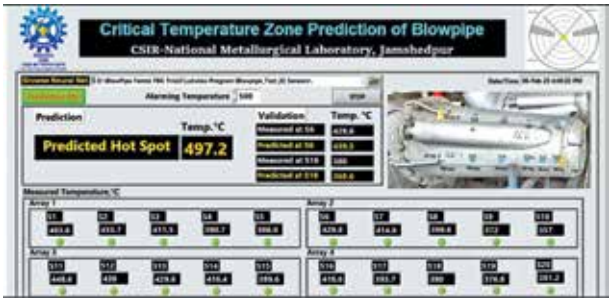


Figure 9: Blowpipe Real-time Data Logging & Hot Spot Prediction Panel

Development of a Multi-Strand Sensing Device with Closed Loop Feedback Control for Real-Time Zinc Coating Weight Measurement In GI Line

Zinc coating is the most effective and widely used process to prevent corrosion and increase the longevity and performance of steel wire. Zinc coating is generally applied to steel wire by hot dip galvanizing (HDG) process. Zinc coating on steel wire gets done by two wiping technologies; Nitrogen (N2) wiping for thick coating lines (100-500 GSM) and pad wiping (30-90 GSM). The N2 wiping system is equipped with sensor-based closed loop zinc control system for controlling individual wire coating weight. In the pad wiping line, as the wires exit the galvanizer, each wire passes longitudinally between a set of two rectangular pads. Individual screw clamping mechanisms are provided to compress each set of pads together to tightly wipe the wire. There is no such real time automatic control system is existing in the pad wiping line. Present practice is to cut a small piece after each shift and measure the coating weight by dissolving

zinc in a solution. This does not assure uniformity of the coating weight along the few km length of the wire. It results over-coating and also under-coating of GI wires. Hence requirement of real time coating weight measurement in the thin coating line to assure uniform coating weight along the length remained as an unmet requirement. CSIR-NML has developed the technology for coating weight measurement of GI line in thin coating line. Under a sponsored project of Tata Steel (CLP 218), a sensing device with two sensors were installated and commissioned at the HDG lines of Tarapur Wire Mill (TWM) of Tata Steel in February, 2022. Positive feedback of the user industry inspired to develop commercially deployable multi-strand system for galvanized system with 10 wires along with closed loop feedback control provision. Under the CSIR Fast Track Commercialisation (FTC) project fabrication of 10 channel system is under process.

Design and Development of an In-House Barrel Electroplating System for Coating Mg-Based Biodegradable Implants

Bone implants are used to fix and position the broken bones during healing. Currently available metallic bone implants are made of titanium alloy, stainless steel etc. Follow up surgery, stress shielding and damage of tissues by using current metallic (titanium alloy, stainless steel) implants motivated us to develop Mg based degradable bio implants but high corrosion rate of Mg demands suitable surface protection, thus the current project is dedicated to in – house development of small size barrel electroplating system to have proper coating on small implants like pin, screw plates etc. By using barrel electroplating, each portion can be coated perfectly, holding / clamping small implants are not needed, this is versatile i.e. plating several objects at the same time and cascading motion produces a more uniformed metal finish.

Design of the barrel electroplating system is done by benchmarking industrial barrel electroplating system. We maintained drum rpm 2 and accordingly designed every component like gear train etc. Samples need to be kept inside drum which is being rotated by motor via gear train. Samples inside the drum is connected to cathode by wire which has been passed through center of drum. The complete experimental set up is shown in below figure.

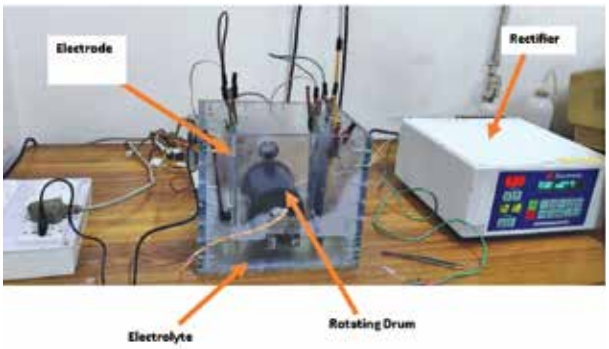


Figure 10: Experimental set-up of Barrel Electroplating System

We successfully developed the barrel electroplating system to coat small implants and able to coat multilayered Zn on bare Mg alloys as shown in below figure. Thus the current project can help us to develop Mg based degradable bio implants which can be commercialized.

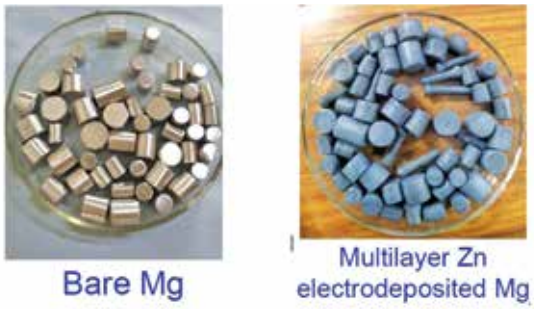
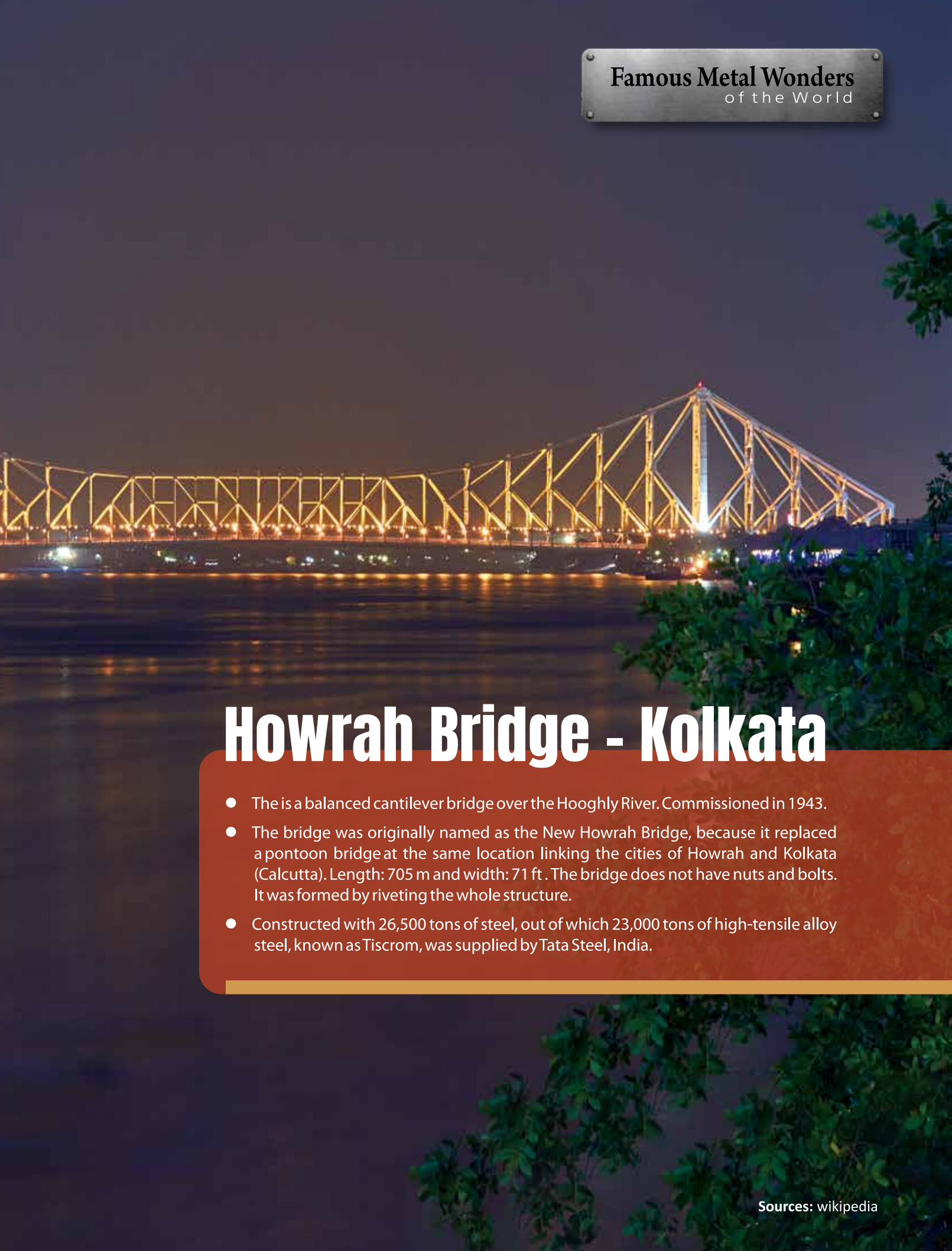


Figure 11: Multilayer Zn electrodeposited on Mg alloy using barrel electroplating

Team -AMP



Howrah Bridge - Kolkata

- The is a balanced cantilever bridge over the Hooghly River. Commissioned in 1943.
- The bridge was originally named as the New Howrah Bridge, because it replaced a pontoon bridge at the same location linking the cities of Howrah and Kolkata (Calcutta). Length: 705 m and width: 71 ft . The bridge does not have nuts and bolts. It was formed by riveting the whole structure.
- Constructed with 26,500 tons of steel, out of which 23,000 tons of high-tensile alloy steel, known as Tiscrom, was supplied by Tata Steel, India.

Sources: wikipedia

Metal Extraction and Recycling

Metals Extraction and Recycling (MER) Division is one of the core R&D divisions involved in process and technology development for sustainable extraction of metal values from primary and secondary resources and valorization of industrial wastes and by-products. The division consists of three major research groups, namely, Ferrous Process, Non-ferrous Process, and, Secondary and Resources Utilization. The major activities of Ferrous Process group are process advancement in agglomeration and utilization of iron ore fines and ferruginous wastes of steel plant, and preparation and quality improvement of different ferro-alloys. The Non Ferrous Process group is actively pursuing research activities in harnessing secondary and lean grade resources for extraction of non-ferrous metal values in either elemental form or as useful compounds and extraction of strategic metals for specialty applications. The Secondary and Resources Utilization group is working on extraction of rare earth and energy metals from secondary resources, and valorization of industrial wastes by converting them to value added products.

Some of the major ongoing programs are urban ores recycling that includes PCB, batteries, magnets, florescent bulb, etc.; and, holistic utilization of red mud (a national mission under the guidance of NitiAyog where three R&D institute namely CSIR-NML, CSIR-IMMT, JNARDDC and three industries namely NALCO, VEDANTA and HINDALCO are participating). The division is equipped with state of the art bench and pilot scale facilities in the areas of hydro, pyro and electro-metallurgy and waste processing. Some of the unique facilities in the division are 'Urban Ore Recycling Centre', Mechano-chemical activation devices, Geopolymer pilot plant, Melting furnaces of various capacities, Solvent extraction units, and many more. Some of the important projects carried out by this division are detailed below.

Development of Briquetting Technique for Utilization of Steel Plant Solid Waste

Several iron oxide fines such as Basic Oxygen Furnace (BOF) sludge, Blast Furnace (BF) sludge, Electro Static Precipitator (ESP) dust, sinter returns, BF flue dust, etc. generated in different units of a steel plant. A major portion of these fines is still unused. The present study aims at utilizing these fines in BOF after producing briquettes. First, the process parameters for good-quality briquettes have been optimized on the laboratory scale. The mix ratio, suitable binder, and its quantity of addition, etc. have been optimized and finally developed cylindrical briquettes in the laboratory scale, which can provide 280 kg/cm^2 cold crushing strength. In the second phase of the project, the large-scale production of briquettes of around 50 tons has been carried out. These briquettes have been used for the plant trial in a BOF of 100-ton capacity to assess its performance. The trial has been conducted successfully in SMS 3 of the Bhilai Steel Plant (BSP). Approximately, 2- 4 tons per heat has been charged in the 160-180 tons capacity converter by replacing a proportional amount of iron ore/scrap as coolant. A total of around 18 heats were conducted in BSP. The furnace operation was smooth. There was no breaking of briquettes during handling, no excessive fumes generation was observed, and better slag formation with normal final slag chemistry.

Smelting of Vanadium Pentoxide for Preparation of Ferro-Vanadium (FeV)

Vanadium is a very important constituent element of several alloy steel which is generally added in form of ferrovanadium during alloy steel making. Due to very limited primary resources in India, a substantial quantity of it is being imported from other countries (Korea, China, Japan, etc.) and a minor quantity is produced from very lean-grade resources and by-products. The present

study aims at preparing Fe-V80 from V_2O_5 by the aluminothermic route. This study develops the process parameters such as the quantity of Al-metal required and its fineness, the requirement of lime, and other conditions to prepare Fe-V from commercial grade high purity V_2O_5 and produce Fe-V80 alloy. The aluminothermic reduction experiments have been conducted at a 5 kg scale to develop the process parameters. Good recovery (>90%) and grade (>80%V) have been obtained. The process has been upscaled to 10 kg V_2O_5 per batch.

Figure 1: Aluminothermic reaction

Figure 2: Product (Fe-V alloy)

Calcined Colemanite / Calcined Ulexite Addition in Pelletizing Hematite Ore To Develop Pellet for Using In Blast Furnace

Colemanite is a mineral of boron which consists of mainly Boron oxide 50%, silicon oxide 7%, and magnesium oxide 2.6%, with a significant amount of combined moisture and other minor impurities. Ulexite is also a mineral of boron which is mainly sodium calcium borate. As B_2O_3 is a very low melting compound, it can decrease the melting point of slag and its viscosity. There may have some beneficial effects of these two B_2O_5-containing materials in the pyrometallurgical system. Therefore, the feasibility of using these two materials in iron ore pelletizing has been studied. It has been found that both calcined colemanite and ulexite can increase the cold-crushing strength of the hematite pellet and may reduce the induration temperature. Reduction degradation properties (RDI) of pellets have also been improved for use of colemanite and ulexite. Other properties need to be investigated to optimize the appropriate addition level of Colemanite and Ulexite.

Development of A Cost Effective Green Technology for Pre Reduction of Chromite Ore in Tunnel Kiln & Production of High Carbon Ferro Chrome in SAF

This project work was sponsored by Ministry of Steel, Govt. of India to utilize chromite ore fines to produce ferrochrome in an innovative way to reduce the power consumption during the process. The proposed process is aimed at application of a tunnel kiln furnace for pre reduction of a mixture of chrome ore, solid reductant, fluxes and binder to around 1350 ^{0}C -1400 ^{0}C to form a direct reduced ferro chrome (DRFC). This DRFC will be further processed in submerged electric arc furnace to produce high carbon ferro chrome. Tunnel Kiln consumes low energy as it is a closed type tunnel furnace with much better heat transfer efficiency and utilization. Hence the pre reduction in tunnel kiln is expected to reduce the overall energy requirement for the production of high carbon Ferro chrome per ton. Conventional SAF process, specific power energy for the production of high carbon Ferro Chrome is approximately 4500 kWH/

Ton to 5000 kWH/Ton. In proposed project the pre reduction of chromite ore in tunnel kiln furnace couple with smelting reduction in SAF furnace would bring down the overall energy requirement to about 3500 kWH/Ton - 4000kWH. Hence the proposed process would approximately save 1000 kWH/Ton of electrical power equivalent. The overall carbon emission of tunnel kiln and equivalent carbon emission of electricity power saved in SAF furnace would reduce drastically. Therefore, the proposed process is expected to an environment friendly process and economically more viable process compared to convention process. Efficiency of subsequent SAF process is also likely to go up due to tap to tap time of furnace will be reduced significantly resulting increased productivity.

23 MT of reduced chrome pellet received at CSIR-NML from M/s MECPL, for reduction smelting trials. 18 pilot plant trails on continuous basis have been conducted on 500 KVA submerged electric arc furnace by varying the reduction parameters to produce 11 MT high carbon Ferrochrome having 52-55% Cr. All the produced 11 MT Ferrochrome alloy and 13 MT slag has been sent to M/s MECPL, Rairangpur to carry out the market survey for commercial use of produced FeCr alloy.

Figure 3: Reduced Chromite in Tunnel Kiln

Figure 4: 500 KVA SAF furnace

Figure 5: Ferrochrome alloy

Hot Stage Engineering of Copper Smelter Slag for Recovery of Iron and Subsequent Use Of Resulting Slag in Blended Cement

Copper slag is a waste produced from copper manufacturing through the pyrometallurgical process. Globally, each ton of copper metal production generates about 2.2-3.0 tons of slag, which is estimated at approximately 40 million tons of slag generation annually. India is generating about 1.7 million tons of copper slag annually. A significantly minimal percentage is utilized for

low-end applications and rest is mostly dumped, thus occupying large space for a longer duration. Till date, this slag has been mostly utilized as aggregates in road construction and concrete, mine backfilling, etc. Few studies highlight to use as supplementary cementitious materials after granulating the molten slag by water quenching. However, its high iron content (~35-60%) and lack of suitable oxide components limit its utilization into blended cement. Therefore, a process that can address both the recovery of high iron value at the molten stage and modify the resulting slag by adjusting chemical composition for subsequent use in blended cement.

The carbothermic reduction smelting of the copper slag by using carbonaceous material, metallurgical coke is carried out to remove Fe from the FeO-SiO_2-(Al_2O_3) slag vis-a-vis modify the liquid slag composition using lime (CaO) to create CaO-SiO_2-(Al_2O_3), which can be a suitable component for blended cement. The raw or pre-calcined limestone is used as a flux. The smelting of the charge mixture is carried out into a 50kVA electric arc furnace at 1500-1600°C temperature and reduced the FeO content into pig iron, which accumulated at the bottom due to inherent high density and finally tapped from the bottom. The chemical composition of extracted metal was 94-96% Fe, 3.5-5% C, and Si 0.5-2%, which can find application in general usage similar to cast iron.

The resulting slag is tapped and water quenched in an indigenously developed granulation tank to get a high reactive glassy material. This modified slag after granulation is grinded and mixed with clinker and tested for Portland slag cement composition. The physical properties of the mortar samples are meeting the Indian standard IS4031:1988.

Scale up Study for the Recovery of Potash Fertilizer and Iron Oxide From Indian Glauconitic Rocks.

This project intends to up-scale the lab scale process for the production of potash fertilizer and iron oxide from Indian glauconitic rocks up to pilot scale level (10-20 kg) for better assessment of techno-economic feasibility. Glauconite is a naturally occurring group of dioctahedral, potassium, iron-rich micaceous clay mineral of marine origin with very low weathering resistant and easily available at surface to sub-surface level. The structure of glauconite consists of dioctahedral T-O-T (Tetrahedral - Octahedral - Tetrahedral) sheets. Potassium and iron were the part of this stable alumina-silicate T-O-T matrix. The biggest challenge in order to utilize glauconite is to break the alumina-silicate structure to recover potassium from this matrix in an economical and eco-friendly way. Along with potassium, iron is also considered as valuable element present in the glauconite. The previously studied and reported processes use high concentration of acid, high solid to alkali ratio, hazardous salts such as fluorides, chlorides etc. to achieve high dissolution of potassium only. For one reason or another, mainly due to availability of highly soluble potash salt of marine origin and process economics, none of these processes has been commercially successful. A careful study of these attempts warrants the statement that solution of this problem depends entirely upon simultaneous recovery of high value by-products along with low value potash.The process developed at lab scale is economic, environment friendly and sustainable in comparison to earlier developed processes. From the overall composition of glauconite and basic structure analysis it is evident that iron is only the week link present in the complex structure of glauconite. It can easily change its oxidation number under different oxidizing and reducing atmosphere thus can break the matrix easily during its conversion to form different species. Therefore, subsequent attempt was made to break the structure by reduction roasting and redox roasting of glauconite before acid dissolution to recover maximum potassium values. The process uses very mild acid for its dissolution that make process cleaner. This process had added advantage

of simultaneous recovery of iron oxides along with the recovery of potash fertilizer. The overall research showed that the recovery of potassium is more than 98% and recovered in the form of soluble salts along with valuable by-product in the form of nano-sized iron oxide particles. Project work is going on smoothly and initial characterization studies are performed. The future/remaining work: Pre-treatment followed by potash and iron oxide recovery from glauconitic rocks.

Impact on Society / Industry :

The final product of this process is potash fertilizer, that is used by fertilizer Industry & iron oxide for pigment industry. This will help more than 60% of India's population whose primary source of livelihood is agriculture. It will also help in reduction the 100% potash fertilizer import.

Development of a Cost-Effective Refractory Lining Materials for Induction Melting Furnace Suitable for Production of Quality Steel: Phase Ii (Industrial Trials)

Generally, the steelmaking route is categorized into two viz are (i) primary steel sector (integrated steel plant) and (ii) secondary steel sector. Primary steel sectors produce the steel through the BF-BOF route whereas secondary steel sectors produce the steel from DRI/Sponge Iron/ Steel scrap using either an electric induction furnace (IF) or an electric arc furnace (EAF). Electric Arc Furnace and Induction Furnace based steel sectors contribute around 57 % of the total steel production in India. The steelmaking through the induction furnace route is approximately 29 % of the total steel production. However, many Indian induction furnaces use acid ramming mass. Due to low spalling resistance and cost, induction furnaces rarely use the basic lining materials. According to BIS standards, the phosphorus content in any structural steel varies between 0.03%.to 0.06% depending on the grade of steel. The presence of high phosphorus in engineering steel components causes cold shortness, i.e. the phosphorus increases the brittle-ductile transition temperature. However, the Induction Furnace route has its own limitations for the refining of liquid metal mainly for the production of low phosphorus and sulphur steel. In view of the above, CSIR NML has developed flux for both sulphur and phosphorous removal in an induction furnace lined with MgO ramming mass to achieve the BIS standards during steelmaking. **Participating institutes:** CSIR–NML, CSIR-CGCRI & NISST

The objectives of the project are to validate the newly developed ramming mass in an industrial induction furnace (a) Suitability of the basic lining mass under basic and oxidising flux (b) To assess the lining erosion pattern during refining (c) Techno-economic feasibility of the lining material. Initially, the laboratory trial in a 40 kg induction furnace at CSIR NML is completed using CGCRI's ramming mass with different varying % of flux materials as per industrial feed ratio. From laboratory experiments, the life of reflationary lining is around 28 heats with treatment with CSIR-NML-developed flux for dephosphorization of steel. The phosphorous in steel is reduced to 0.03-0.04 wt % from 0.10 wt%. with flux treatment on a laboratory scale. As part of this project, the first industrial trials have been conducted in Ispat India on 11-19th July 2022 by NISST, CSIR-CGCRI and CSIR-NML Jamshedpur. Some observations during the above-mentioned plant trials and their preparation for plant trials are as follows:

1. CSIR-CGCRI has supplied 6 tonnes of MgO-based ramming mass to the plant site of ISPAT, Raipur for industrial trial using CGCRI's ramming mass and NML's flux. Moreover, CSIR-NML Jamshedpur has supplied prepared flux to ISPAT, Raipur for industrial trials. However, the trial could not be continued after 9 heats due to bottom leakage.
2. Few operational issues were observed which may be responsible for lower refractory life- i) Improper ramming, ii) power shutdown after ramming, iii) Use of excess water in the top lining iv) water splashing during removal of slag, v) water splashing after each heat to

check lining condition, vi) improper design of the metal forma (vi) Deslagging is the main issue during plant trials. (vii) Temperature is always high (more than 1580 °C).

3. As per lab trials at NML, a minimum of 4-5 wt % flux is required. However, we have added only a max of 3 wt % during the last plant trials. Deslagging is the main issue during plant trials. Temperature is always high (more than 1580 °C) A minimum of 15 minutes of flux treatment time is required and it's crucial as well. However, sometime treatment time may shorten by plant personnel.

4. Phosphorus in steel achieved was 0.035 to 0.045 wt % by flux treatment of 1.5 -2 wt%.

Future Course of Actions:

1. 2nd Industrial trial is required to ascertain the performance of the ramming mass.

2. More no. of trials is required to optimize the flux addition for industrial scale

Figure 6: Melting of DRI and Scrap in 8-Ton Induction Furnace

Figure 7: Deslagging during melting

Figure 8: Treatment of flux in induction Furnace

Figure9: Tapping of steel after flux treatment

Figure 10: Personal from CSIR-NML, CGCRI, NISST and Ispat India

Electrochemical Conversion of CO_2 to Value Added Product

Carbon capture and utilization (CCU) is one of critically important area in Steel and Chemical Industry. The success of CCU relies not only on the capture but also on the recovery of value-added product as the cost of pure CO_2 lies in the lower range. This stresses the point that the valuable product should have high commercial value to accommodate OPEX. In this research proposal,

the electrocatalysis of the CO_2 reduction reaction (CO_2RR) will be explored. This route has potential to produce products of economic value like, CO, acids and alcohols which may have fuel value or can be used as feed stock. Development of economical and efficient catalyst plays a challenging role for the commercial acceptance. In this work, we will develop a two dimensional material supported heterogeneous catalyst for efficient CO_2 conversion to value-added product. The objectives of the project are: Facility creation for electrocatalytic experiments, Development of electrocatalyst, Electrode fabrication, and Performance evaluation of the electrocatalyst for CO_2 reduction. The facilities created under the project are: Single channel electrochemical workstation, Flue gas analyser, Ultrasonic bath sonicator, Type-I and Type-II water purifier system, Analytical balance, Electrochemical cell. With respect to the development of electrocatalyst, procurement of chemicals is going on to synthesize borophene. Ni foam has been purchased for electrode fabrication. After synthesis of the electrocatalyst, Ni foam will be coated. After electrode fabrication, it will be tested for CO_2 reduction.

Figure 11: Electrochemical workstation

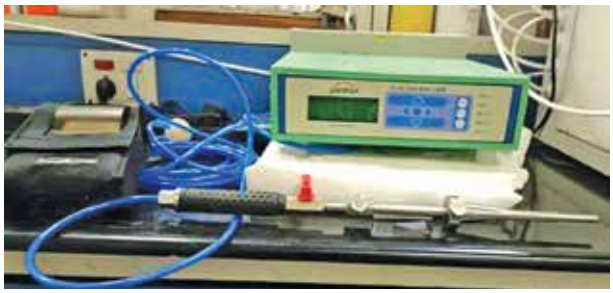


Figure 12: Pantron True gas analyser

Figure 13: Type-I and Type-II water purifier

Technology Development for Holistic Utilization of Red Mud for Extraction of Metallic Values & Residue Utilisation

NITI AAYOG RARE EARTH COMMITTEE chaired by Dr. V.K. Saraswat, paved way for development of a holistic process to extract Al, Fe, Ti and REEs from various red mud samples and its demonstration on 100kg batch per unit operation. This project is being coordinated by CSIR-NML associated with CSIR-IMMT, JNARDDC as R&D labs; and HINDALCO, NALCO and VEDANTA as industrial partners. The project is co-funded by CSIR, Ministry of Mines, and all industrial partners to the tune of Rs. 5.12 crores.

At this stage, Demonstration on 10 kg feed scale red mud has been given to NALCO, HINDALCO, VEDANTA on 16-17th Feb 2023 at CSIR-NML.

The process validation at undergoing for 50kg scale.

Processing of Tin Slag and Technological Extraction of Critical Elements for High Strength Low Alloy Steels

Tin slag is a potential resource of Niobium (Nb), Tantalum (Ta), and other critical metals. With a project supported by Ministry of Steel, it is aimed to recover Nb and Ta as high pure (>95%) salts; and concurrently as ferro-niobium (63% Nb). These products shall be evaluated for applications in steel. The project is governed by objectives to beneficiate tin slag, and use the concentrate/as received sample to extract Nb and Ta, by a non-HF process. At present, the material has been subjected to mineral liberation analysis and flotation circuits. Concurrently, the material has been subjected to hydrometallurgical processing.

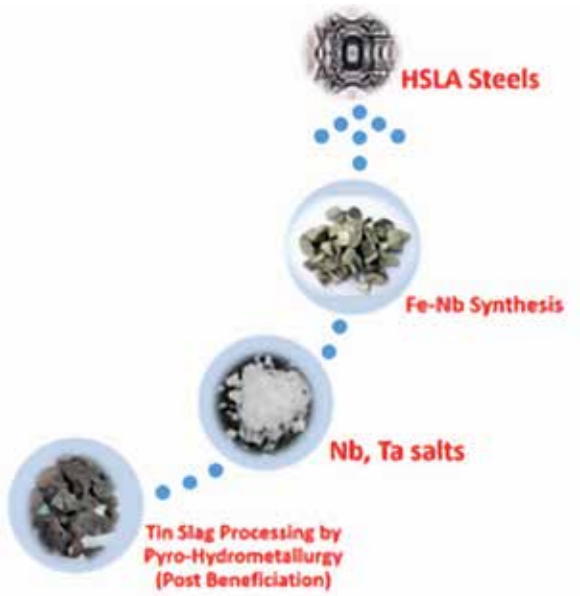


Figure 14: Proposed flowsheet for processing of Tin Slag

Development of Innovative Hydrometallurgical Process for Extraction of Rare Earth Elements From Metallurgical and Chemical Process Wastes (Innova-Rare)

The project aims to extract all metals from RED MUD and PHOSPHOGYPSUM, followed by utilisation of residue for building material and other applications. The work plan of this proposed project (INNOVARARE) are to understand the availability, generation, detailed composition of Red Mud (RM) and Phosphogypsum (PG) Dumps In India, Exploit Them For Efficient

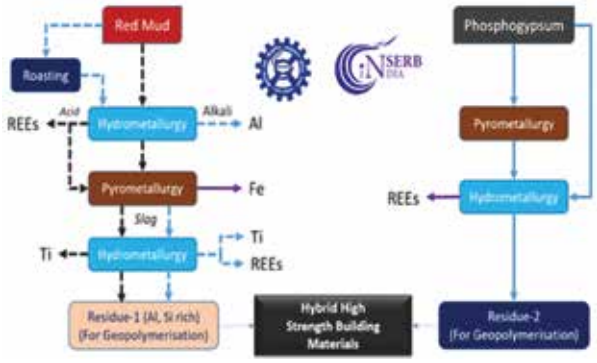


Figure 15: Formulated flowsheet for holistic utilisation of red mud and phosphogypsum

extraction (with individual separation) of Fe, Al, Ti and REEs, and the preparation of new building materials with, followed by scale-up validation and life cycle analysis of process developed. NALCO is the industrial partner in this project.

The work on REE extraction from red mud has been completed. The deliverable to extract REEs from PG is under progress.

Analysis and Upgradation of Subgrade Iron Ore Fines Through Fluidized Bed Reduction with Separation

With the depleting reserves of high-grade iron ore in the world, the high alumina content and the loss on ignition (LOI) of iron ores are expected to gradually increase. Alumina plays a negative role in operation of the blast furnace when the content is higher than the requirement. Therefore, alumina of iron ores should be removed to the low level (lower than 2-2.5 %) to meet the requirement for the feed of blast furnace. Direct reduction in fluidized beds is more appealing, since it is a more environmentally friendly alternative for iron making. To reduce the carbon dioxide (CO_2) emission during iron making operation and make an environment friendly iron making process, the production of iron from low-grade iron ore fines using hydrogen has been used instead of coal /coke in a fluidized bed reactor.

Results

Metallization achieved was:

- 87 % at 1kg scale
- 91% at 250gms scale
- 2.51% Al2O3 was obtained under the optimum conditions

Figure 16: Process Flow Sheet

Geopolymerisation for Radioactive Waste Immobilization

Low level and intermediate level radioactive wastes need immobilization in suitable matrices to restrict their mobility. This is done by stabilizing the radioactive wastes in materials of low aqueous solubility and having good mechanical strength. Encapsulation of low and intermediate level radioactive wastes are typically done in low cost, readily available cement-based substances. Owing to the emergence of novel waste streams, advanced matrices are being explored continuously. This project explores the suitability of geopolymers for such emerging waste streams. The new geopolymer matrix being explored is expected to have a longer durability than that of the cement based matrices, which are currently in use for the purpose. Immobilization of volatile and long-lived fission products (LLFP) such as of technetium, iodine etc. is the ultimate target of this endeavour.

Among the several geopolymer matrices developed, the matrices with fly ash (FA) in combination with ground granulated blast furnace slag (GGBFS) are found to be having the desired characteristics of robustness and low permeability. Based on the compressive strength and porosity values, the formulations with certain proportions of FA and GGBFS were selected. The selected formulations satisfied the other requirements such as durability in water and in various acid media of pH=2.5 (sulphuric acid, hydrochloric acids, nitric acids) also. The samples also conformed to the standard water penetration tests and hydraulic conductivity tests. The leachability of selected elements in distilled water and ground water was within the acceptable limits. The matrix developed (70 mm cubic blocks) were up-scaled to 5kg monoliths initially and then 100 kg monoliths. The preparation of 100 kg product was made utilizing pilot level setup available at CSIR-NML. Radioactive plant adaptation of the process requires a different approach in material handling. Powder/liquid spillage should be avoided. Movement of materials should be minimal during preparation. Owing to the same, options in flowsheets has been provided by NML based on NML's experience and information received from BARC. The figure 1 shows the photographs taken at various stages of 100 kg geopolymer preparation.

Figure 17: Photographs at different stages of 100 kg geopolymer preparation (Clock-wise from top left): Dry mixing, binder addition, transfer to the mold, and vibration

Development of Fire Resistant Lightweight Structural Materials by Hybridization of Inorganic-Organic Polymers

The benefits of using lightweight polymer composites are well known, however their wider adoption has been hindered by uncertainty over their performance when subjected to extreme heat. Lightweight structural materials must retain strength under fire exposure and must be

made from non-flammable or flame retardant materials to limit fire spread, releasing smoke and heat. Significant advantages can be achieved by identifying a material system that is lightweight, fire resistant and has sufficient strength for use in tactical shelters and other structures as well as in aerospace and other transport sectors. In this work, inorganic/organic hybrid geopolymers were synthesized by using metakaolin (MK) and solid organic components comprising an epoxy resin - diglycidyl ether of bisphenol A (DGEBA), and a hardener - dicyandiamide (DICY). Solid organics were chosen to obtain a homogeneous mix upon co-milling all the solid precursors' viz. MK, DGEBA and DICY in a planetary ball mill prior to geopolymerisation. Inorganic/organic hybrid geopolymers synthesized were then characterized for thermal, structural and mechanical properties. Thermogravimetric analysis (TG-DTG) revealed that hybrid geopolymers restricted the degradation of organics (~72% and ~79% organics loss corresponding to 10 mass% and 20 mass% DGEBA addition, respectively) compared to their milled counterparts (~95% and ~100% organics loss corresponding to 10 mass% and 20 mass % DGEBA addition, respectively) suggesting strong inorganic/organic interactions. This was substantiated by structural characterization via X-ray diffraction (XRD) and Fourier-transform infrared (FTIR) spectroscopy. Major changes in DGEBA peak positions (FTIR) and disappearance of DICY peaks (XRD, FTIR) corroborated the MK-DGEBA-DICY reactions during geopolymerisation. Microstructural studies (scanning electron microscopy and transmission electron microscopy) coupled with elemental line scan and area maps, confirmed the homogeneous distribution of organics into the inorganic geopolymer matrix with no phase separation. Figure 18 shows the EDS spectra acquired across a line for a hybridized geopolymer with corresponding elemental distribution profiles shown. Similar distribution profiles of C, Si and Al in the geopolymer gel illustrates the simultaneous presence of the inorganic and organic phases which furthermore implies the chemical reaction and good compatibility between the two. Incorporating 20 mass% epoxy resulted in improved compressive strength from ~20.2 MPa to ~50.6 MPa (2.5 times superior vis-`a-vis only MK-based geopolymer) and higher flexural strength of 5.4 MPa. The significantly enhanced mechanical properties of hybrid geopolymers were indicative of effective inorganic/organic interactions. The physical properties (water absorption, apparent porosity and bulk density) illustrated that the hybrid geopolymers were dense, less porous and lightweight; this corroborated the MIP/BET results. Increased time to ignition and decreased mean heat release rate observed for the hybrid geopolymers demonstrated the flame-retardant effect of hybrids.

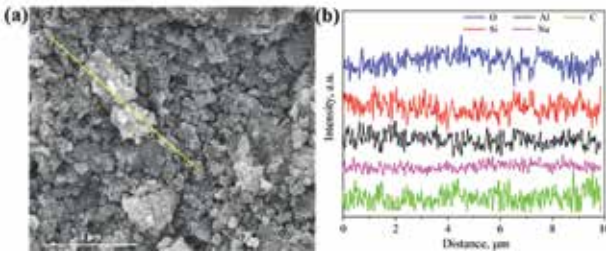


Figure 18: SEM-EDS of the hybrid geopolymer depicting individual elemental distribution profiles across the line.

Team - MER

Minerals Processing

Characterization and Beneficiation Study of Low Grade Iron Ore Sample from Karnataka.

The low-grade Iron ore sample from Bellari District, Karnataka having 50.9% Fe was studied for characterization and detail beneficiation. Objective of the study was to upgrade the Fe content in lumps of +1mm to 58% Fe and fines to 62% Fe. It was found from the characterization study that goethite and hematite are the main iron bearing ore minerals with kaolinite, gibbsite, quartz as gangueminerals (Fig.4). The upgradation of Fe-content in lumps is difficult due to poor liberation characteristics. However, the liberation is quite adequate at finer sizes, below 100 µm. In gravity separation study, air pulsated Batac Jig was used to beneficiate the coarse fraction of -10 +1mm of washed feed. The results show that Fe-content in the product could be possible to enhance to 54.12% with 14.8% yield. Processing of Jig middling with fines produces a product with 60.3% Fe with yield of 23.3% with respect to feed. It has been found that beneficiation of direct fines causes loss of iron values. It was possible to achieve 46.4% product yield with 58% Fe content using a deslimed product of -100 µm feed by two stages magnetic separation.

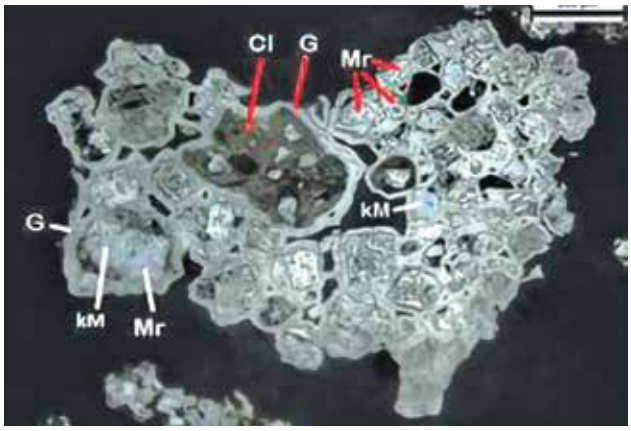


Figure 1: Martite with relict kenomagnetite, clay cemented by colloform goethite. Liberation is possiblebe low 100 micron size

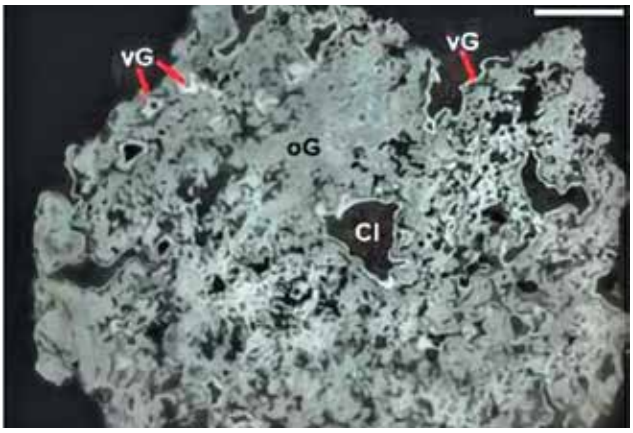


Figure 2: Colloform ochreous goethite and vitreous goethite with clay showing interlocking at very finesize.

Beneficiation of Tailing Samples using Column Flotation

Processing of iron tailing sample is a challenging task as it contains a significant amount of silicates and different types of aluminates as gangue minerals. In any froth flotation process the hydrophobic particles are carried out from pulp zone to froth zone by means of true flotation, but undesirable gangue minerals also report to the concentrate through entrainment and entrapment rather than true flotation. The column flotation process has a substantial advantage over the mechanical batch flotation process for achieving higher grades with reduced maintenance cost as well as better control on the froth depth.

Investigations were carried out to beneficiate two plant tailing samples having Fe-content of around 35% and more than 35% silica with fine particle size distribution (Fig.-2). The objective of the study was to develop a column flotation based process to produce iron concentrate with 55% Fe from 35% Fe. The reverse flotation was found to be effective to improve the Fe-content in concentrate. Different types of cationic collectors were used to float the silicate gangue minerals. It could be possible to achieve more 55-59% Fe with the deslimed feed of

tailing sample.

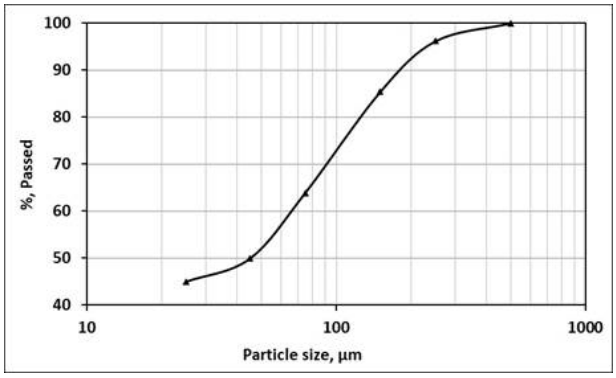


Figure 3: Particle size distribution in as-received Plant tailing sample

Studies on Processing of Iron Ore Sample for Beneficiation Plant at AM/NS, Dabuna

The objective of the project was to undertake studies on the characterization of iron ore samples and accessing the metallurgical performance of hydrocyclone and WHIMS for producing the pellet grade concentrate with a particle granulometry of d_{80}:75 micron (maximum). Studies were undertaken on characterization and assessing hydrocyclone and WHIMS's performance for processing iron ore samples from AM/NS, Dabuna. The as-received sample was assayed 61.60 % Fe, 2.72 % Al_2O_3 with 5.70 % SiO_2, and 2.87 % LOI. A mineralogical study of the sample revealed that the iron ore consists of a substantial amount of goethite and hematite. In a coarser fraction, most of the hematite is interlocked with goethite and clay minerals. The gangue minerals like clay, limonitic clay, quartz, etc., are noticed to be present as fracture filling, cavity filling, vein filling, and grain boundaries minerals. Liberation studies were carried out by modal analysis on different size classes using zoom stereo microscope indicated that interlocking of gangue and ore minerals persists and is significant in coarser fraction. Around 88% liberation of different mineral phases is expected below 0.15 mm. Detailed comminution studies were carried to achieve the desired particle granulometry. Grounded product was processed through hydrocyclone followed by WHIMS to assess the metallurgical performance of the unit operation for the processing of iron ore from Dabuna. Significant variation in concentrate yield (53- 63 wt.%) is observed with 64-66 % iron content. However, considering the desirable particle granulometry around 66-67% by weight (magnetic and middling product), pellet grade is produced with an iron content of around 63.5%.

Figure 4: Laboratory hydrocyclone test rig

Pilot Scale Trial from Oily Bubble Flotation of Coal.

The project was undertaken for analyzing the performance of flotation of coal with the application of an oily bubble. Coal flotation is the most practiced technique to beneficiate coal fines (-0.5 mm) by diminishing impurities. Coal flotation is a multi-phase, complex operation (particles, oil droplets, and air bubbles). The molecules of a reagent and the dissolved ions in water are two examples of additional species with which these phases simultaneously interact. The outcome of the flotation process is determined by the physical and chemical interactions. The main cause of the selectivity issues in coal flotation could be attributed to non-selective particle aggregation resulting from physical and chemical interactions. It can be addressed by physical (conditioning) or chemical (promoters) pretreatment before or during flotation.

In the present work, the collector reagent was purged in the form of vapor along with the air into

the flotation cell to enhance the bubble particle attachment as compared to the Conventional flotation technique. Bubbles coated with a thin layer of oil act as a carrier in flotation ensuring a high collecting efficiency. Oil-coated bubble flotation can eliminate the addition of a collector to the aqueous phase.

Two coal fines (-0.5 mm) samples from two different seams were analyzed and found to be composing ash content of 26.7% and 27.4% respectively. Studies will be carried out with varied parameters like dosage of Collector, frothier, and oil bubble on the flotation of coal fines at the pilot scale of 60-80 kg per hour feed rate. Impactful to coal washery as it can help in reducing the reagent consumption during flotation of coal fines.

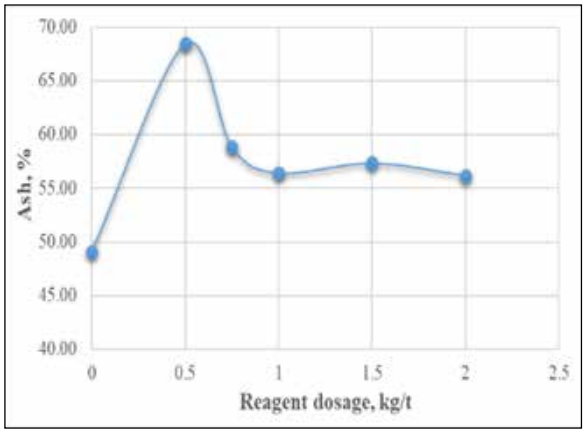


Figure 5: Effect of reagent dosage on Clean coal Ash.

Figure 6: Froth collection during pilot scale trials

A Study on Hydrodynamics Characteristics in Separation of Minerals in a Monolithic Flotation Column (Module-II).

The project aims to develop a monolithic flotation column and to study the effects of Frictional Pressure drop and bubble size distribution in the monolithic flotation column and modeling.

Flotation column is one type of multiphase contacting device where a liquid is in a continuous phase whereas gas and solid are dispersed. It is a function of the probability of particle-bubble collision, attachment, and detachment determining the separation efficiency. To enhance performance of flotation column for beneficiation process, a thorough study of hydrodynamic characteristics has to be carried out as it is difficult to understand the complete behaviour due to their complexity. It has been reported that there is considerable degree of backmixing, low interfacial area due to high coalescence rate, the short residence time of gas bubbles, channeling, non-homogeneous bubble size and its distribution, uneven flow pattern, and pressure drop in the flotation column. All these factors impact and leads to poor separation performance and the targeted output could not be achieved in many industrial flotation columns. In order to minimize the effect of these factors, a monolithic flotation column will be developed. The present study is aimed to explore the effects of pressure drop and the bubble size and its distribution in a monolithic flotation column. Pressure drop measurement helps in the determination of energy required for fluid transportation in a system. Information on dissipation of energy is provided by the pressure drop, which helps in assessment and modeling of the performance of the system. It is also important to obtain information on bubble size and their distribution in the flotation column. Bubble properties determine the gas-liquid interfacial area, an important parameter for the scale-up and design of a system. A higher gas-

liquid interfacial area is available due to the small bubble size, increasing the flotation efficiency. All these research findings will be useful in eliminating the backmixing in the gas and liquid phase, reduce channeling, low coalescence rate and will provide homogeneous bubble size distribution. Modeling and simulation will also be carried out to validate the experimentalfindings. Understanding the effects of frictional pressure drop and bubble size and its distribution will be advantageous in up-scaling the monolithic flotation column. Development of the monolithic flotation column and studying the effects of hydrodynamic characteristics in the monolithic flotation column is ongoing.

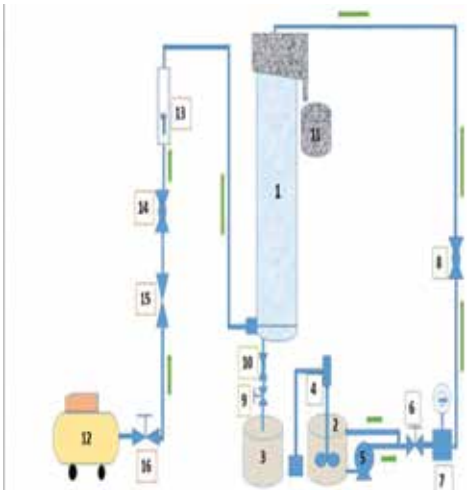


Figure 7: Experimental Set-up of the present work

Figure 8: Newly designed monolithic flotation column Figure

9: Channels inside the column

Continuous Pilot Scale Reverse Flotation of Iron Ore

The increase in production of iron metal in recent times consumes large amount of iron ore as raw material. As a result, there is a depletion of high grade iron ores and the thrust is on beneficiation of low grade ores. Moreover, decrease in threshold value of tailings/reject Fe (< 45%) as per statutory norms demands beneficiation of inferior grade iron ore. These ores comprise hematite, goethite (iron minerals) along with kaolinite, quartz (gangue minerals). Reverse flotation method is used for beneficiation of iron ores wherein silica gangue is selectively floated from iron ore using reagents. The objective of the present study is to obtain an iron rich concentrate with alumina ≤3% with maximum yield and tailings with Fe <45% with maximum alumina from inferior grade iron ore through froth flotation process. The sponsor had carried out studies on different reagent scheme to improve the selectivity of the flotation process. With the encouraging results of batch pilot scale studies (20-25 kg) in earlier project carried out at CSIR-NML, continuous pilot scale flotation of 15 tonnes of de-slimed product of iron ore slime was conducted and validated the bench scale results showed a concentrate of 2.77% Al2O3 with 83.8% yield and tailings with 43.2% Fe at 1kg/ton collector dosage.

Figure 9: Pilot Scale processing of iron ore slime

Dry Beneficiation of Limestone Samples for Removal of Iron Bearing and other Magnetic Impurities

The high-grade limestone resources for white cement clinker production are depleting day by day. With depletion of high cement grade limestone,

presently white cement industry is facing an acute shortage of cement making raw material. To prepare clinker for white cement, it is pertinent to minimize the extent of iron and other transition elements content (titanium, chromium, manganese, nickel and zinc) in the raw mix composition. High-grade limestone containing less than 0.068% Fe2O3 and less than 0.015% MnO is generally used for such purpose. Limestone deposits in Birla White Cement (BWC) mines is highly associated with lateritic coating. The iron in laterite adversely effects the white cement quality. Hence a serious thought is essential not only for detailed exploration of limestone deposits to convert the resources to reserves, but also for development of a cost effective dry beneficiation technique for up gradation of the low and sub-marginal grade limestone.

The current dry magnetic separation results showed the possibility of reduction of iron from 1.5% to 0.08% Fe2O3 for rejected limestone sample and 0.2% to 0.08% for regular limestone. Attempt was also made to reduce the transition elements content from limestone of BWC to improve the clinker quality. Based on characterization and liberation studies, it was explored the beneficiation of limestone through dry magnetic separation and Air table for the separation of contaminants from limestone. In addition, it was also developed beneficiation process for reduction of impurities present in rejected limestone sample at the mining site for its ultimate utilization.

Study on Performance Improvement of Coking Coal Washery Under Coal India Ltd Through Modelling and Simulation Analysis.

The coal quality, its ash content and washability characteristics change from deposit to deposit and even in various seams in a given deposit. So the feed characteristics to washery change over a period of mining. It may affect Plant performance, energy efficiency and cannot be optimized through trial and error method. It needs an evaluation of Washery design, process parameters so as to optimize processing high ash coking coal feed at present. The work aims at steady state plant scale model for unit operations (crushing, classification, flotation, gravity separation) in coking coal washery, and to prediction of optimum parameters for improving the performance of Moonidih coal washery though simulation analysis. Systematic sampling at plant site was carried out and data was generated in the laboratory. The work is under progress.

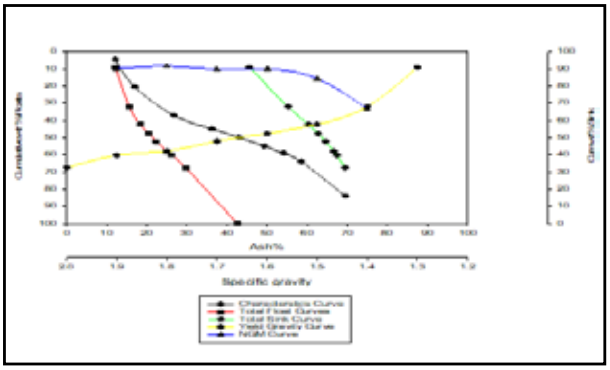


Figure 10 : Washablity Studies (-37+13 mm)

Team : MNP

Materials Engineering

Materials Engineering Division works mainly in four research verticals: Corrosion Engineering, Materials mechanics, Materials processing and Microstructural engineering. The goal of the division is to develop metallic materials, technical support to various industries in materials property evaluation, critical testing, root cause analysis and solution to failed components. The division has state of the art infrastructure: Creep facilities (2nd largest in terms of number of testing points), Fatigue-fracture related equipment, FEG (Field Emission Gun) Scanning Electron Microscopes with EDS, WDS and EBSD as well as FEG Transmission Electron Microscope with EDS and EELS facilities, Gleeble Thermomechanical Simulator, Forming machine for Forming Limit Diagram as well as Hole Expansion Ratio evaluation, Laboratory scale 2 high rolling Mill and various equipment for corrosion rate as well as evaluation of corrosion products.

Effect of Creep-Fatigue Interaction on Disk Forgings

Aero engine manufactures are continuously striving for higher efficiency and therefore, temperature capability of disc alloys is of paramount importance, particularly the 1st stages where the stress and temperature are highest. Temperature gradient in different parts of the disc is schematically shown in Figure 1

Figure 1: Aero engine gas turbine disk's thermal analysis in a high bypass ratio engine showing thermal gradient from Hub to Rim of the disk; Lower the bypass ratio higher will be the temperature

There is a constant endeavor to develop wrought alloys for manufacturing turbine discs with enhanced mechanical properties up to 700°C. Alloy SU 718, which is extensively used for manufacturing turbine discs, is not capable of withstanding temperatures higher than 600°C due to coarsening of γ''. SU 720, which is strengthened by γ' phase, has greater temperature capability and can be processed by conventional forging route. This ability to be processed by conventional route make this alloy a cost effective alternative for application up to 650°C (Please refer to Figure 2). Gas Turbine Research Establishment (GTRE) has also identified SU 720 as a candidate alloy for manufacturing turbine discs for current and future projects and for that extensive experiment on thermal fatigue and creep fatigue interaction behaviour of alloy SU 720 vis-à-vis SU 718 was carried out and shared with the design team of GTRE

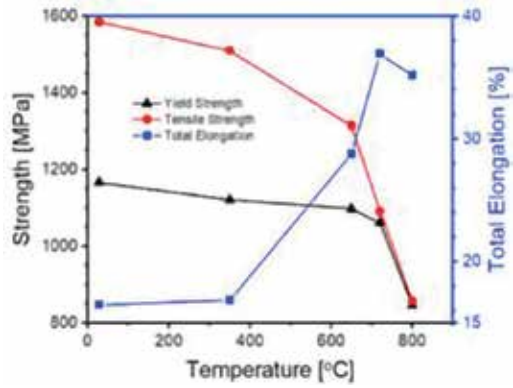


Figure 2 : Variation of tensile properties of SU 720 with temperature. Yield strength remains constant in the temperature range 25 to 650°C.

The fatigue life of SU 720Li alloy is almost 45% higher compare to its predecessor alloy SU 718 tested at 650°C. (Refer Figure 3)

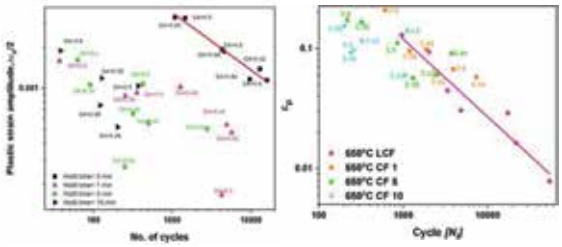


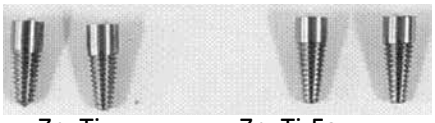
Figure 3: Coffin – Manson plot of SU 718 alloy LCF and CF tested at 600°C and SU 720 alloy LCF and CF tested at 650°C

Multi Component Zr Based Biocompatible Alloys with Modulus ≤50 GPa and Density ~2.8 Gm/Cm³ For Biomedical Application

The primary objectives of the proposed project are a) Development of novel alloys based on the *Zr-Ca-Si-Ti-Fe* system for biomaterial application with

modulus closer to that of bone, b) the targeted alloy modulus should be ≤ 50 GPa and density ~2.8 gm/cm^3, c) Excellent Biocompatible for implant application, Currently development of an ZrTiFe based alloy which is suitable for dental implant application has been achieved. Further, five compositions of ZrTiFe alloy of 450 grams have been prepared at sponsor's premises. Calcium mono Silicide (CaSi) and ZrTiFe master alloy was melted. Consequently, alloy composition of $Zr_{24}.5Ti_{24.5}Fe_2Ca_{24.5}Si_{24.5}$ is modified to $Zr_{24.12}Ti_{24.19}Fe_{1.97}Ca_{20.49}Si_{29.3}$. Very less Calcium was found in developed alloy. Biological test and toxicity test of ZrTiFe alloys are ongoing at the collaborator's premises. It has also been planned to conduct biological test on ZrTiFe alloys and to develop ZrTiFeCaSi alloy.

Relevant images:



$Zr_{90}Ti_{10}$ $Zr_{90}Ti_9Fe_1$

Figure 4: Fabricated ZrTi based dental implant

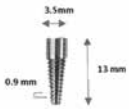


Figure 5: Design of the dental Implant

High Entropy Alloys (HEA) for Hydrogen Storage Application Operable at Room Temperature (Heart)

A CSIR-Mission Mode project having objectives a) Screening of novel HEAs suitable for hydrogen storage through CALPHAD approach, b) development of HEAs using arc melting route with an optimum composition range and c) know-how of bulk scale (1-5 kg) preparation of selected HEAs by induction melting and casting followed by thermo-mechanical processing. This project deals with design and development of multicomponent alloys (often termed as High Entropy Alloys), suitable for reversible solid-state hydrogen storage in ambient temperature. The targeted properties are gravimetric storage capacity of ≥ 2.5 wt.% hydrogen along with near ambient conditions desorption temperatures and pressures. The alloys are intended to possess good hydrogen absorption kinetics as well as cyclic reversibility for possible commercial applications. The final deliverable of the project would be development of high entropy alloy for hydrogen storage. Currently, the project is focusing on activities like CALPHAD based phase equilibria assessment of HEAs focusing on AB_2 type Laves and BCC dominating matrix, arc melting and casting of selected HEAs (05 Nos. (02 Laves and 03 BCC based), microstructural characterization and phase determination of the as-cast state heat treatment study of selected alloys and characterization of hydrogen storage properties of a few selected developed HEAs using Sievert-type PCT apparatus. In future, below activities have been planned:

1. Design of suitable heat treatment schedule to obtain desired phases in the final microstructure
2. Evaluation of the hydrogen storage performance of the arc melted alloys
3. Compositional tailoring based on the hydrogen storage kinetics of the developed alloys
4. Trial for induction melting (1-5 kg) of selected alloys will be taken up for bulk production.
5. Detailed material and hydrogen storage characterization of the alloys

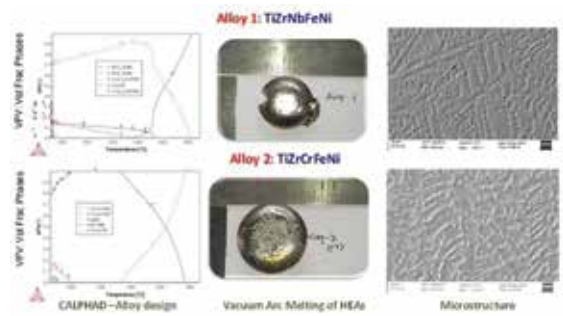


Figure 6: Shows CALPHAD analysis and microstructural characterization of a Alloy

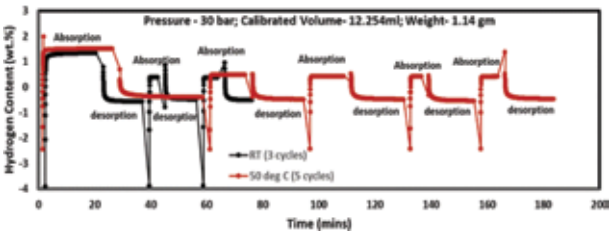


Figure 7: Shows the H_2 absorption not desorption behaviour of Alloy 2

Precipitation Hardened Compositionally Complex Alloys (CCAs) Aided with Hetero-Deformation Induced (HDI) Strengthening

The specific aims of the present work under CSIR-FIRST Scheme are a) to design a new compositionally complex alloy (CCA) along with a process schedule, b) Optimization of the process parameters for superior properties in comparison to some of the existing superalloys and c) to enhance the understanding of heterogeneous deformation

induced (HDI) strengthening mechanism. The project is an effort towards alloy design for high temperature applications using the core concepts of high entropy alloys. Sluggish diffusion and lattice distortion in such multicomponent alloy systems can be beneficial for high temperature stability as well as strengthening. Further, precipitation hardening has been incorporated via design of $L1_2$ phases in face centred cubic (FCC) matrix which is similar to the famous γ-γ′ microstructure observed in superalloys. A suitable thermo-mechanical process schedule for designed alloy/s will be finalized. A suitable design of thermo-mechanical process route for some of the designed alloys seems to be challenging due to high alloying addition and formation of various as-cast precipitates. Mechanical property evaluation to be carried out at room and elevated temperatures. Microstructural stability at targeted temperatures will also be evaluated to assess potential of designed alloys for high temperature applications. Final deliverable will be a novel alloy for high temperature applications, which is expected to exhibit superior mechanical properties in comparison to some of the existing Ni-based superalloys. Ongoing activities of the project are experimental work, design of compositionally complex Ni-based alloys with a high to medium entropy matrix based on CALPHAD approach (Figure 8). All the alloys have been prepared based on induction melting and casting. Initial studies have been carried out on Alloy A and process schedule have been designed for the same. Microstructural analysis of as-cast Alloy A has been carried out (Figure 9). Suitable process schedule design for Alloy A is in progress based on the understanding of recrystallization and precipitation mechanisms (Figure 10). Detailed microstructural characterization of thermo-mechanically process specimens (Figure 11) has been done. The activities planned for future are:

- Design of few more alloys based on CALPHAD approach
- Optimization of thermo-mechanical process route/s for suitable alloy/s
- Detailed characterization of prepared alloys
- Mechanical property evaluation at room and elevated temperatures
- Evaluation of microstructural stability of selected alloys at elevated temperature

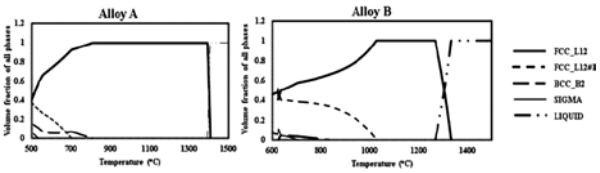


Figure 8: Property diagram designed via CALPHAD approach for (a) Alloy A and (b) Alloy B

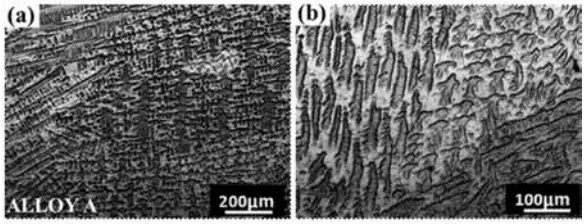


Figure 9: Optical micrograph of Alloy A at (a) low magnification revealing dendritic microstructure (b) high magnification revealing some fine as-cast precipitates at interdendritic regions

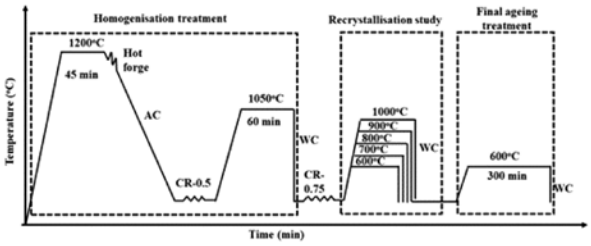


Figure 10. Thermo-mechanical process schedule for Alloy A

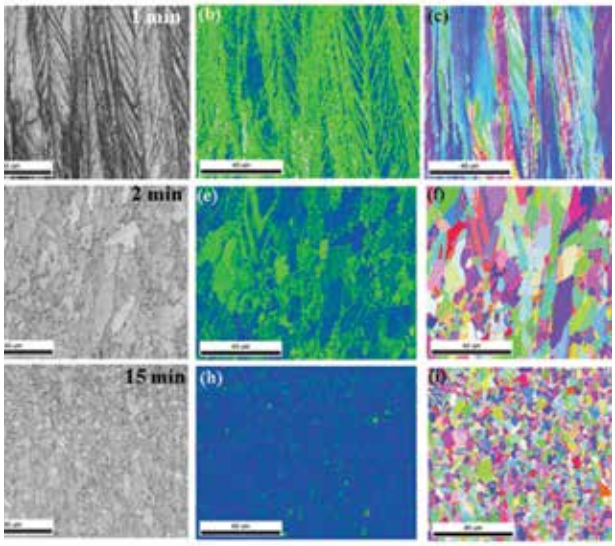


Figure 11: EBSD micrograph of (a-c) 1min annealed sample post cold deformation of 73%. These micrographs show image quality (IQ) map, Kernel Average Misorientation (KAM) map and inverse pole figure (IPF) respectively. (d-f) IQ, KAM and IPF maps for 2 min annealed sample (g-i) IQ, KAM and IPF map for 15 min annealed sample

Investigation on Weldability of 8 and 20 mm Thick High Nitrogen Steel with Strength of about 800 - 1200 MPa

The structure of armoured vehicles is traditionally made by medium carbon low alloy steels with different hardness levels. However, there is always a need for developing newer material which will enable further weight reduction. In this regard, high nitrogen steel (HNS) with high strength and good toughness is a potential material for armour applications. Despite having the desired combination of the properties in the base metal, the weldability of HNS could be an issue due to higher nitrogen content. The objectives **of the work are to** optimize the process parameters in welding HNS of thickness 8 and 10 mm, assess the weldiability of HNS using available filler wires of austenitic and duplex stainless steel grades, evaluate the microstructure, mechanical properties and susceptibility of cracking of welded samples, adopt suitable methodology in controlling porosity within the acceptable limits in the weldments, develop a new filler wire in welding HNS plates with SMAW process based on assessing the weladability using available filler wires. Bulk chemical composition analyses have been carried out for virgin alloy of HNS plates of 8 and 20 mm thickness. The chemical composition (in wt%) of major elements Cr, Mn, Fe and N in both plates are around 19.07, 21.78, 61.30 and 0.5%, respectively. Microstructural characterization has been carried out along longitudinal and thickness direction for both plates. The specimens were examined under optical (Make: Leica DM2500M) and scanning electron (Make: Zeiss EVO18) microscopes to reveal global and specific characteristics, respectively. Figures 2(a)-(b) show the optical images of 8 mm thick plate in longitudinal and transverse directions, respectively. Similarly, Figure 12(c)-(d) exhibit the optical images of 20 mm thick plate in longitudinal and transverse direction, respectively. By and large microstructure exhibited the existence of polygonal austenitic grains containing twins. Qualitatively, 8 mm thick plate exhibits finer grain structure of 7.4 – 9.4μm as compare to 20 mm thick plate of 14.3 – 17.6μm.

The bulk hardness measurement for both type of plates was determined using Vicker's Micro-hardness tester (Model : NVH-AUTO, Make: OMNI-TECH) with load and dwell time of 30 kg and 10 s, respectively. The average values of hardness were 333 – 352 and 252 – 254 HV for 8 and 20 mm thick plates, respectively. The Charpy impact testing has been attempted using instrumented Charpy Machine (Make: Zwick-Roell) for both plates and the toughness was around 40 (±2.7) J at room temperature.

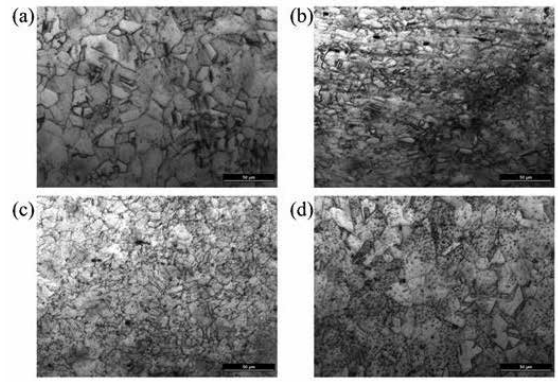


Figure 12 : Optical images of 8 mm thick plate in (a,b) longitudinal and transverse directions, and 20 mm thick plate in (c,d) longitudinal and transverse directions

The tensile tests have been performed in a 50 kN INSTRON 8800 universal tensile testing machine at a crosshead speed of ~0.5 mm min^{-1}. Figure 13 shows one of the representative plots of engineering stress vs. engineering strain of 8 mm thick plate. Reproducibility of data was confirmed by repeating the test for same type of samples three times. The yield strength, ultimate tensile strength, and % elongation of the particular plate were ~975 MPa, ~1137 MPa and ~36.1%, respectively. Other experimentations like fabrication of joints, structural and mechanical characterization of assemblies, corrosion study are in progress as per the commitment portrayed in project proposal.

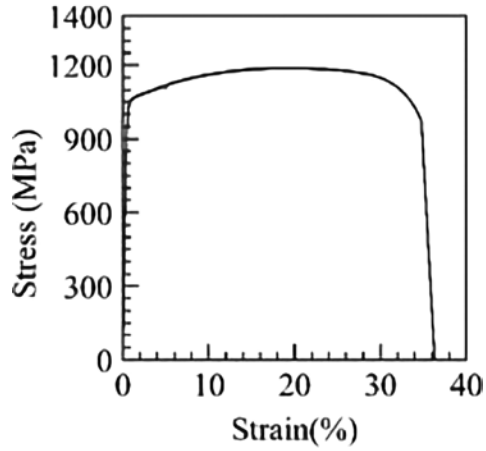
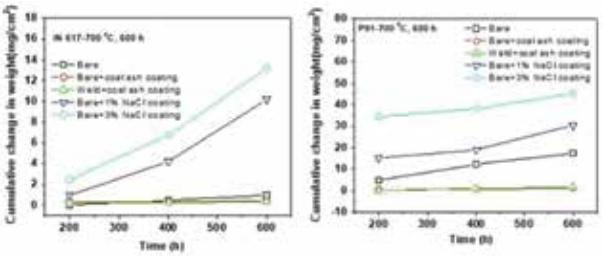


Figure 13: Engineering stress-strain curve of 8 mm thick plate

High Temperature Oxidation and Hot Corrosion Behavior of Selected Materials for Clean Coal Technologies for Power Plant Applications

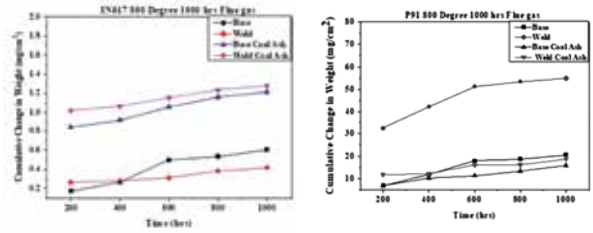
The hot corrosion studies were carried out on unwelded & LH welded IN 617 and P 91alloy samples. The samples were coated with (i) coal ash and (ii) salt coating. The coated samples along with uncoated samples were exposed at 600-800 °C in flue gas environment for 600-1000 h. The major objectives of the study were: oxidation and hot corrosion studies (varied salt elements and proportion thereof) of boiler materials (IN617, P91, T23, T24 and SS347) under varied salt proportions and cyclic loading effects during short and long term exposure, optimization of laser hybrid (LH) welding parameters for their influence on oxidation and hot corrosion behavior, creep-hot corrosion simulation at predefined loads/stress and time, post exposure characterization of specimens and oxide scales subjected to creep-hot corrosion tests and Evolution of possible degradation mechanism.

The hot corrosion studies were carried out on as-received IN 617, P 91 alloys and laser welded IN 617 (W) and P 91(W) alloys with and without coal ash coating exposed to 600-800 °C in flue gas environment for 600-1000h. The hot corrosion kinetics at 600 °C was found to be the lowest for IN 617 (base) followed by IN 617(weld), coal ash coated IN 617(base) and coal ash coated IN 617(weld). While for P91 alloys, the lowest oxidation kinetics were observed for coal ash coated P91 (base) followed by coal ash coated P91 (weld), P91(base) and P91(weld). The change in mass per unit area was found be very low for IN 617 alloy and ranges in 0-1.5 mg/cm^2 while for P91 it is 0.1-7 mg/cm^2. The oxidation kinetics at 700 °C (Figure 14) was found to be the lowest for coal ash coated IN 617(weld) and coal ash coated IN 617(bases) than IN 617 (base). In case of salt-coated samples, the corrosion kinetic was increasing on increasing NaCl from 1-3%, similar kind of behaviour was also observed for the P91 alloy samples. The change in mass per unit area was observed be very low for IN 617 alloy (0.1-12 mg/cm^2) while for P91 it is relatively much larger and ranges from 0.1-40 mg/cm^2. The oxidation kinetics at 800 °C (as shown in Figure 15) was lowest for IN 617(weld) followed by IN 617(base), coal ash coated IN 617(base) and coal ash coated IN 617(weld). For P91 alloys, the lowest oxidation kinetics were found for coal ash coated P91 (base) followed by coal ash coated P91(weld), P91(base) and P91(weld). The change in mass per unit area was low for IN 617 alloy (0.2-1.1 mg/cm^2) while for P91 is (0.1-55 mg/cm^2). The oxide phases formed on hot corroded specimens of the base and welded P91 alloys at various corrosive conditions as identified by XRD. The XRD patterns indexed reveal the major diffraction peaks of Fe_2O_3 and $FeCr_2O_4$ for base and weld specimens (without coal ash coating) of P91 alloys. In case of coal ash coated wot corroded base and welded specimens of P91 alloys, the oxide scale mainly comprised of $FeCr_2O_4$ in addition to other oxides such as Cr_2O_3, $(Na, K)_2SO_4$ and Al_2O_3. The SEM/EPMA characterization of as-received IN 617, P 91 alloys and laser weld IN 617 (Weld) and P 91(Weld) alloys with and without coal ash /salt coating depicted the top surface morphology. On comparison the SEM images, it was obvious that the roughness of the oxide scale formed on IN 617 (Weld) is larger than IN 617 (Base) followed by its corresponding coal ash coated counter parts. The bulk EDS spectrum reflects peak of Ni, Cr, Fe, and O elements which corresponds to presence of $NiCr_2O_4$ in the oxide scale delineated by XRD. The outer surface morphology of the oxide scale formed on base and welded P91 alloys with or without coal ash coated and hot corroded at 700 °C in flue gas environment exposed for 600h. SEM images analysis confirmed, the roughness of the oxide scale formed on base P91 (Base) alloys was larger than P91(Weld) followed by coal ash counter parts. The bulk EDS spectrum on the top surface contained peak of Cr, Fe, and O elements corresponded to formation of Fe_2O_3 and $FeCr_2O_4$ as identified by XRD.



(a) (b)

Figure 14: Weight change per unit area of the specimens hot corroded at 700 °C for 600 h: (a) IN617 alloys and (b) P91 alloys.



(a) (b)

Figure 15: Weight change per unit area of the specimens hot corroded at 800 °C for 1000 h: (a) IN617 alloys and (b) P91 alloys.

Development of High Ballistic Strength Armour Steel with 2 GPa Tensile Strength and Min 50mpam$^{1/2}$ Fracture Toughness

The project aims at the development of an indigenous technology for armour steel with enhanced ballistic performance, which will be extremely useful for Indian Defence. Considering the strength of currently available armour plates, the present work also envisages achieving higher strength to reduce the thickness of steel plates, which will lead to light-weighing. The developed technology can have low cost of production due to no requirement of tempering process, elimination of isothermal holding in conventional Q & P process and reduced and cost-effective alloying additions. In the current project, the steel compositions have been designed with minimal alloying additions and apply novel or recently developed processing scheme to achieve a multiphase microstructure. In addition, the industrial feasibility, i.e. production of these steels with existing facilities has also been considered to avoid difficulties in industrial translation in future. Four different alloys have been designed based on the theoretical simulations, literature review and patent search. These alloys have been treated through various processing schemes, i.e. through (i) 'continuous cooling' to room temperature at various cooling rates and (ii) 'quenching and non-isothermal partitioning' in the bainite and martensite regions (Figure 16). The above-mentioned processing has been applied to eliminate the isothermal holding as required in the tempering and/or conventional quenching and partitioning processes. All the designed alloys have been heat treated, followed by evaluation of microstructure and mechanical properties. The microstructure of steel shows the presence of martensite and retained austenite with some amount of carbides and bainite in some cases. The mechanical properties achieved for the developed alloys are shown in Figure 17, and compared with literature and DMR 1700 data. The results so far suggest the achievement of tensile properties closer to the project target (2 GPa ultimate tensile strength and 7-10% total elongation). Based on these lab scale findings/optimization, one of the best alloy has been chosen for large/pilot scale processing. All of these above research activities are expected to provide an optimized alloy composition and process technology for plant trial in future, followed by indigenous production of armour grade steel. The project could develop a) medium carbon low alloy steel through energy-efficient quenching and non-isothermal partitioning route b) developed an optimized process methodology to achieve advanced high strength combined with good ductility and impact toughness.

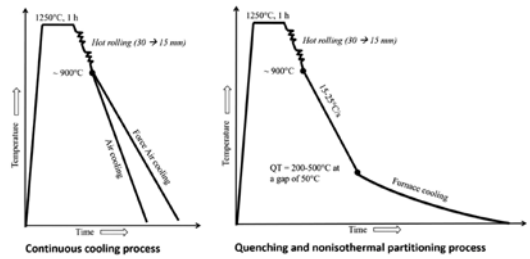


Figure 16: Schematic of the applied processing schedule on designed alloys

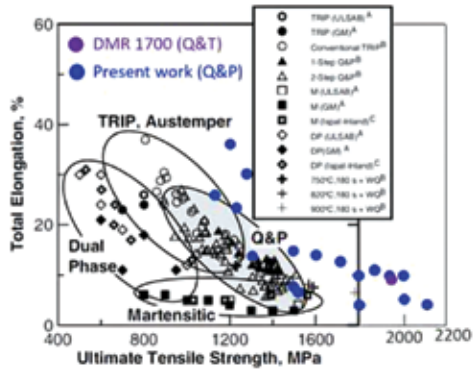


Figure 17: Mechanical properties achieved for the developed alloys compared with literature and DMR 1700.

Unveiling Abnormal Grain Growth Mechanism in Grain Oriented Silicon Steels

The project has objectives of (a) Statistical assessment of the evolution of crystallographic character of grain boundaries surrounding Goss grains by EBSD and its variation with primary recrystallization texture,

(b) Correlations of the evaluated GBCD with the evolution of pinning effect of inhibitors present on the corresponding boundary segments.

Grain-oriented (GO) steels with a strong Goss texture ({110} <001>) are predominantly used in transformers for power generation and distribution. The rapidly expanding power sector of India demands indigenous technologies and know-how for GO steel production, in order to facilitate high-cost import substitution. However, the major challenge in the development of GO steels lies in identifying the suitable precursor

Unveiling abnormal grain growth mechanism in grain oriented silicon steels

Grain-oriented (GO) steels with a strong Goss texture ({110} <001>) are predominantly used in transformers for power generation and distribution. The rapidly expanding power sector of India demands indigenous technologies and know-how for GO steel production, in order to facilitate high-cost import substitution. However, the major challenge in the development of GO steels lies in identifying the suitable precursor microstructure and texture that can exhibit effective abnormal grain growth (AGG) of Goss grains during the secondary recrystallization (SRX) step. The proposed work aims to identify the responsible mechanism for abnormal grain growth of Goss grains in GO steels, for which two 3.2 wt.% Si steels with different aluminum contents (0.02 wt.% and 0.04 wt.%) have been prepared by vacuum induction melting and casting. The variation in aluminum content has been made basically to attain a consequent variation in AlN precipitate fraction, which would act as the major inhibitor (along with minor effect from MnS) for grains other than Goss oriented grains during SRX, thereby allowing AGG. Figure 1 depicts: the process (consisting of vacuum induction melting, casting, hot forging and hot rolling) adopted for lab scale development of hot bands wherein the desired microstructural gradient (i.e. fine recrystallized/partially recrystallized grains at surface and recovered/deformed grains at center) and texture gradient (strong Goss texture at surface and mixture of gamma fiber and alpha fiber at center) are achieved.

Current Status: CALPHAD based phase equilibria assessment; Homogenization of the cast ingots followed by hot-forging till thickness suitable for lab scale hot rolling; Real time cooling profile measurements using thermocouples welded at the center of samples, during each pass (and after each pass) of designed hot-rolling schedule; Microstructural and microtextural characterization of as forged and as rolled specimens (after quenching post each pass of hot-rolling) to understand the microstructural and textural evolution; Rigorous large area precipitate analysis using scanning electron microscopy based energy dispersive x-ray spectroscopy (SEM-EDS) of the hot rolled samples (post each pass) so as to understand the precipitate evolution in terms of fraction, size distribution, position (i.e. at grain boundaries or within grain matrix) and morphology; Design of customized high temperature furnace for annealing under controlled atmosphere along with quenching facility so as to enable various treatments such as decarburization, nitriding, PRX and SRX.

Future Deliverables: Cold rolling and secondary recrystallization annealing process optimization, crystallographic character of GOSS grains and effect of inhibitors on GBCD evolution.

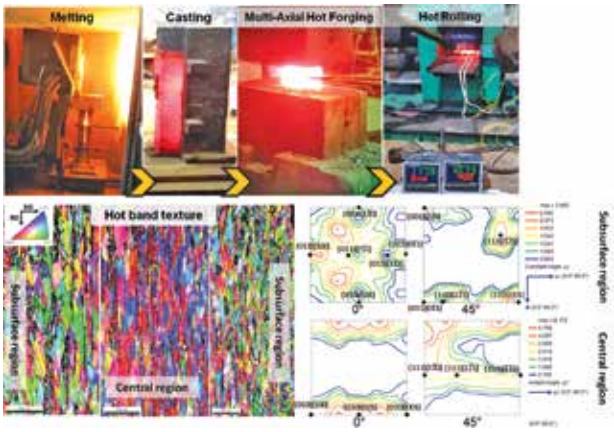


Figure 18 : Processing of the CRGO steel upto hot rolling stage and its hot band texture.

The following activities have been completed with respect to the designed alloys:

- CALPHAD based phase equilibria assessment
- Homogenization of the cast ingots followed by hot-forging till thickness suitable for lab scale hot rolling

- Real time cooling profile measurements using thermocouples welded at the center of samples, during each pass (and after each pass) of designed hot-rolling schedule
- Microstructural and microtextural characterization of as forged and as rolled specimens (after quenching post each pass of hot-rolling) to understand the microstructural and textural evolution
- Rigorous large area precipitate analysis using scanning electron microscopy based energy dispersive x-ray spectroscopy (SEM-EDS) of the hot rolled samples (post each pass) so as to understand the precipitate evolution in terms of fraction, size distribution, position (i.e. at grain boundaries or within grain matrix) and morphology
- Design of customized high temperature furnace for annealing under controlled atmosphere along with quenching facility so as to enable various treatments such as decarburization, nitriding, PRX and SRX.

Future Deliverables : Cold rolling and secondary recrystallization annealing process optimization, crystallographic character of GOSS grains and effect of inhibitors on GBCD evolution.

Material Analysis and Reclamation of Gas Collector for GTG 1250-2E

The objectives of the project are : Development of an in-depth understanding of the Gas Collector material and use it to further its mechanical properties from its existing level, Reversal of the degradation of the material due to service exploitation by selective annealing cycles and Design of a heating process and device for component-level annealing. Our study demonstrated that the microstructure degradation that occurred due to service exploitation could be reversed by heat treatment above the service exploitation temperature. Based on these observations a two-stage annealing/heat treatment cycle is suggested and which is found to recover the deteriorated microstructure

Remaining Life Assessment of Crude and Vacuum Heater Tubes

Crude Distillation Unit-2 which was commissioned in the year 1996 has two heaters i.e. Crude Heater and Vacuum Heater tubes, were operated for more than 21 years and 11 years respectively in stringent conditions. These tubes are prone to exhibit creep related failure due to long-term thermal exposure. The main objective of the present investigation is to assess remaining life of Crude and Vacuum heater tube material supplied by MRPL after service. Residual Life Assessment (RLA) of Crude and Vacuum Heater tubes will be carried out through destructive testing to arrive at remaining life prediction of the heater tubes during shutdown of the plant. Operating parameters were maintained and controlled to avoid overheating failure during service. However total economic loss during shut down of the plant.

Team - MTE

Burj Khalifa - Dubai

- It is the world's tallest manmade structure, having height of 829.8m. Using a bundled tube design to reduce the amount of steel required.
- Constructed with the 31,400 metric tonnes of steel rebar. The building is also made up of 39,000 metric tonnes of reinforced steel and 166,800 sq ft of embossed stainless steel.

Sources: wikipedia

CSIR NML Madras Centre

Research and Development activity related to Flotation and Column flotation of different minerals has been the mainstay of CSIR-NML Madras Centre for the past three decades, as flotation accounts for more than fifty percent of the ore/mineral concentrates generated globally. Additionally, materials evaluation activities are also carried out. The research carried out in the reporting year are indicated below.

Consultancy on Design, Erection, Commissioning of Flotation Column at a Coal Processing Unit

The project work of design, erection, commissioning of 200 tpd flotation column at the Coal Preparation Plant of sponsor for beneficiation of coal fines was executed in collaboration with our engineering partner, M/s McNally Sayaji Engineering Co. Ltd. Bengaluru. The erection of all the mechanical equipment, piping work, electrical and instrumentation was completed. Initial water trials followed by coal slurry feed trials in the flotation column was completed and the plant was commissioned and has been in operation since then.

The below images show the 200 tpd flotation column installed at the Coal Preparation Plant of the sponsor.

Figure 1: 200 tpd flotation column installed at Coal Preparation Plant

Figure 2: 200 tpd flotation column commissioned at Coal Preparation Plant

Figure 3: Image showing froth formation during coal flotation in 200 tpd flotation column

Development of Graphene-Based Membranes from Graphite Ore for Desalination

The project was executed in collaboration with CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram. The objective of the project was to develop a novel, innovative

approach for scalable synthesis of graphene from low-grade graphite ore. This low-grade ore was beneficiated using a newly developed non-petroleum and natural product-based environment friendly flotation reagent as collector for graphite. The graphite concentrate with 4% ash content after six stages of cleaning of rougher float was obtained by flotation of graphite ore. This concentrate was used for the synthesis of graphene powder. The SEM image of the graphite concentrate obtained after beneficiation by the reduction of associated impurities like quartz and silicate minerals in the separation process that intrinsically intercalate graphite, as shown in the figure below, depicts the micro-scale graphite thick layers with exfoliated morphology. Flotation process parameters optimization was carried out using statistical design of experiments (DoE). The flotation performance evaluation of this bio-collector was compared with that of conventionally used hydrocarbon oil as collector. The graphite concentrate obtained by flotation using bio-collector was found to produce concentrate with lower ash content than conventional reagents. This research work on value addition of graphite mineral provides an opportunity for the development of new and cost effective technologies for the production of high quality graphene and its composites.

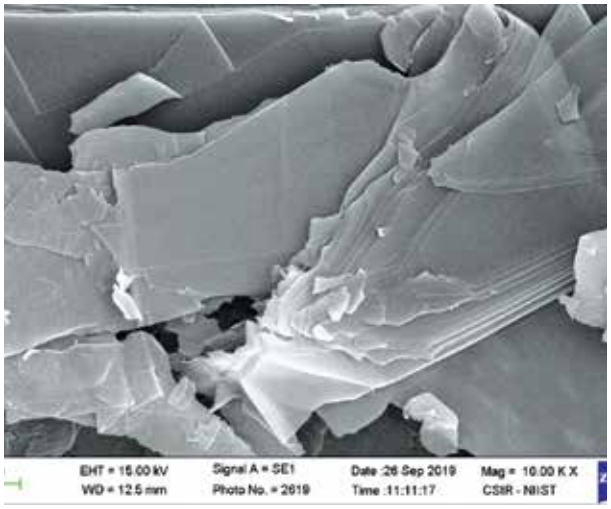


Figure 4: SEM image of graphite final concentrate obtained using the bio-collector

Failure Investigation of Molybdenum Electrode in Glass Melting Furnace

A comprehensive study was undertaken by the Centre. Various metallurgical characterisation techniques were used to establish the failure namely Optical microscopy for micro-structural studies, Scanning Electron Microscopy for microstructural analysis and Fractography studies and energy dispersive spectroscopy for surface corrosion deposits analysis. Based on the results obtained on the failed molybdenum electrode and supported with relevant scientific literature, the molybdenum electrode in the glass melting furnace failed mainly due to the intergranular corrosion / grain boundary corrosion resulted by the exposure of Mo electrode material to corroding elements present in the glass melt. Grain boundary corrosion or intergranular corrosion was due to possible formation of corrosive oxide deposits at the grain boundaries in different combinations which resulted in the grain boundary weakening.

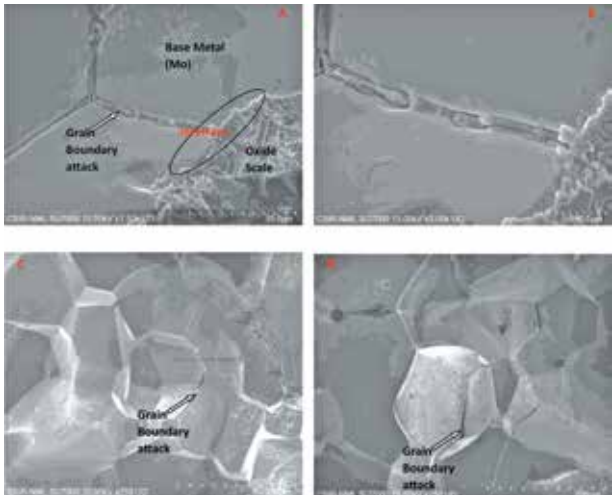
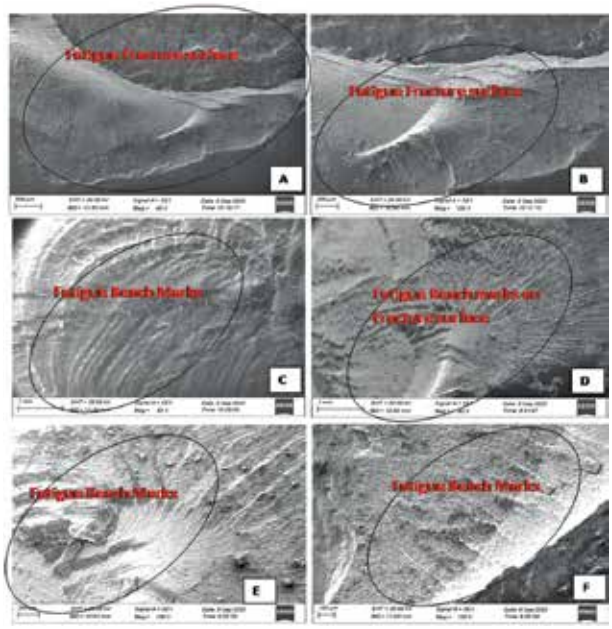


Figure 5 : Microstructural Images

Failure Analysis of Rollers in Slew Bearings of GOTTAWALD make Harbour Mobile Crane

Various metallurgical characterisation techniques were used to establish the failure namely Optical microscopy for micro-structural studies, Scanning Electron Microscopy for microstructural analysis and Fractography studies and energy dispersive

spectroscopy for surface corrosion deposits analysis. Based on the results obtained the failed rollers samples confirmed the fatigue features with beach marks at the crack initiated fracture surface, pitting on the failed surface, spalling on the surface and the elliptical crack opening on the surface and the prevailed damage characteristics on the failed roller samples were clearly confirmed the operation of *rolling contact fatigue (*RCF) on the roller surface.



Metallurgical Failure Analysis of Boiler Tubes of Thermal Power Plant

Various metallurgical characterisation techniques were used to establish the failure namely Optical microscopy for micro-structural studies, Scanning Electron Microscopy for microstructural analysis and Fractography studies and energy dispersive spectroscopy for surface corrosion deposits analysis. Based on the results obtained, it was concluded that the waterside of the tubes were undergone uniform corrosion to the depth of 0.1-0.15 mm from the surface. The firesides of the tubes werere exposed localised corrosion and damage was progressed up to 0.15 - 0.2 mm. Normal localized Iron oxide corrosion was observed on the fireside surface of the tube due to the exposure of tube to atmosphere, and Sodium, Phosphorous and oxygen induced uniform corrosion was observed on the waterside of the tube surface.

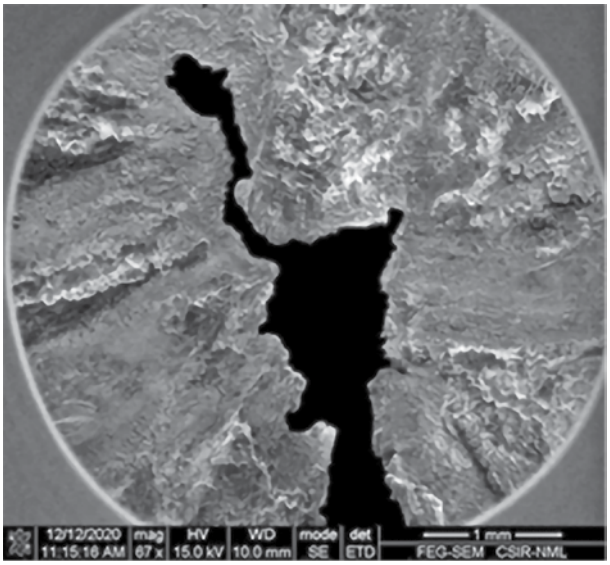


Figure 7: Fracture surface shows the deformation around the crack region and crack tip..

Feasibility Studies on Beneficiation of Low Grade Goan Iron Ore

The project was sponsored to study the feasibility of beneficiation of low grade iron ore from 48-50% Fe to 55-56% Fe by the reduction of alumina and silica content with optimum recovery by adopting suitable beneficiation techniques. The photomicrographs for characterization of the ore are shown in below figures.

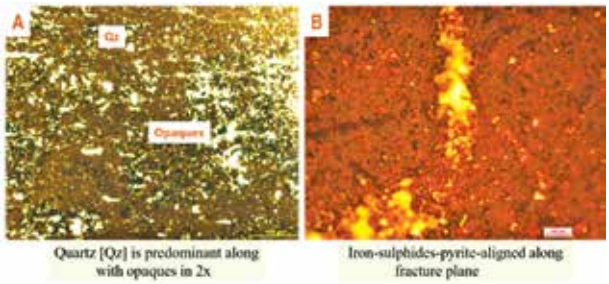


Figure 8: Petrology images of low grade iron ore

From the pertrology studies, the quartz was alternating with opaques and ferro-amphiboles at places. Magnetite phase is isotropic and the polished sections of iron ore sample showed some sulphide specks and concentration along fracture/shear plane. The opaques seen in incident light are clearly

brought out in reflected light in 10x magnification. The liberation and process optimization studies involving multiple unit operations for obtaining a concentrate with 55-56% Fe was carried out by jigging for coarser size-fraction and flotation for fines. A concentrate of 55.64 Fe% was obtained from feed grade of 48-50% Fe under optimized jigging process conditions. Flotation of ultra fines was found to be encouraging.

Feasibility Studies on Flotation of High Magnesia Limestone from Maharashtra

The project was undertaken to study the feasibility of beneficiation of high magnesia limestone sample sourced from Maharashtra by flotation with the objective of obtaining a concentrate with maximum possible recovery and reduction of SiO_2 and MgO. The characterization of limestone sourced from Maharashtra for mineralogy is shown in the below figures.

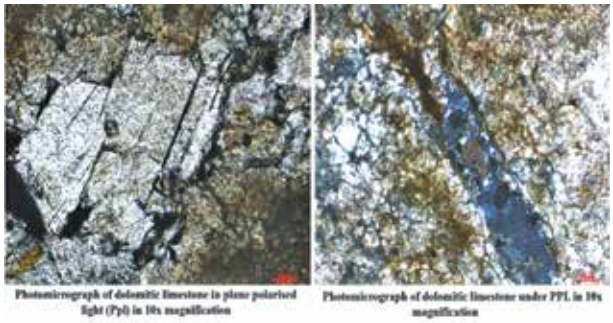


Figure 9: Petrology images of high magnesia limestone

Petrology study of the sample showed medium to fine grained rock and colourless in plane polarized light, rhombohedra cleavage was seen clearly and there was change in relief on rotation of stage. These images show crystalline shapes confirming the presence of siliceous matter. Rhombohedron crystal blocks with non-metallic lustre indicated the presence of calcite and dolomite. Dolomite occurs frequently as a diagenetic alteration of calcite. Secondary dolomite often forms a mosaic of rhombic crystals. The laboratory scale feasibility studies on limestone with a grade of 41.72% CaO, 6.04% SiO_2 and 8.05% MgO for reduction of MgO by flotation using different collectors was carried out. A flotation concentrate with CaO content of 47.44%, 3.57% SiO_2 and 5.19% MgO at optimized process parameters was obtained using eco-friendly collector. It was observed that the sample responds to value addition or quality improvement by substantial reduction of silica and MgO.

Feasibility Studies on Flotation of High Silica Limestone from Rajasthan

The project was undertaken to study the feasibility of beneficiation of high silica limestone sample sourced from Rajasthan by flotation with the objective of obtaining sweetener and cement grade concentrates. The pertrological studies of the high silica limestone revealed that the compaction of the rock compresses it in some directions but opens up tiny fractures in others. The fractures are filled with more carbonate crystals, but these new ones are free of the tiny grains of opaque matter that give the rock its grey colour as shown in below figures.

Figure 10: Petrology images of high silica limestone

Laboratory scale feasibility studies on high silica limestone sourced from Rajasthan analysing 42.21% CaO, 15.71% SiO_2 and 1.22% MgO were taken up for the reduction of SiO_2 and improving the CaO content so as to meet the sweetener grade (CaO ≥ 50% and SiO_2 < 5%) and cement grade (CaO ≥ 43% and SiO_2: 10-12%) for cement manufacturing. A flotation concentrate of 45.60% CaO, 11.4% SiO_2 with 82.97% concentrate weight recovery for cement grade and 48.84% CaO, 5.64% SiO_2 with 43.76% concentrate weight recovery for sweetener grade was obtained by flotation using eco-friendly collector.

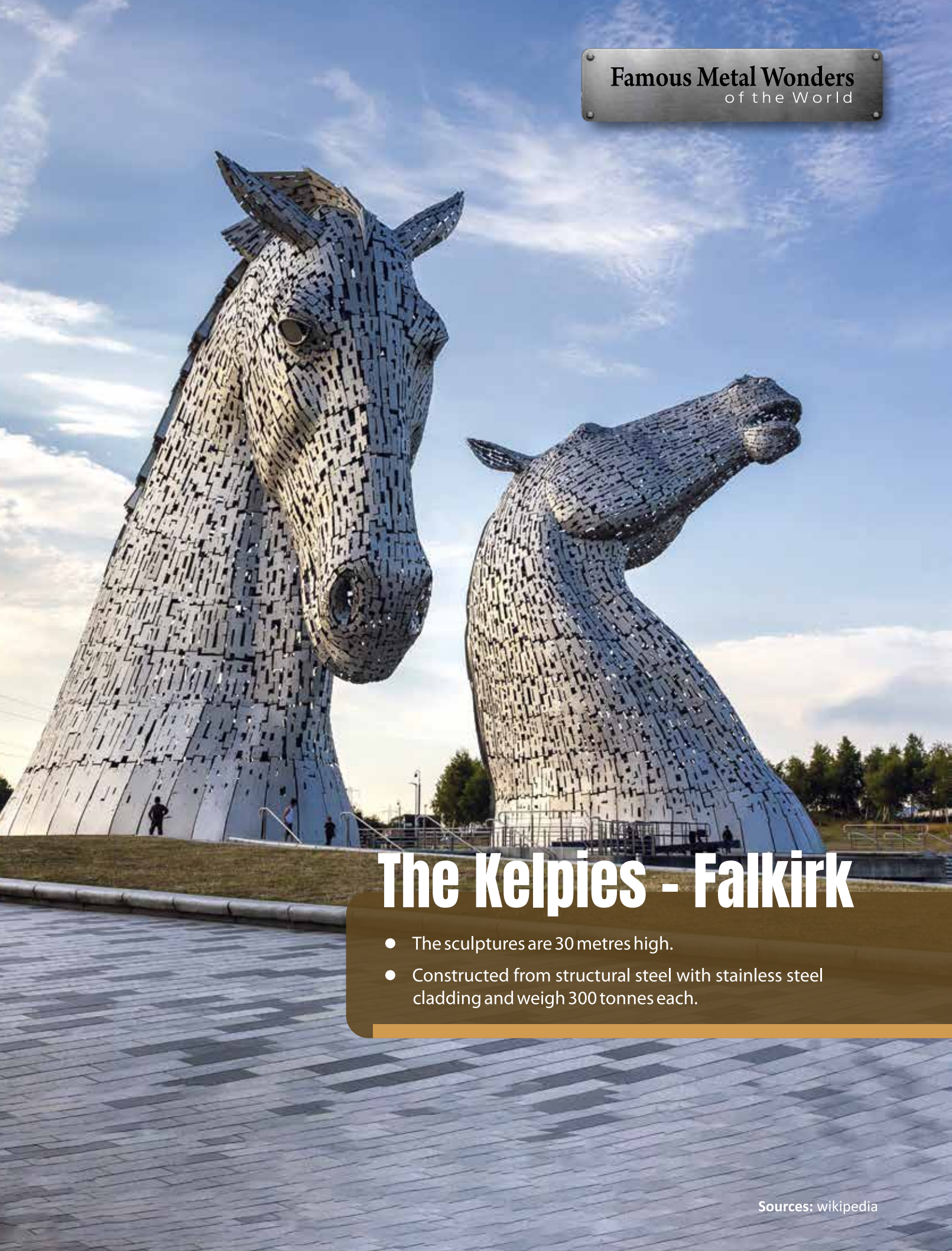
Preparation of DPR on Modernization and Improving Mineral Recovery in Mineral Separation Plant of Sponsor

The project was undertaken to prepare the DPR for modernization and mineral recovery improvement due to the ageing of the plant equipment and advent of modern technologies. The objective of the project also includes assessing the performance of the existing plant. The performance of the wet mill circuit and dry mill circuits of the Mineral Separation Plant was evaluated. The bottlenecks and underperformance of the circuit were identified and necessary remedial measures are being suggested based on the collected plant data.

Preparation of DPR on Wet Concentration Plant No.1 Upgradation & Separating Sillimanite Rich Fraction from the Concentration Plants No.1 & 2 for Sillimanite Recovery Circuit in Ms Plant of Sponsor

The project was undertaken to prepare the DPR for upgradation of wet concentration plant and improving sillimanite mineral recovery. The objective of the project was to analyze the plant's performance by sample collection from the operating plant, identify the bottlenecks and suggest measures for upgradation to achieve optimal performance. The possibility of using floatex density separator for improving the heavy minerals recovery, especially that of sillimanite, is being evaluated.

Team - CSIR-NML-MC



The Kelpies - Falkirk

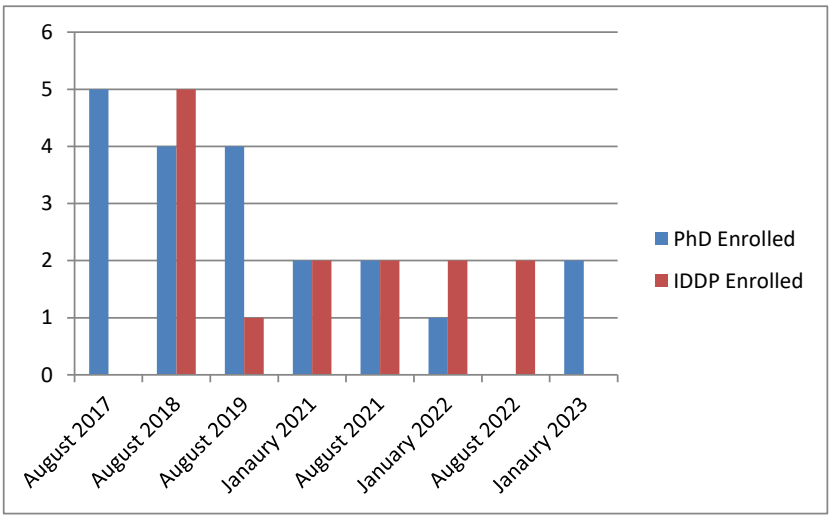
- The sculptures are 30 metres high.
- Constructed from structural steel with stainless steel cladding and weigh 300 tonnes each.

Sources: wikipedia

AcSIR

New Admission Details

January 2023		
Student Name	**Program**	**Sponsorship**
Roshan Kumar	PhD	Internal Candidate
Neelam Sharma	PhD	Self Sponsored



Student Enrollment

Total Number of Students :

PhD : 27

IDDP : 7

The students who complete their doctoral degree in the Academic Session 2022-2023 are-

1. Dr. Dilip Makhija (Industry Sponsored, Tata Steel Ltd.)- June, 2022
2. Dr. Ammasi A. (Senior Scientist, CSIR-NML)- July, 2022
3. Dr. Premkumar M. (Senior Scientist, CSIR-NML)- December, 2022
4. Dr. Biraj Kumar Sahoo (Senior Scientist, CSIR-NML)- February, 2023

Harbour Bridge -Sydney

- World's largest steel arch bridge (not the longest)
- Constructed with 52,800 tonnes steel, with 39,000 in the arch.
- International symbol of Australia. Its 49m wide deck carries eight lanes of traffic, two train lines, a footpath and a cycle path.
- It took nine years to construct the iconic bridgewith the aim of connecting the city's Central Business District to the North Shore. It is the tallest steel arch bridge in the world, measuring 134m above water level.

Sources: wikipedia

Intellectual Property

Patents Filed in FY 2022-23

S.N	Application No.	Title	Inventors	Provisional Filing Date	Complete Filing Date
1	202111039713	A MAGNETO-IMPEDANCE [MI] ARRAY SENSOR AND A PROCESS FOR ARRANGEMENT OF AMORPHOUS / NANOSTRUCTURED MICROWIRES IN AN ARRAY FOR ENHANCEMENT OF SIGNAL RESPONSE	ASHIS KUMAR PANDA, SOMNATH DAS, TARUN KUMAR DAS, PREMKUMAR MURUGAIYAN, RAJAT KUMAR ROY, ABHISHEK KUMAR SINGH	02-Sep-21	13-May-22
2	202111040165	A PROCESS FOR SELECTIVE EXTRACTION-SEPARATION-RECOVERY OF LITHIUM FROM SPENT LITHIUM BASED BATTERIES OF ANY/MIXED CHEMISTRY	Abhilash, Pratima Meshram, Sanjay Kumar	04-Sep-21	01-Sep-22
3	202111040164	A closed-loop process for separation and recovery of Lithium, Nickel, Cobalt, Manganese and Graphite from Spent/Waste/Scrap Lithium based batteries of mixed chemistries	Pratima Meshram, Abhilash, Sanjay Kumar, Vikash Bharti	04-Sep-21	02-Sep-22
4	202211013669	A PROCESS TO RECOVER LITHIUM (Li) AND MANGANESE (Mn) FROM EFFLUENT AND BLACK CATHODIC MATERIAL OF SPENT LIBs	Manis Kumar Jha, Ranjeet Kumar Singh, Jhumki Hait, Pankaj Kumar Choubey, Rekha Panda	11-Mar-22	03-Mar-23
5	202211029391	HIGHLY PURE TITANIUM-BASED MAX PHASE AND PROCESS FOR PREPARATION THEREOF	Pallab Bhattacharya, Nisha Gupta, Trilochan Mishra, Himangshu Bapari	---	20-May-22
6	202211044096	A novel arrangement for clay mould preheating and thereof resin recovery for energy efficient melting-furnace	NIMAI HALDAR, ROHIT BUDDHAM MESHRAM, USHA YENNI, PALASH PODDAR, KANAI LAL SAHOO	---	01-Aug-22
7	202211046652	POST FUNCTIONALIZED METAL ORGANIC FRAMEWORK AND ITS COMPOSITE POLYMER BEADS FOR SEPARATION OF RARE EARTH METAL	Shivendra Sinha, Devabrata Mishra, Kamla Kanta Sahu, Saurabh Shekhar, Archana Agarwal	---	12-Aug-22
8	202211048085	Improved Water-Cooled Rotating Wheel to Produce Thin Alloy Strips	USHA YENNI, NIMAI HALDAR, PREMKUMAR MURUGAIYAN, RAJAT KUMAR ROY, UDAYA BHASKARA RAO MODAVALASA, RAJNEESH KUMAR, ASHIS KUMAR PANDA	23-Aug-22	---

S.N	Application No.	Title	Inventors	Provisional Filing Date	Complete Filing Date
9	202211051486	Magnetically enhanced Dry Gravity Separator	Ganesh Chalavadi, Ranjeet Kumar Singh, Abhishek Kumar, Ajit Kumar Swain, R K Rath	---	08-Sep-22
10	202211059358	A Process for the Production of electrolytic grade Cu, Ni, Co, Mn from the purified leach liquors of e-waste	Manis Kumar Jha, Jhumki Hait, Ranjeet Kumar Singh, Sanchita Chakravarty, Pankaj Kumar Choubey, Rekha Panda, Om Shankar Dinkar	17-Oct-22	----
11	202211076610	Producing Iron-copper alloy and blended cement from smelter copper slag using coal and process thereof	Navneet Singh Randhawa, Susanta Kumar Nath, Sanjay Kumar, Jayati Priya	28-Dec-22	---
12	202311010693	PROCESS FOR EXTRACTION OF LITHIUM AS HIGH PURE LITHIUM CARBONATE FROM SPODUMENE ORE / CONCENTRATE	Devabrata Mishra, Kamala Kanta Sahu, Saurabh Shekhar, Manoj Kumar Mohanta, Shobhana Dey, Kalicharan Hembrom, Tanusree Dutta, Rahul Kumar	---	16-Feb-23

Copyright(s)

Title	CSIR ref. No.	Authors
In-Agreement"- A web-based information system to manage the MoUs of CSIR-National Metallurgical Laboratory	065CR2022	Beena Kumari and SK Pal

Patents Granted FY 2022-23 :

S.N	Title	Inventors	Proisional Filing Date	Complete Filing Date	Application No.	Grant Date	Patent No.
1	AN IMPROVED COKE BASED ENERGY EFFICIENT NON-FERROUS MELTING FURNACE	KANCHAN KUMAR PAUL, DURBADAL MANDAL, PALASH PODDAR, KANAI LAL SAHOO	01-Mar-13	14-Feb-14	0596DEL2013	25-Apr-22	395305
2	An improved process for the production of titanium oxide and metallic iron from Ilmenite	SRINIVASAN RANGANATHAN, DEEPAK CHANDRA SAU, C RAGHU KUMAR, T VENUGOPALAN	---	27-Jul-13	0878KOL2013	07-Jun-22	398702
3	A PROCESS THE RECOVERY OF MAGNETITE AND IRON FROM BAUXITE RESIDUE BY SEGREGATION ROASTING	MAITRYEE BHATTACHARYA, SRINIVASAN RANGANATHAN, SHOBHANA DEY	---	13-Sep-17	201711032401	16-Jun-22	399314

S.N	Title	Inventors	Proisional Filing Date	Complete Filing Date	Application No.	Grant Date	Patent No.
4	AN IMPROVED PROCESS FOR UTILISATION OF POTSH VALUES FROM GLAUCONITIC SANDSTONE	RASHMI SINGLA, RAKESH KUMAR, THOMAS C ALEX	---	08-Jun-18	201811021505	24-Jun-22	399966
5	A PROCESS FOR THE PRODUCTION OF PURE TUNGSTEN POWDER FROM TUNGSTEN-COPPER BORINGS	MANOJ KUMAR, MAITREYEE BHATTACHARYA, DEEPAK CHANDRA SAU, ARCHANA AGARWAL	30-Aug-12	12-Feb-13	2685DEL2012	20-Sep-22	407163
6	A PROCESS FOR THE RECOVERY OF POTASH FROM GLAUCONITIC SANDSTONE	SAURABH SHEKHAR, KAMALA KANTA SAHU, DEVABRATA MISHRA, ARCHANA AGRAWAL	---	05-Jan-17	201711000452	22-Sep-22	407381
7	A PROCESS FOR THE RECOVERY OF POTASH AND HIGH PURE IRON OXIDE FROM IRON RICH GLAUCONITIC CLAY	SAURABH SHEKHAR, SHIVENDRA SINHA, DEVABRATA MISHRA, ARCHANA AGRAWAL, KAMLA KANTA SAHU	---	23-Jan-19	201911002747	28-Sep-22	407825
8	Portable Automated Ball Indentation (PABI) device for In-situ Evaluation of Mechanical Properties of Metallic Components	GOUTAM DAS, KANCHAN KUMAR PAUL, SOUMITRA TARAFDER, SWATANTRA PRAKASH, NANDURY VENKATA SATYANARAYANA, MOUSUMI DAS	---	28-Feb-12	0549DEL2012	20-Oct-22	409500
9	A BIOMIMETIC PROCESS FOR THE PREPARATION OF STEEL FIBER REINFORCED HYDROXYAPATITE POLYMER NANOCOMPOSITES USEFUL AS BONE GRAFTS	SUBHADRA GARAI, ARVIND SINHA, CHITRANGDA SINGH	---	27-Nov-14	3438DEL2014	31-Oct-22	410500
10	A PROCESS FOR THE PREPARATION OF NICKEL-CADMIUM FERRITE FROM SPENT Ni-Cd BATTERIES	Kamala Kanta Sahu, Archana Agrawal, Devabrata Mishra	---	18-Feb-16	201611005646	31-Oct-22	410576
11	A PROCESS FOR CONVERTING NON-COKING COAL TO COKING COAL USING EXPANDABLE GRAPHITE AND MOLASSES	Chakravarty Sanchita, Mohanty ashok kumar, Chakladar Saswati, Sharma Mamta, Das Biswas Rupa, Mallick Subhajit	---	06-Jun-18	201811021093	02-Nov-22	410829
12	AN ENVIRONMENT FRIENDLY NICKEL ELECTROPLATING PROCESS ON MAGNESIUM ALLOY IN NON-AQUEOUS BATH	CHARU SINGH, RAGHUVIR SINGH, SHASHI KANT TIWARI	---	27-Nov-18	201811044639	04-Nov-22	410996

S.N	Title	Inventors	Proisional Filing Date	Complete Filing Date	Application No.	Grant Date	Patent No.
13	A PROCESS FOR THE RECOVERY OF RARE EARTH METALS FROM SCRAP FLUORESCENT TUBES	MANIS KUMAR JHA, AMRITA KUMARI JHA, JHUMKI HAIT, VINAY KUMAR	---	30-Jan-14	0280DEL2014	06-Dec-22	413758
14	An improved process for preparation of briquettes for iron making using iron ore slime and jhama coal	JAGANNATH PAL, SANJAY KUMAR	---	31-Oct-13	1246KOL2013	23-Dec-22	415294
15	A DEVICE BASED ON HIGHER HARMONIC ANALYSIS OF ULTRASOUND WAVES FOR STRUCTURAL DAMAGE EVALUATION OF IN-SERVICE COMPONENTS	SARMISHTHA PALIT SAGAR, NILIMA DAS, INDRANIL CHATORAJ	---	04-Sep-13	2618DEL2013	27-Dec-22	415532
16	A NON-INVASIVE PROCESS FOR SORTING OF ALUMINA RICH IRON ORES	ARPITA GHOSH, TARUN KUMAR DAS, BIBHU RANJAN NAYAK, SARMISHTHA PALIT SAGAR	---	06-Aug-12	2446DEL2012	28-Dec-22	415868
17	Auxiliary Cold Chamber for an improved Annealing Simulator Device	B Ravi Kumar, S K Mandal, Nimai Halder, R K Sharma	---	30-Mar-15	0352KOL2015	04-Jan-23	416702
18	A PROCESS FOR THE PREPARATION OF HIGH CHROMIUM CAST IRON FOR GRINDING MEDIA APPLICATIONS	Minal Shah, Swapan Kumar Das, Kani Lal Sahoo, Gautam Das, Palash Poddar, Sandeep Ghosh Chowdhury, Moolchandra Gupta, Manmohan Rathi, Bharat Kumandas Tanna, Narendra Kumar Singh	---	12-Apr-18	201811013970	06-Feb-23	420589

In-house Project Support Group (i-PSG)

In-house Project Support Group (*i*-PSG) at CSIR-National Metallurgical Laboratory strives to achieve excellence in in-house research by enabling the researchers and supporting their aspirations. The group supports the research in pre-identified thematic areas, on technology development initiatives and researches of scholastic nature leading to masters or doctoral degrees. The aim of these projects is directed towards improvement in performance, relevance and impact of research undertaken. A total of forty-two i-PSG supported projects were in progress during the year 2022-23. Some of the significant outcomes/achievements of these projects are as follows:

- Indigenous development of a planar flow caster (PFC) system at CSIR-NML, which is first of its kind in India. Continuous strip of 5-meter length with average thickness of 250 microns can be obtained at a casting speed of 15 m/s.
- Development of a magnetic hydrocyclone for separating fine magnetic particles from non- magnetic particles. The system is beneficial during beneficiation of iron ore slime. The permanent magnets used can be replaced by electromagnets for having better variability in magnetism.
- A prototype established for producing magnesium at the scale of 15 kg charge with 2.5 kg Mg. This is based on retort technology (Pidgeon process) for Mg metal production using dolomite as primary material.
- "Influence of temperatures on structure, thermoelectric and mechanical properties of nanocrystalline SnSe thin films deposited by thermal evaporation" published in Mater. Today Commun. 32 (2022) 103880.
- "Optimization of selective laser melting (SLM) additive manufacturing process parameters of 316L austenitic stainless steel" published in Transactions IIM 76 (2023) 335–345.
- "Effect of nickel addition on enhancing nano-structuring and suppressing TRIP effect in Fe40Mn40Co10Cr10 high entropy alloy during high-pressure torsion" published in International Pournal of Plasticity 150 (2022) 103193.

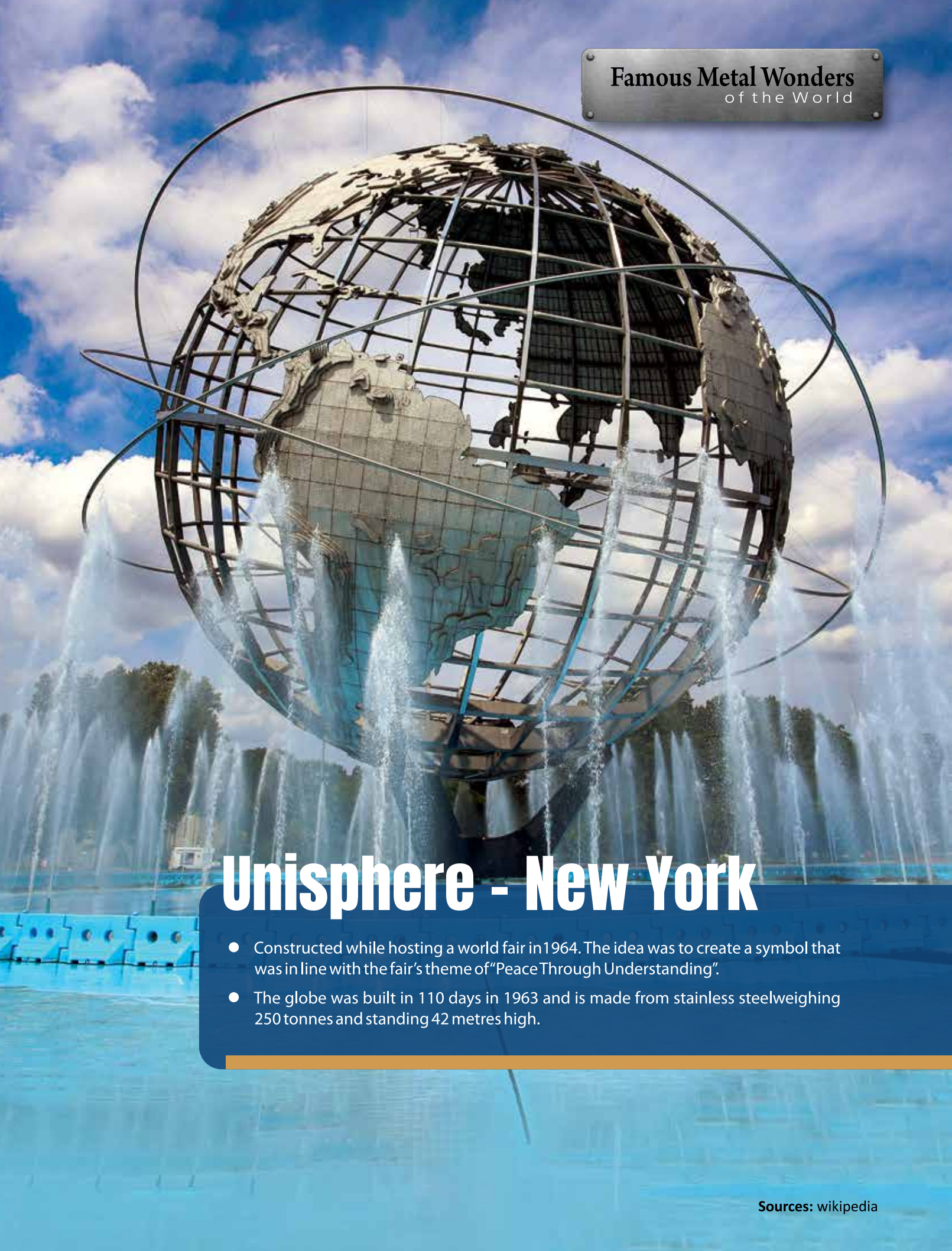
Professor Shilowbhadra Banerjee award for the best in-house project completed in 2020

Dr. Ashok K

Dr. A K Upadhyay

Dr. A K Mohanty

Dr. Ashok K and his team received '*Prof. Shilowbhadra Banerjee award 2022*' for the best in-house project 2020 entitled "Preparation and certification of Hydrogen Standard (CRM) in Steel" from Professor T N Singh, Director, Indian Institute of Technology, Patna, during 73rd CSIR-NML Foundation Day function held on November 26, 2022, in Jamshedpur.

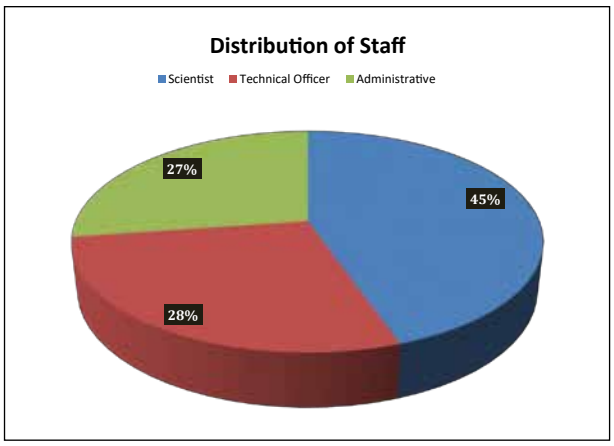


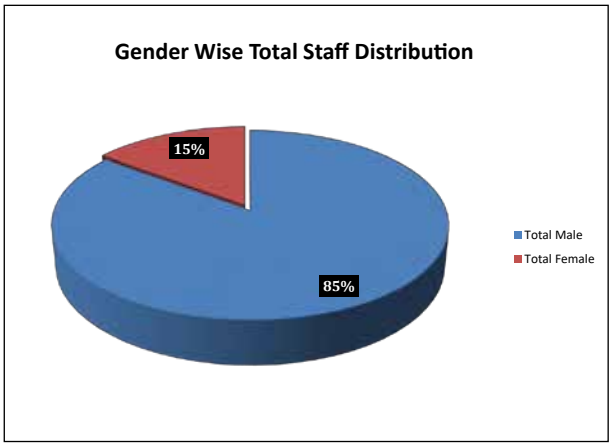
Unisphere - New York

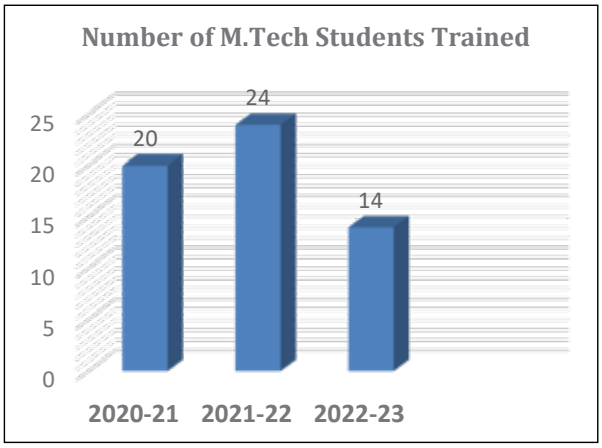
- Constructed while hosting a world fair in1964. The idea was to create a symbol that was in line with the fair's theme of "Peace Through Understanding".
- The globe was built in 110 days in 1963 and is made from stainless steelweighing 250 tonnes and standing 42 metres high.

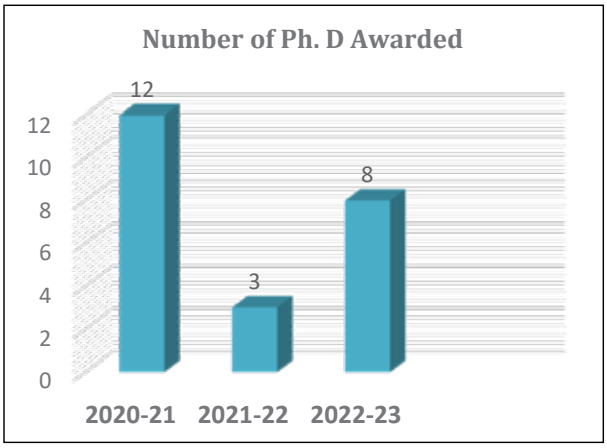
Sources: wikipedia

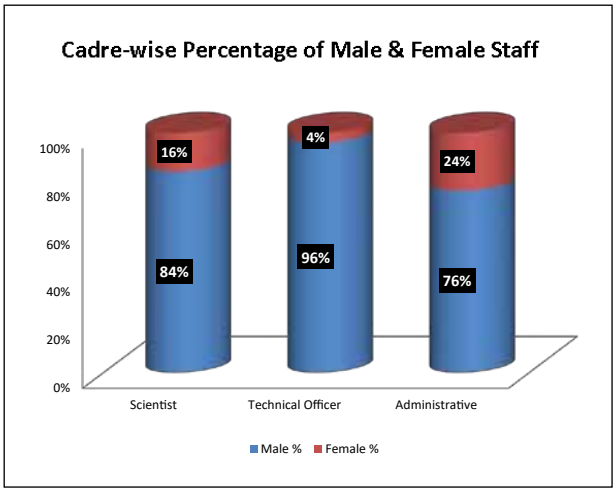
Human Resource

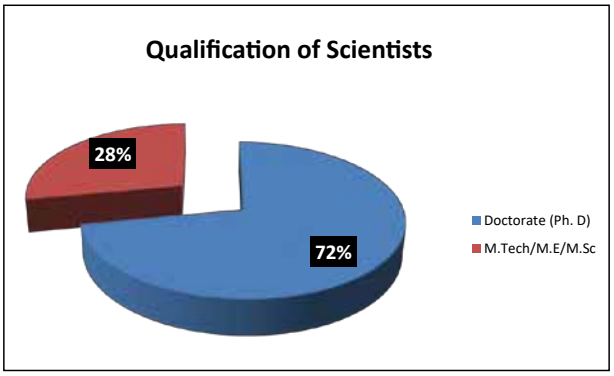


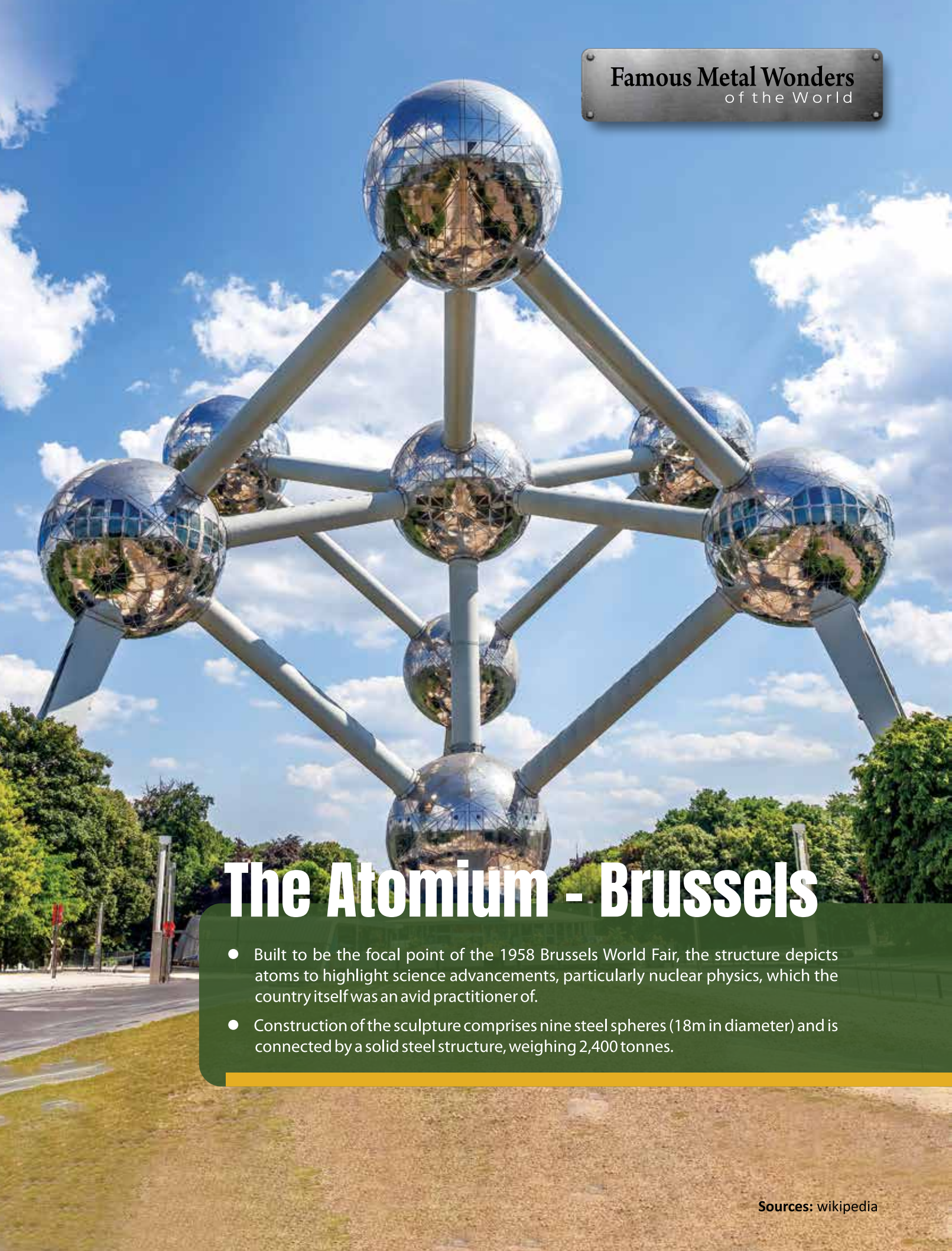












The Atomium - Brussels

- Built to be the focal point of the 1958 Brussels World Fair, the structure depicts atoms to highlight science advancements, particularly nuclear physics, which the country itself was an avid practitioner of.
- Construction of the sculpture comprises nine steel spheres (18m in diameter) and is connected by a solid steel structure, weighing 2,400 tonnes.

Sources: wikipedia

Staff News

NEW JOINEE(S)

(Welcome to the new joinees and wishing them a rewarding career ahead!)

Mr. Ranjeet Kumar
Scientist
D.O.J. 18-08-2022

Dr. Animesh Jana
Senior Scientist
D.O.J. 18-08-2022

Dr. Sreeda P
Senior Scientist
D.O.J. 18-08-2022

Mr. Mudila Danunjaya Rao
Scientist
D.O.J. 18-08-2022

Dr. Satyajit Mukherjee
Senior Scientist
D.O.J. 26-08-2022

Mr. Vankadoth Shiva
Scientist
D.O.J. 28-08-2022

Dr. Mousumi Gharai
Scientist
D.O.J. 28-08-2022

Dr. Nikhil Kumar
Scientist
D.O.J. 02-09-2022

Dr. Vinod Belbanshi
Scientist
D.O.J. 21-11-2022

Mr. Ankur Sharma
Scientist
D.O.J. 25-01-2023

Dr. Alok Kumar Mehar
Scientist
D.O.J. 07-02-2023

Dr. Kuldeep Singh Gour
Scientist
D.O.J. 27-02-2023

STAFF TRANSFERRED FROM SISTER LABORATORY TO JOIN CSIR-NML

Transfer from CSIR-CSIO, Chandigarh

Dr. Suman Tewary
Scientist
D.O.J. 04-04-2022

Transferred from CSIR Headquarters, New Delhi

Mr. Aditya Mainak
Administrative Officer
D.O.J. 14-11-2022

Transferred from CSIR-CGCRI

Dr. (Mrs.) Ranu Verma
Section Officer (G)
D.O.J. 21-11-2022

Transferred from CSIR-IMMT

Mr. Anil Kumar Dash Choudhury
Stores and Purchase Officer
D.O.J. 12-12-2022

STAFF TRANSFERRED FROM CSIR-NML TO JOIN SISTER LABORATORY

"We wish them success in their future endeavors"

Transferred to CSIR-CGCRI, Kolkata

Ms. Monalisa Bhattacharya
Section Officer (G)
16-11-2022

Transferred to CSIR-IMMT, Bhubaneswar

Mr. Ratnakar Behera
Controller of Finance & Accounts
18-11-2022

Transferred to CSIR-IICB, Kolkata

Ms. Rubai Ray
COSP
14-12-2022

STAFF SUPERANNUATED

"We Thank Them For Their Dedicated Survives"

Mr. Tapan Kumar Chakraborty
Multi-Tasking Staff
D.O.J. 30-06-2022

Mr. Ramkumar
PS to Director
D.O.J. 31-08-2022

Shri Abhijit Ghose
Section Officer (G)
D.O.J. 31-10-2022

Shri T. K. Saha
Principal Technical Officer
D.O.J. 31-10-2022

Shri A.K. Arya
Sr. Technician(2)
D.O.J. 30-09-2022

Dr. Indranil Chattoraj
Director
D.O.J. 30-09-2022

Mr. Vimal Kumar Dixit
Laboratory Assistant
D.O.J. 30-11-2022

Dr. Lokesh Chandra Pathak
Chief Scientist
D.O.J. 30-11-2022

Mr. T.K. Mohanty
Sr. Technician (2)
D.O.J. 31-12-2022

Shri Satrughan Singh
Lab Assistant
D.O.J. 31-01-2023

Dr. Arvind Sinha
Chief Scientist
D.O.J. 31-01-2023

Dr. Kapildeo Mehta
Senior Principal Scientist
D.O.J. 31-01-2023

Dr.(Ms.) Archana Agrawal
Chief Scientist
D.O.J. 31-01-2023

Shri. Ramashray Ram
Senior Technician (2)
D.O.J. 31-01-2023

Shri. Mihir Desai
Multi-Tasking Staff
D.O.J. 31-01-2023

Shri. Mahabir Prasad
Multi-Tasking Staff
D.O.J. 28-02-2023

Deputations

International Deputations

Sl. N.	Name & Designation	Participation As	Event/ Purpose	Place of Visit / Organized By	Duration of Visit
1	Dr. Pratima Meshram, Principal Scientist	Researcher	Raman Research Fellowship for 2020-21	Univ. of British Colombia, Canada	20th August-19th November 2022
2	Dr. Sarmishtha Palit Sagar, Chief scientist & GL -NDE & MM Group	Speaker	Invited talk on NDT in AIMTEK-2022:One day Int. Conference	Biz Events Management; AIMTEK International, Abu Dhabi, Yas Island	07th June 2022
3	Mr. Avanish Kumar Chandan, Senior Scientist	Delegate	Symposium on "High Entropy Alloys: Potential For Industrial Applications"	Fraunhofer Institute For Material And Beam Technology IWS, Germany	12th May 2022

National Deputations

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
1	Dr. Sanjay Prasad, Principal Scientist	International Conference on "Powder Metallurgy" and 47th annual technical meeting of PMAI 2022	Association Of Powder Metallurgy, Mumbai	18th -20th April 2022
2	Dr. Sanjay Agarwal, Senior Principal Scientist	Conference on "Technological Advancement In Ferroalloys & Opportunities For Growth"	Steel Tech, Kolkata	11th April 2022
3	Md. Dr. Murtuja Hussain, Principal Scientist	ICS Annual Foundation Day Celebration-2022	Indian Ceramic Society, Jamshedpur	20th April 2022
4	Dr. Sanghita Mridha, Project Scientist-I	9th International Mining, Equipment, Minerals & Metals Exhibition	MGMI & TAFCON, Kolkata	04th -07th April 2022
5	Dr. Aniket Kumar Dutt, Project Scientist-II			
6	Dr. S.K. Nath, Principal Scientist	International Conference on "Refractories"	ICS Jamshedpur Chapter, CSIR-NML, CSIR-CGCRI, Jamshedpur	05th May 2022

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
7	Mr. Chandan Dutta, CSIR-SRF	IEEE IAS Global Conference on "Emerging Technolgies (Globconet) For Humanity"	IEEE Industry Application Society, Greater Noida, New Delhi NCR & Online (Hybrid)	20th -21st May 2022
8	Mr. Aniket Kumar Dutt, Project Scientist-II	International Conference on "Additive Manufacturing and Allied Technologies"	NIT, Tiruchirappali	10th-11th June 2022
9	Mr. Mahesh Gulab Walunj, Senior Scientist	International conference and Exhibition on "Metal, Corrosion & Inspection Technology" (MCI-2022)	MatCorr, New Delhi	23rd -24th June 2022
10	Dr. Manis Kumar Jha, Chief Scientist	National symposium on "Electrochemical science and Technology(NSEST-2021)"	The Electrochemical society of India, Bengaluru, ARCI, Hyderabad, Telangana	24th-25th June 2022
11	Dr. Pankaj Kumar Choubey, Senior Project Associate			
12	Dr. Asit Baran Panda, Senior Principal Scientist	International Workshop on "Water Purification Technologies, Arsenic Removal from Groundwater and Integrated Water Management (IWWPT-2022)"	CSIR-CSMRI, Bhavnagar	28th -30th June 2022
13	Dr. Sanjay Prasad, Principal Scientist	International Conference on Frontiers in Materials for Technological Applications	IMMT, Bhubneswar	03rd-05th August 2022
14	Dr. Arvind Kumar Upadhyay , Senior Technical Officer	6th Proficiency Testing Providers (PTP) / Reference Materials Producers (RMP)	Bengaluru, Karnataka	25th -26th August 2022
15	Dr. Abhilash, Senior Principal Scientist	One Day Workshop on NEP-2020	Karim City College, Jamshedpur and NASI Jharkhand	05th September 2022
16	Dr. Sanchita Chakravarty, Chief Scientist	Annual Meeting and Symposium of "The International Committee for Coal & Organic Petrology (ICCP 2022)"	CSIR- Central Institute of Mining and Fuel Research, Kolkata	18th -25th September 2022
17	Ms. Riya Banerjee, Project Associate-II			
18	Dr. Rajen Kundu, Scientist			
19	Mr. Alok Kumar, Sr. Scientist			
20	Ms. Saswati Chakladar, Senior Project Associate II			
21	Mr. Mahesh Gulab Walunj, Senior Scientist	A Course in "Atomistic Modeling for Microstructural Evolution"	Indian Institute of Technology, Bombay	19th-30th September 2022
22	Dr. Sushanta Kumar Nath-Principal Scientist	Conference on "Valorization of Fly Ash & Steel Slag: Challenges, Innovation & Future Trend"	Tata Steel, Jamshedpur	22nd-23rd September 2022
23	Dr. Ammasi A, Senior Scientist			
24	Mr. Aniket Kumar Dutta, Project Scientist			
25	Ms. Sanghita Mirdha, Project Scientist			
26	Dr. Rachit Ghosh, Principal Technical Officer			
27	Ms. Sonam Kumari, Project Associate			
28	Mr. Surojit Kundu, Scientific Administrator			

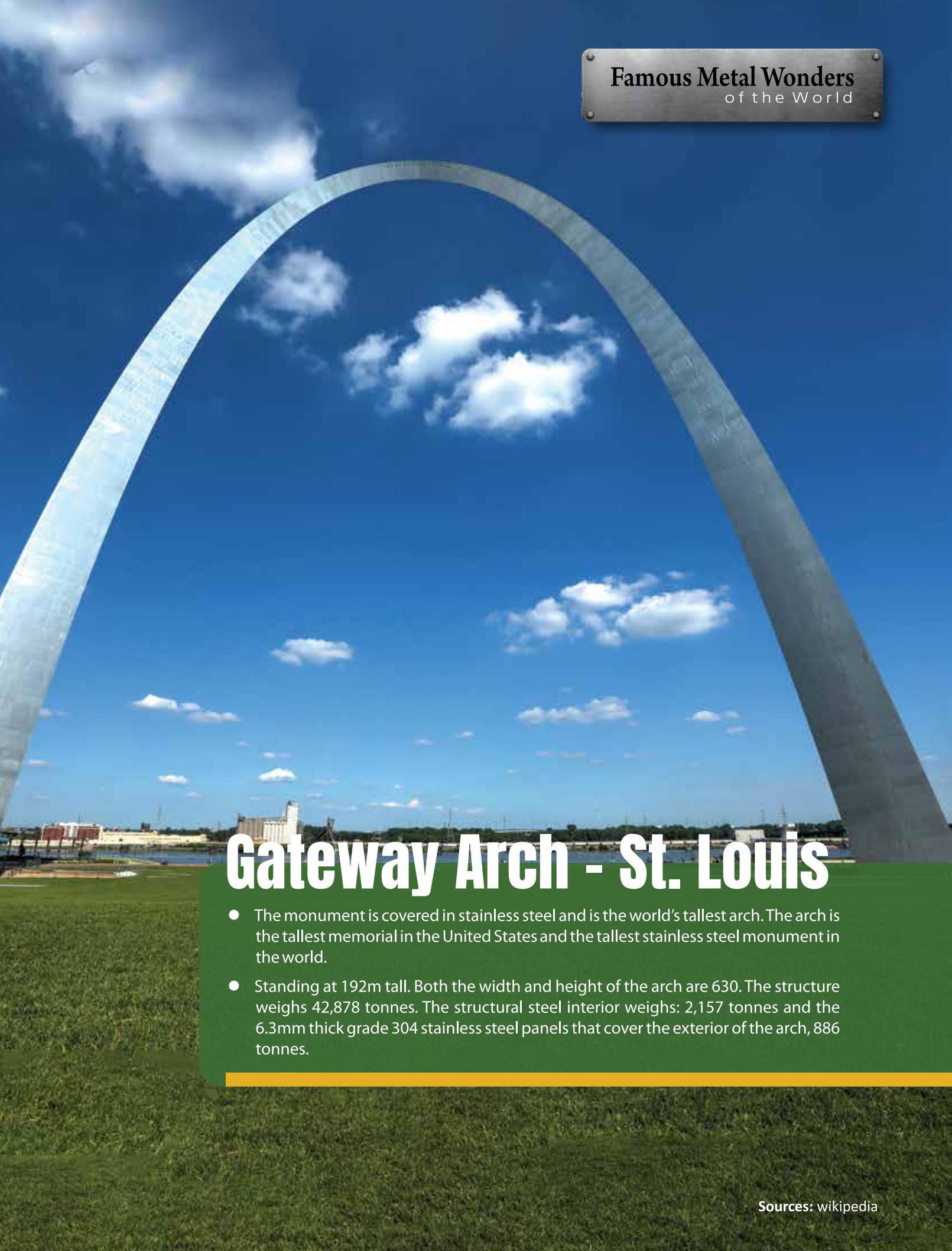
Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
29	Mr. Mahesh Parmanik, Field Worker	Conference on "Valorization of Fly Ash & Steel Slag: Challenges, Innovation & Future Trend"	Tata Steel, Jamshedpur	22nd-23rd September 2022
30	Dr. Sanjay Kumar, Chief Scientist			
31	Dr. Madan M, Principal Scientist			
32	Dr. Navneet Singh Randhawa, Senior Technical Officer(2)			
33	Dr. S.K Sahu, Senior Principal Scientist	National Conference on "Science, Technology and Applications of Rare Earths (STAR-2022)"	Rare Earth Association of India, Tirupati, Andhra Pradesh	22nd-23rd September 2022
34	Dr. Mita Tarafder, Chief Scientist	Training of Master Trainer	Management & Entrepreneurship and Professional Skills Council	26th September- 01st October 2022
35	Dr. Rajen Kundu, Scientist	Online Training on "ISO/IEC 17025:2017 Requirements" and Internal Audit	Dr. S.K Breja, Quality Guru	11th-14th October 2022
36	Mr. Pankaj Kumar, Senior Technical Officer(1)	Workshop on "Capacity Building in Manufacturing Aligned Technology"	CMERI, Durgapur	11th-14th October 2022
37	Mr. Roshan Kumar, Scientist			
38	Mr. Nimai Haldar, Senior Technical Officer(1)			
39	Dr. Manoj Kumar, Senior Principal Scientist	Conference on "Advances in Materials & Processing: Challenges & Opportunities"	Indian Institute of Technology, Roorkee	17th-19th October 2022
40	Mr. Gaurav Kumar Bansal, Scientist			
41	Mr. Snehashish Tripathy, Senior Scientist			
42	Mr. Vikash Kumar Sahu, GATE-JRF			
43	Mr. Vaibhav Gaur, AcSIR Student			
44	Dr. Shobhana Dey , Chief Scientist	International Conference & "Exhibition on Mineral Business Development"	Mineral Information & Development Centre and Federation of Indian Mineral Industries, Nagpur, Maharashtra	10th-12th November 2022
45	Mrs. Y Usha, Senior Scientist	Conference on "Applied Mechanics"	National Institute of Technology, Jamshedpur and Society of Applied Mechanics	11th-13th November 2022
46	Mr. Mohana Rao Andavarapu, Technical Officer	Symposium on "Accelerated Materials Design and Additive Manufacturing: Scientific & Technological Perspectives"	Indian Institute of Metals, Hyderabad & Visakhapatnam	13th-16th November 2022
47	Mr. Bhupendra Kumhare, AcSIR PhD			
48	Dr. Arvind Kumar Upadhyay, Principal Technical Officer	Training Program on "Characterization and Assessment of Homogeneity and Stability of Referential Material"	National Accreditation Board for Testing and Calibration Laboratories, Gurugram	15th-17th November 2022
49	Dr. Asit Baran Panda , Senior Principal Scientist	Conference on "33 rd AGM of MRSI & 4 TH Indian Materials Conclave, IUMRS-ICA 2022"	International Union of Materials Research Society, Market Research Society of India and Indian Institute of Technology, Jodhpur	19th-23rd November 2022

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
50	Mr. Amit Prakash, Senior Technical Officer (3)	Faculty Development Program on "Advanced Remanufacturing Technology"	National Institute of Advanced Manufacturing Technology, Ranchi	19th-23rd November 2022
51	Mr. Abhishek Kumar, Senior Scientist	Seminar on "Engineering Simulation using ANSYS & CFD"	Engineering Staff College of India	21st-25th November 2022
52	Dr. Vinod Belwanshi, Scientist	2nd International Conference On "Advances In Materials And Manufacturing Technology (ICAMMT- 2022) "	Maulana Azad National Institute of Technology Bhopal, MP, India	22nd-26th November 2022
53	Mrs. Y Usha, Senior Scientist	Conference & Exhibition on "Non-Destructive Evaluation"	Indian Society of Non-Destructive Testing, Pune, Maharashtra	24th-26th November 2022
54	Dr. S. Palit Sagar, Chief Scientist			
55	Mr. Chandan Dutta, Senior Project Associate			
56	Dr. Avijit Kumar Metya, Principal Scientist			
57	Dr. Tarun Kumar Das, Senior Principal Scientist			
58	Mr. Aniket Kumar Dutt, Project Scientist	Workshop on "National Creativity Olympiad 2022"	The Institution of Engineers, XLRI Campus, Jamshedpur	26th-27th November 2022
59	Ms. Sanghita Mirdha, Project Scientist			
60	Mr. Mahesh Pramanik, Field Worker	Online Training on "Training Program- Office Assistant Job Role"	Management & Entrepreneurship and Professional Skills Council	28th November – 02nd December 2022
61	Ms. Sanghita Mridha, Project Scientist			
62	Mr. Om Shankar Dinkar, Senior Project Associate	Seminar on "Industrial Metal Finishing, Electroplating Technologies & Aerospace Chemical Processes"	The Electrochemical Society of India, Indian Institute of Science, Bengaluru, Karnataka	01st-03rd December 2022
63	Dr. Pankaj Kumar Choubey, Senior Project Associate			
64	Mr. Aniket Kumar Dutta , Project Scientist	International Conference on "Corrosion and Coating"	Indian Institute of Metals Jamshedpur Chapter in Association with Tata Steel, CSIR- NML & NIT, Jamshedpur	07th-08th December 2022
65	Ms. Sanghita Mirdha, Project Scientist			
66	Mrs. Shubhada Kar, GATE-Senior Research Felloships			
67	Mr. Vikas Shivam, SERB-National Post Doctoral Fellowship			
68	Ms. Alka Kumari, PA			
69	Dr. Lalit Kumar Meena, Senior Scientist			
70	Md. Dr. Murtuja Hussain, Principal Scientist			
71	Dr. Shailendra Kumar Jha, Principal Scientist			
72	Mr. Roshan Kumar, Scientist			
73	Mr. Mohit Kumar Singh, Project Associate			

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
74	Dr. Asit Baran Panda, Senior Principal Scientist	International Conference on "Corrosion and Coating"	Indian Institute of Metals Jamshedpur Chapter in Association with Tata Steel, CSIR- NML & NIT, Jamshedpur	07th-08th December 2022
75	Mr. Mahesh Gulab Walunj, Senior Scientist			
76	Dr. Gorja Sudhakar Rao, Senior Scientist			
77	Dr. Biraj Kumar Sahoo, Senior Scientist			
78	Dr. Sumanta Kumar Pradhan, Scientist			
79	Dr. Subhajit Ghosh, Senior Project Associate			
80	Dr. Ashok Kumar Mohanty, Senior Principal Scientist			
81	Mr. Chandan Dutta, Senior Project Associate			
82	Mr. Prabir Kumar Roy, Principal Technical Officer	International Conference on "Global Trends in Traditional to Space Ceramics"	Indian Ceramics Society & Indian Institute of Technology- BHU	08th-09th December 2022
83	Mr. Raju Das, Project Associate-I			
84	Dr. Vinod Kumar, Principal Technical Officer			
85	Dr. Sushant Kumar Nath, Principal Scientist			
86	Mr. Arindam Sen, Project Associate	International Conference on "Net- Zero Emission Technologies for Sustainable Development, Challenges and Opoortunities"	Indian Institute of Technology- Indian School of Mines, Dhanbad	12th-13th December 2022
87	Dr. Rajen Kundu, Scientist			
88	Mr. Sudip Kumar, Project Assistant			
89	Dr. Ammasi A, Senior Scientist	International Conference on "Science and Technology of Iron making and Steelmaking"	Department of Metallurgical Engineering and Materials Science, IIT Bombay	13th-16th December 2022
90	Dr. Sanjay Agarwal, Senior Principal Scientist			
91	Mr. Vaibhav Gaur, Academy of Scientific & Innovative Research	International Conference on "International Conference on Frontiers in Materials Engineering"	Indian Institute of Technology- Indore.	14th-16th December 2022
92	Dr. Asit Baran Panda , Senior Principal Scientist	International Conference & Convention on "59th Annual Convention Chemists and Recent Trends in Chemical Science"	Indian Institute of Metals Jamshedpur Chapter in Association with Tata Steel, CSIR- NML & NIT, Jamshedpur	16th-18th December 2022
93	Dr. Vinod Kumar, Principal Technical Officer	National Workshop on "Advancement in Minerals Processing Techniques with Special Reference to Iron Ore and Coal"	Department of Metallurgical Engineering and Materials Science, NIT Jamshedpur	20th-24th December 2022
94	Mr. Mohan Rao Andavarapu, Technical Officer			
95	Dr. Vinod Belwanshi, Scientist	Initiative Industry 4.0 - Nascent Technologies and Sustainability for 'Make in India' Initiative	Bharatiya Vidya Bhavan's Sardar Patel College of Engineering (SPCE), Mumbai	22nd-23rd December 2022
96	Dr. Navneet Singh Randhawa, Senior Technical Officer (2)	"Manganese/Chromo Ores, EMM and Ferro- Alloys" Summit	Federation of Indian Mineral Industries, New Delhi	04th January 2023
97	Dr. Sanjay Agarwal, Senior Principal Scientist			

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
98	Ms. Sanghita Mrida, Project Scientist	108th Indian Science Congress	The Indian Science Congress Association, Nagpur, Maharashtra	03rd-07th January 2023
99	Mr. Aniket Kumar Dutt, Project Scientist			
100	Dr. Animesh Jana, Senior Scientist			
101	Ms. Mausmi Sarkar, Scientific Administrative Assistant			
102	Ms. Pragati Jha, Project Associate			
103	Ms. Manoti Kumari , Field worker	108th Indian Science Congress	Indian Science Congress Association	03rd-07th January 2023
104	Mr. Abhishek Kumar, Senior Scientist	International Conference on sintering & Pelletizing 2023	M/s Tata Steel Ltd., Jamshedpur	18th-19th January 2023
105	Dr. Ammasi A , Senior Scientist			
106	Dr. Ranjeet Kumar Singh, Principal Scientist			
107	Dr. Jagannath Pal, Chief Scientist			
108	Dr. Sushant Kumar Nath, Principal Scientist	National Conference on "Valuing Low-grade Ore and Waste: Challenges and Remedies"	The Institutions of Engineers (india), Durgapur Local Centre	21st-22nd January 2023
109	Dr, Vinod Belwanshi, Scientist	International Conference on "Micro/ Nano Electronics Devices, Circuits & System"	NIT, Silchar	29th-31st January 2023
110	Dr. Nikhil Kumar, Scientist	Seminar on "SCO Young Scientist Conclave"	Department of Science and Technology, Bengaluru Karnataka	06th-10th February 2023
111	Dr. Shailendra Kumar Jha, Principal Scientist	Conference on "Electrochemistry for Industry, Health and Environment"	BARC, Mumbai	07th-11th February 2023
112	Dr. Ganesh Chalavadi, Senior Scientist	Meeting on "Project Evaluation of 3 Districts for INSPIRE Award"	District Education Department	08th February 2023
113	Dr. A K Pramanik, Senior Principal Scientist	International Conference on "Electron Microscopy & XLI Annual Meeting of Electron Microscope Society of India"	Electron Microscopy Society of India & University of Delhi	8th-10th February 2023
114	Mr. PS Manoranjan Jena, GATE-SRF			
115	Dr. Biraj Kumar Sahoo - Senior Scientist			
116	Mr. Rattanvir Singh - Project Associate-II			
117	Dr. Premkumar M - Senior Scientist			
118	Dr. Sreeda P, Senior Scientist	Induction Programme for the Newly Recruited Scientists	CSIR- Human Resource Development Centre, Ghaziabad	10th-20th February 2023
119	Dr. Saurabh Shekhar, Senior Scientist	International Conference on "Global Zinc Summit"	International Zinc Association	16th-17th February 2023
120	Mr. Shivendra Sinha, Senior Scientist			
121	Dr. Sandip Ghosh Chowdhury, Chief Scientist	International Conference on "Recent Advances in Composite Materials (ICRACM-2023)"	SRM Institute of Science & Technology, Kattankulathur	22nd -24th February 2023

Sl. N.	Name & Designation	Event / Purpose	Place of Visit /Organized By	Duration
122	Mr. Shivendra Sinha, Senior Scientist	International Conference on "Management and Recycling of Metallurgical Wastes"	Indian Institute of Technology- BHU	27th-28th February 2023
123	Dr. Saurabh Shekhar, senior Scientist			
124	Mr. Rajanikant Choudhari, Technical Officer			
125	Dr. M. Malathi, Principal Scientist			
126	Dr. Dayanand Paswan, Principal Scientist			
127	Mr. Krishna Kumar, Senior Scientist			
128	Dr. Mudila Dhanunjaya Rao, Scientist			
129	Mr. Rohit B. Meshram, Senior Scientist	International Conference on "Management and Recycling of Metallurgical Wastes"	Indian Institute of Technology- BHU	25th February-01st March 2023
130	Mr. Arindam Sen, Project Associate	International Conference on "Recent Advances in Materials Chemistry and Catalysis"	Dibrugarh University	01st-03rd March 2023
131	Mr. Ajit Kumar Swain, Principal Scientist	Online Course on "USIM PAC Simulator"	Caspeo, France	01st-05th March 2023
132	Dr. Atanu Das, Senior Scientist	International Conference on "Advanced Materials and Manufacturing Processes"	Jawaharlal Nehru Technological University-Gurajada Vizianagaram, Andhra Pradesh	03rd-04th March 2023
133	Dr. Premkumar M , Senior Scientist	Conference on "Advance Nanomaterials and their Applications"	Central University of South Bihar (Gaya)	13th-22nd March 2023
134	Mr. Tipu Kumar ,Senior Technical Officer(1)	National Workshop on "Physical Simulation of Thermal-Mechanical Processing of Materials"	School of Mechanical Engineering (KIIT Deemed), Odisha	16th-18th March 2023
135	Dr. Ranjeet Kumar, Scientist			
136	Dr. Sandip Ghosh Chowdhury, Chief Scientist			
137	Dr. Sunil Kumar, Senior Scientist	International Conference on "Green Hydrogen for Global Decarbonization"	Pandit Deendayal Energy University Gandhinagar, Gujarat	17th-18th March 2023
138	Mr. Roshan Kumar, Scientist			
139	Dr. Ranjan K Sahu, Chief Scientist			
140	Dr. Mousumi Das, CSIR-Senior Research Associateship	International Conference on "Mechanical and Production Engineering"	World Research Forum for Engineers and Researchers	19th March 2023
141	Dr. Alok Kumar Meher, Scientist	Training Programme on "Laboratory Quality Management System and Internal Audit as per IS/ISO/IEC 17025:2017"	The Bureau of Indian Standards, India	21st-24th March 2023
142	Ms. Rupa Das Biswas - Senior Technical Officer	Training Program on "Characterization and Assessment of Homogeneity and Stability of Reference Material"	National Accreditation Board for Testing and Calibration Laboratories	23rd-25th March 2023



Gateway Arch - St. Louis

- The monument is covered in stainless steel and is the world's tallest arch. The arch is the tallest memorial in the United States and the tallest stainless steel monument in the world.
- Standing at 192m tall. Both the width and height of the arch are 630. The structure weighs 42,878 tonnes. The structural steel interior weighs: 2,157 tonnes and the 6.3mm thick grade 304 stainless steel panels that cover the exterior of the arch, 886 tonnes.

Sources: wikipedia

Distinguished Visitors

#	Visitor		Date	Topic of Lecture(s)
1.	**Professor Gordana Medunic,** Full Professor of Environmental Earth Science, University of Zagreb, Faculty of Science, Department of Geology, Croatia		23rd May 2022	"Collaboration between Croatia and India and Erasmus Project"
			24th May 2022	"Opportunity on Post Doc Fellowship under European Union"
2.	**Professor Cemal Basaran**, University of Buffalo, New York,		02nd June 2022	"Low and High cycle fatigue"
3.	**Mr. Rajeev Nair**, Coach, Cricket, Tata Sports Complex, Tata Steel, Jamshedpur and Director Indian Institute of Yoga and Management, Haryana		21st June 2022	"Importance of Yoga for a Healthy Life"
4.	**Dr. John S Thella,** Application and Business Development Specialist, ZEISS Research Microscopy Solutions		06th July 2022	"Zeiss Advanced Automated Mineralogy Work Flows"
5.	**Mr. Mukund Sahay,** Ex-COA, CSIR		29th August 2022	"CCS Conduct Rules, Sexual Harassment of Women at Workplace and RTI"
6.	**Mr. BVA Patnaik** , Associate Director, Gas Turbine Research Establishment (GTRE)		06th September 2022	"Gas Turbine Engine Phenomena from Structural Engineering Perspective"

#	Visitor		Date	Topic of Lecture(s)
7.	**Mr. Binay Kumar Kar**, Ex. Sr. COA, CSIR-IICB		30th October 2022	"Cultural remedy for preventing corruption"
8.	**Professor T. N. Singh**, Director, IIT Patna		26th November 2022	"E-Waste Recycling"
9.	**Prof. Arun Majumdar,** IIT, Kharagpur		15th December 2022	"Application of Artificial Intelligence in Mineral Processing"
10.	**Mrs. Shalini Sulakshna** Ramesh, Head-Ethics Department, Tata Steel		19th December 2022	"Elimination of all forms of violence and discrimination against women and on sensitization for employees to make them aware about the provisions of the Sexual Harrassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013 and towards the need of upholding the dignity of women and end gender stereotypes so as to encourage more and more women"

Hindi Cell

Official Language Implementation

CSIR-NML has an active program for the Implementation of the official language, Rajbhasha Hindi. In addition to the regular official works and various translations into Hindi, CSIR-NML proactively initiates a series of activities throughout the year, which include publications, conducting trainings, workshops, talks, annual competitions, and divisional inspections for enhancement of Hindi use in the divisional activities.

Publications in Hindi

Annual Report, CSIR-NML Newsletter and Brochures have been published in Hindi, which are circulated to CSIR units and various organizations of the Govt. of India. Press releases were issued in Hindi and published in daily newspapers.

Promotional Activities for Hindi Implementation

- Four inspections were conducted by the Hindi Officer covering various divisions for identifying the areas of Hindi implementation and enhancing the use of Hindi in divisional activities.
- Incentive Scheme for working in Hindi has been introduced and employees are actively participating Eleven Employees Shri Parmarth Suman, Shri Sudhir Kumar, Shri C.R. Chakraborty, Md. Nayeem Ansari, Shri Santosh Kumar Ray, Shree Nandlaal Paswan, Shree Anil kumar, Shree Jyoti Kumar, Shree Ravi Ranjan Kumar, Shree Rohit Mudi and Shree G. Dharma Rao were given awards in this scheme.

Hindi Workshop

Four Table Workshops were conducted in the Administrative sections. The objectives of the workshops were to address the issues encountered for preparing the Quarterly Hindi Progress Report, Hindi Noting and Drafting and imparting training of Unicode.

Hindi Competition

Hindi Competitions were organized from 1st to 9th September, 2022, for CSIR-NML Employees. The competitions included discussions on implementation of Hindi, self-written poetry recitations and singing, etc. The program had wide participation by NML employees.

World Hindi Day

On the "World Hindi Day", technical lectures were organized on 10th January, 2023, on different scientific topics. In this event, many senior scientists, research scholars and members of the technical lecture organizing committee of CSIR-NML participated with enthusiasm. The dedicated scientific lectures in Hindi language were simple, easy-to-communicate and very comprehensible. The lecturers included Dr. Arvind Sinha, Chief Scientist & Advisor Management, Dr. Pratima Meshram, Principal Scientist, Dr. S.K. Jha, Principal Scientist, Dr. Krishna Kumar, Sr. Scientist, Mr. Somnath Das, Project Assistant-II, Mr. Ajit Gangwar, Project Associate.

Activities of Hindi implementation for TOLIC, Jamshedpur

CSIR-National Metallurgical Laboratory is the Secretariat of Town Official Language Implementation Committee (TOLIC), Jamshedpur. It has 62 Members from all the Central Govt. offices located in and around Jamshedpur, with the Director, CSIR-NML as Chairman of this committee. Under the aegis of the Town Official Language Implementation Committee, Jamshedpur, a literary and Culture Programme was organised on 7th September, 2022 at CSIR-National Metallurgical Laboratory, Jamshedpur. More than three hundred officers from different Central Government offices

graced the occasion. Along with the staging of a short play "Khamosh Adalat Jari Hai", Songs, Ghazals by famous artists were also performed. The presence of all Heads of different central Government organizations infused enthusiasm into the function.

Prize Distribution Ceremony for the Winners :

Popular Drama Staged by Artists :

Knowledge Resource and Information Technology

The division deals with knowledge resource management and offers IT infrastructural support to CSIR-NML. There are two independent groups, led by group leaders :

1. Knowledge Resource Group (KRG)
2. Information technology Group (ITG)

Knowledge Resource Group (KRG)

KRG manages the library resources including e-library, develops multimedia content, publishes the Journal of Metallurgy and Materials Science (JMMS) and conducts CSIR integrated skill trainings. The other significant activities of KRG includes website development and maintenance, maintenance of Online Public Access Catalogue (OPAC) and institutional repositories (e-prints), development of contents for CSIR Virtual Laboratory, public information delivery through RTI responses and PG Portal, scientometric analyses, conducting CSIR Jigyasha - an outreach program for schools and colleges, taking responsibility of the institutional branding through exhibitions, press releases, advertisements, and, maintenance of the archives and museum.

A. CSIR-NML Library

During the financial year 2022-23, KRC (library) added 196 documents, including books and bound-volume journals, and subscribed to 13 periodicals in the area of minerals, metals, metallurgy, and materials science. Besides these, the CSIR-NML KRC has received databases and standards through NKRC consortia like ASTM standards, Clarivate Analytics- Web of Science, iThenticate, etc. The library currently has 55941 documents, including textbooks, reference books, technical reports, conference proceedings, standards, and bound volumes of journals.

B. In-house Publication :

Journal of Metallurgy and Materials Science (JMMS) publishes original articles, review reports and short communications in the areas of minerals, metals and materials tracing the overall life cycle of structural as well as functional materials. The JMMS is a quarterly publication. In 2022-23, the volume 64 consisting of two issues (January to June) were published.

C. Knowledge Delivery

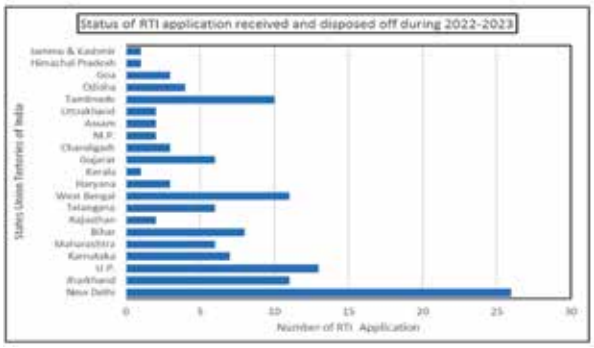
The laboratory is implementing CSIR Integrated Skill Training Initiative since 2017, with the objectives of utilizing CSIR knowledgebase and infrastructure for contributing to national skill mission through special up-skilling/training for societal benefits and improving national skills, and promoting entrepreneurship/ technopreneurship.

The different categories of training programs provided at CSIR-NML include Corporate Training Programs (CTP) and Professional Training Programs (PTP), which are paid trainings for professionals, NSDC Training Programs (NTP) and Societal Training Programs (STP), which are low cost or free training provided to school drop outs, and, International Training Programs (ITP) for international clients on demand. Special free training are also conducted for women from economically weaker sections.

D. Public Information Delivery

During 2022-2023, CSIR-NML received 128 RTI applications from 21 states and union territories of India. A maximum 26 application received from the New Delhi followed by the Uttar Pradesh has filed 13 applications whereas from the Jharkhand and the West Bengal sent us an equal number of the eleven application. The overall distribution of the RTI application among others states are highlighted in figure. We have also received 10 appeals, which were successfully disposed of, as per RTI guidelines. Most of the RTI queries were related to the Administration. The CSIR-NML Transparency portal

(http://transparency.nmlindia.org) contains all the information as per the requirement of THE RIGHT TO INFORMATION ACT, 2005. This information is updated periodically.



In addition to mandatory public information, information about the strengths and achievements of CSIR-NML is disseminated through its Annual Report, Equipment Brochure, CSIR-NML Technology videos, CSIR-NML Technology Handbook, and many other publications, both soft and hard.

E. CSIR Jigyasa : Outreach Programs for Schools

CSIR-Jigyasa Virtual Laboratory Project under the CSIR-Jigyasa program is an initiative taken by CSIR during its Platinum Jubilee year, which was inspired by our Honourable Prime Minister's vision of a new India and Scientific Social Responsibility (SSR) for CSIR. The project "CSIR-Jigyasa Virtual Laboratory" aims to encourage students to learn science effortlessly with fun and enthusiasm. Under this project, CSIR-NML aims to organize various types of scientist interaction programs for school students and teachers, to create innovative learning tools and contents through Virtual Laboratory (VL) by utilizing advanced digital technology focusing on the areas of minerals, metals, materials, and metallurgy. The targeted beneficiaries of this project are school students from Std. VIII to XII, focusing on Government-funded schools located in rural areas. In FY22-23, CSIR-NML organized the following scientist interaction programs for school students and teachers: I. Visit of scientists to different schools. II. Scientists and science teachers' conclave. III. Teachers training on innovation. IV. Mentoring of Atal Tinkering Labs (ATL) of different schools V. Popular lecture series on various technical and scientific topics. VI. Global Battery experiment. Additionally, CSIR-NML developed Solenoid and Gas Detector "DO IT YOURSELF" (DIY) Kits for school students to understand the science with fun and enthusiasm. In Solenoid DIY Kit, students can make a solenoid using paper, copper wire, a nail, and a battery, which will help students to understand the concept of the solenoid. Using Gas Detector Kit, students can make and understand the working of the gas detector. During school visits, CSIR-NML scientists demonstrated the DIY kits to school students. Under the Virtual Laboratory part of this project, CSIR-NML developed various digital contents like, "Crystallographic structure of metals", "Why materials fail", "Additive manufacturing process", "Heat engines", and others. In FY22-23, CSIR-NML organized the following Programme: One-day NML visit of school students and teachers. II. Visit of scientists to different schools. III. World Youth Skills Day. IV. Popular Lecture Series on Fractal Geometry, Basics of Computational Materials, Decontamination of drinking water a technological and social challenge, Global Battery Experiment, and National Creativity Olympiad. Almost 1284 students and teachers were involved in all these activities.

Visit of St. Joshep High School Golmuri, Jamshedpur at CSIR-NML

Connecting CSIR Jigyasa Program with **Atal Tinkering Lab (ATL)** is one of the initiatives of CSIR. This initiative includes adoption of schools with ATL facility which are in the proximity of CSIR Labs. CSIR-NML adopted three schools which have Atal Tinkering Labs, namely, Kendriya Vidyalaya, Surda; SS High School, Childag Angara; and, DAV Public

School, Barkakhana. On 10th Feb. 2022 and 15th March 2022 a team from CSIR-NML visited Kendriya Vidyalaya, Surda and SS High School, Childag to foster students' ideas through do-it-yourself (DIY) model, to develop innovation skills, and to teach students various methods of learning.

Information Technology Group (ITG)

The Information Technology Group [ITG] caters to and co-ordinates the lab-wide needs for IT resources and management in terms of creation of IT infrastructure, its services & maintenance. The group is mainly looking after the development and services of IT facilities & infrastructure at CSIR-NML from basic to advanced needs. The group is well equipped with computational facilities in terms of hardware and software. The team IT consists of scientists and technologists who are actively involved to support the lab level R&D activities by providing reliable and efficient IT infrastructure with uninterrupted Internet service.

CSIR-NML is making use of the IT infrastructure primarily for data transfer, communication, exchange of manuscripts and data with authors and referees, generation of knowledge base through internet, Email communication, ERP, conducting HR interviews/assessments, important project meetings around the globe through video conferencing/ Skype/ MS Team etc.

Besides day-to-day routine activities, following are some of the major milestones achieved while equipping the three campuses of CSIR-NML and two residential dispensaries with the requisite IT infrastructure during 2022-2023:

(a) Upgradation of existing server in terms of hardware & software.

(b) Planning, estimation & installation of IT facility required by users at various renovated sites of CSIR-NML.

(c) Coordination and management of lab wide maintenance services of CSIR-NML's IT assets.

(d) Preventive maintenance of IT infrastructure installed across campuses of CSIR-NML.

(e) Provisioning of IT facilities in terms of network connections and utility services to new recruits.

(f) Development and maintenance of several in-house utility web applications.

(g) IT support to Human Resource Group (HRG) for performing various HR activities (interviews/ assessments/DPCs).

(h) Conduction of Video Conferencing for important meetings and various project review activities.

(i) Procurement and installation of Large Format Display (LFD) for various locations of NML.

(j) Resolution of various technical issues and upgradation and hardware maintenance related to CCTV.

(k) IT support for conduction of seminars, workshops & conferences at NML.

(l) Upkeep of turnstile based attendance system at CSIR-NML for employees and pensioners.

(m) Verification of data and printing of employee identity cards.

(n) Technical maintenance and upkeep of Aadhaar Enabled Biometric Attendance System (AEBAS).

New Facilities / Infrastructure Created in the Reporting Year :

a) 155Mbps Internet leased line from BSNL

b) 100 Mbps Internet & NKN connectivity from NIC via PGCIL

c) Three nos of private leased line from main laboratory to pilot plant areas.

d) 328 Nos of Landline connections from BSNL with teleconferencing facilities.

e) 2 Nos VC facility supporting HD Video and content

f) Website NMLINDIA.ORG for the organization.

Team - KRIT

New Facilities

Potentiostat / Galvanostat System Electrochemical Workstation

Make : IVIUM Technologies, Netherlands; Model – Vertex

The Vertex potentiostat/galvanostat equipped with FRA/EIS was purchased for study of applied electrochemistry in the areas of corrosion monitoring and coatings. The equipment has an applied voltage range of ±10 V and current range of ±600 mA ±10nA. The equipment has the facility to measure Open Circuit Potential, Linear Scan Voltammetry, Cyclic Voltammetry Chronoamperometry, Zero Resistance Ammeter (ZRA), Galvanic Corrosion, Cyclic Polarization, Linear Polarization, Tafel, Electrochemical Noise, Potentiostatic, Potentiodynamic, Galvanostatic, Galvanodynamic, Constant Current, Constant Potential, EIS, Galvanostatic EIS, Mott – Schottky measurements.

100kVA Furnace Transformer

The existing power supply (50 kVA fixed voltage transformer) and accessories connected to EAF have been inadequate for several high-temperature smelting work. A new power supply (3-phase 100 kVA variable transformer with an advanced control system) was necessary for precise control on smelting of copper slag in EAF. The modification helped to collect data on melting behaviour and energy consumption as function of charge mix, time, furnace load etc.

Electric Forklift

Model : ACE AF20E

Current & Future Usages:

- Loading & unloading goods
- Line feeding
- Stacking
- Goods transport within campus

General features:

Mode of operation : Battery

Load Capacity : 2 T

Lifting height : 3000 mm

Fork size : 1070 mm x 100 mm x 40 mm

Tilting angles : 6° ~ 12°

Wheels : 2/2 solid

Battery rating : 48V/440Ah

Mast type : 3-stages

Overall height fork lowered = 2060 mm

Overall height (Overhead guard) = 2150

Single Channel Potentiostat / Galvanostat System with 20 A Booster

Single Channel Potentiostat/Galvanostat System with 20 A Booster. Single Channel Potentiostat/ Galvanostat System i.e., the VersaSTAT 4 having the max current capability to ±2A. High current boosters up to 20A for battery, fuel cell, or electroplating applications. Excellent current measurement resolution for corrosion, coatings, and microelectrode analysis. An internal frequency response analyser option for impedance analysis over the frequency range 10 µHz to 1 MHz Versa Studio software is included with all Versa STAT 4 systems for Voltammetry techniques like : Cyclic Voltammetry, Chrono-techniques and Pulse Voltammetry methods. Corrosion techniques including the most common ASTM standards such as Linear Polarization Resistance (LPR, ASTM G59), Tafel (ASTM G5), Cyclic Polarization (ASTM G61), etc. Impedance added to provide Electrochemical Impedance Spectroscopy techniques response for corrosion, coatings, electro catalysis and fuel cell.

Fabrication of an Industrial Grade Sensing Device

The device, an industrial grade sensing device, comprises of probes/sensors, the sensing device and interfacing & display unit. The EC sensor/ probe is an encircling coil connected in differential configuration, fabricated on a nylon -6 former. The entire assembly has been encapsulated in aluminium alloy housing. The sensing device consists mainly the central processing electronic unit that performs three basic operations. The RF signal energizes the sensing coil and induces an eddy current in the part to be inspected. When a change in fill-factor occurs in the test piece, the coil impedance experiences a change. It processes the responses due to the induced eddy current. The processing unit of the system includes a number of sub functions that include impedance matching network, modulation/demodulation unit, subsequent filtering, offset-gain control network and final amplifier unit. The final output is measured and recorded by PC unit through data acquisition (DAQ) card. The development program and interfacing protocols work on LabVIEW platform. Embedded system of the whole unit is designed by integrating sensor, central processing electronics and the controlling software through interfacing protocols.

Horizon Software (Metal) includes Dongle and Firmware for H25KS UTM

Software Controls Universal Tasting Machine (H25KS)

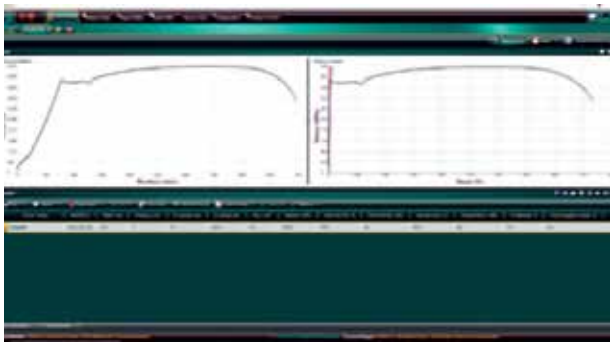
Manufacturer : Tinius Olsen, UK

Key features

- Full PC networking integration and backup across a PC network using industry standard SQL database structure.
- Multiple licensing of Horizon for multiple installations to review methods, results and reports away from the testing machine, lab or plant.

- Multi-level user password capability.
- Recall function enables users to add key data perhaps not available, or missed, prior to the test.
- Built in Team Viewer licenses enabling TO engineers to log in directly, upon request, and provide on-machine technical support.
- Live results during test; there is no limit to the number of results displayed and these do not have to be used in the test report.
- With sufficient PC power and bandwidth, multiple testing machines can be run from a single PC.
- Users can use pre-written international standards methods as templates to modify and build their own test methods.

Materials Testing, Analysis and Reporting Software



Software representing stress-strain curve

Eddy Current Sensing Technique for the Measurement of Coating Thickness

The setup is developed based on an excitation signal from the Eddy Current Device and then amplified using **High-Speed Bipolar Amplifier nF HSA42012**. The amplified excitation signal is fed to the sensor probe to measure coating thickness. The deviations in voltage based on the coating thickness are measured through the Sensing probe, developed in-house, using the **NI PXIe-1071** data acquisition system with the controller. The whole software is running on the **NI PXIe-1071** for the analysis of the output signals.

De- Dusting System for Beneficiation Unit Capacity of Bag Filter ID Fan : 1700m3/hr

De-dusting system for the beneficiation unit's Bag Filter ID Fan, meticulously designed and implemented at CSIR-NML, exemplifies a commitment to environmental excellence, equipment longevity, and uncompromising air quality standards. Through its efficient collaboration between the bag filter and ID Fan, this system stands as an essential component for impactful research practices in the area of metallurgical and materials science.

4HI/2HI Rolling Mill Laboratory Model

The 4HI/2HI Rolling Mill Laboratory Model at CSIR-NML seamlessly integrating into the laboratory's research ecosystem. Its versatile applications in material development, process optimization, and education underscore its value as a key asset in advancing the understanding and application of rolling processes within the metallurgical industry. With precision control systems and tailored capabilities, this laboratory model contributes significantly metallurgical research at CSIR-NML.

Phased Array Ultrasonic System

The Phased Array Ultrasonic System emerges as a technological cornerstone, aligning with the laboratory's commitment to excellence. Through its adaptive beamforming capabilities and high-resolution imaging, this system contributes significantly to ensuring the safety, reliability, and efficiency of various laboratory applications. It stands as a cutting-edge technology for advancing research and development in materials science and metallurgy.

Fabrication of an Electrochemical cell for the Deposition of Manganese Metal

The electrochemical cell designed for manganese metal deposition aligns with the laboratory's stringent standards in material selection, assembly, and operational management, this electrochemical cell emerges as a valuable and reliable tool for producing high-quality manganese coatings, contributing to advancements in various industrial applications.

Laboratory Scale Inert Gas Atomizer for Producing High Purity Spherical Metal/Alloy Powders

CSIR-NML Purchase Order No & Date :

NML-FG/MTE-KGK/40-19/7-2021 Dt. 28.07.2021

Supplier : M/s Precious Alloys Pvt Ltd., Mumbai

Manufacturer : M/s Blue Power, Germany

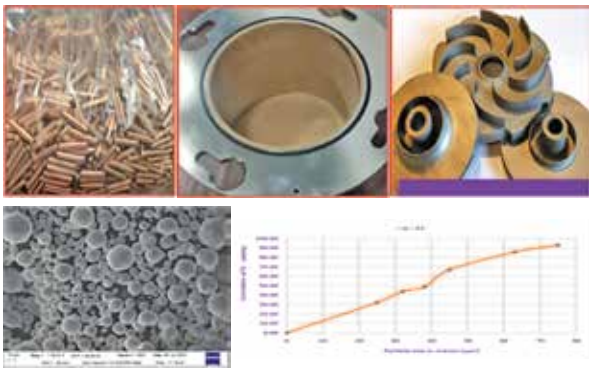
Model : AUG1000

The AUG1000 Inert Gas Atomizer (IGA) Features:

- Gas atomisation involves, breaking up of a molten metal stream using high-pressure inert gas & is an effective method of producing fine spherical metal powders.
- Capable of producing both (i) pure metal powders of Gold (Au), Iron (Fe), Nickel (Ni), Copper (Cu) etc. and (ii) wide range of alloy powders based on Fe, Ni, Co, Au etc.
- Includes melting furnace based on induction heating.
- The melt capacity is 1.0 litre melt with bottom pouring mechanism and close coupled nozzle.
- Provisions to control the particle size, and the typical d_{50} of the produced powders in a batch, found to be about 40±10 µm, where d_{50} is mass median diameter.
- Includes view ports in both melting furnace and atomization chamber. Another port in atomization chamber is fitted with CCD camera.

Laboratory scale Inert Gas Atomizer (AUG 1000) after installation and commissioning

(Inset : (A) Ceramic crucible setup (B) Graphite crucible setup (C) Atomization in process (D) Gold alloy powder



Typical characteristics of the $CuSn_6$ powder produced during the trial run using
AUG1000 inert gas atomizer after installation at CSIR-NML

(A) CuSn6 feed stock (B) Powder in receiver (C) Typical 3D printed pump components (D) SEM image of the powder showing globular particles (E) Size distribution on sieving

Research Planning and Business Development

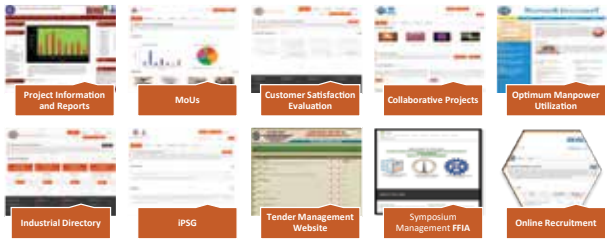
The Research Planning and Business Development (RPBD) Division is engaged in the management of R&D Projects of the laboratory as well as a range of other essential functions for the laboratory. The division interactions with both internal and external stakeholders to fulfill its various functions. Its primary areas of work include:

Research Management, Business Development & Client Interfacing

Role of RPBD is a crucial throughout all stages of research and development project execution, as illustrated above. The Division functions, as the primary point of contact for prospective clients and sponsors seeking solutions for their research and development (R&D) needs. It plays a pivotal role in initiating and fostering relationships between clients and the relevant technical experts. This includes conducting negotiations with potential clients to establish collaborative agreements, covering financial and intellectual property aspects. During the reporting period, the Division was instrumental in making 25 new clients for the Laboratory viz. *Krishak Bharati, Sani electronics, Sandur Manganese & Iron Ore, Welspun Corporation Limited andFrakka Barrage Limited; negotiated 26 new contracts/agreements during this period and signed 24 national and internal contracts/agreements with academia as well as industries viz. Colour Chromes Pvt Ltd., OP Jindal University, Surgiwear Ltd., Shahjahanpur, ReCy Energy Pvt Ltd, Pune, Saint-Gobain India Private Limited, Chennai, Log9Materials, Bengaluru, INDIA GOVERNMENT MINT, HYDERABAD, Vardhman Auto Recycling, New Delhi, IIT, Patna, Diva Envitec Pvt. Ltd., Mumbai, IIT-ISM, Dhanbad, NTPC Limited (NTPC), New Delhi, Raj Borax Private Limited, Mumbai, Jamipol, Jamshedpur, Vedanta Pvt. Ltd., Steel Authority Of India Limited-Bokaro Steel Plant, Bokaro, Enter Engineering Pte. Ltd, Singapore, Ashvini Magnets Pvt. Ltd., University of Stavanger, Norway, Tata Steel, Jamshedpur, BHEL, and Advanced Metals.* 105 additional projects were subjected to evaluation to ensure their alignment CSIR guidelines. The division also generated 1035 invoices to clients for payments. The Division also remained instrumental to collect customer satisfaction and evaluations of more than 15 completed projects (through online platform), resulting in an average CSE Index score of 4.7 out of 5.0. The division also engages in the procurement procedures of different sponsors, therefore acquiring new projects. During the reporting period, the Division issued 45 bids, resulting in the Lab being awarded 36 projects. Several successful bids were submitted to prominent organizations such as *Tata Steel, DMRL, Indian Navy, Geological Survey of India, DRDO, Ministry of Science and Technology, SAIL, Ministry of Steel, BARC, ISRO, JSW Steel Ltd, and Kerala Minerals Metals Ltd.*

Information Systems & Databases

The division develops and maintains many web-based information systems and associated databases internally, with the aim of promoting digital inclusion and enhancing the overall efficiency of the laboratory. The e-information systems and databases facilitate management decision-making by supporting various e-processes. These databases include information on several aspects including projects, manpower, external cash flow, intellectual property, agreements, and more. RPBD is responsible for the preparation and dissemination of a diverse range of reports to both internal and external stakeholders on a regular basis throughout the year. Some of the significant documents are the Key Performance Indicator (KPI) Document, the PMO Portal Data, the Research Utilization Data, the Monthly Reports, the Quarterly Reports, the Annual Plan Document, and the Replies to PMO & Parliament Queries, among others.



Institutional Publications

CSIR-NML disseminates monthly newsletters via RPBD, which highlight the significant activities & achievements of the organization. The division is responsible for coordinating the preparation of the Annual Report of the laboratory. In addition, the division also publishes the RC Agenda, Technology Handbook, Director's Desk, and Equipment Brochure.

IP Services

RPBD group offers IP search and analysis services to both external customers and internal users, with a particular focus on those engaged in the creation of new technologies or processes. The extent and proficiency of the department in these domains. During the 2022-23 period, the division offered a range of services in the field of Minerals, Materials, and Metals. These services included IP search and analysis, Evaluation FTO space, Patent Landscaping, Patent Portfolio Analysis, Patent Mapping, Patent Citation Analysis, White Space Mapping, and Competitive Intelligence.

The group possesses pertinent expertise in delivering competitive intelligence services through various means, including Competitor Tracking and Profiling, Comparative Technology Evaluation,

Market Assessment Studies, Strategic Grouping and Collaboration, Patent SWOT Analysis, Patent Claim Analysis, and Market Segmentation Analysis.

Scientific & Technical Services

RPBD coordinates provision of S&T Service to customers. Testing as per standards are carried out for various organizations every year. Last year 611 customers were provided testing services.

Technology Marketing

The CSIR-NML has a diverse range of technologies and products that are poised for commercialization, with some of them already been successfully introduced into the market. The publication of the second edition of the "Technology Handbook" encompasses a comprehensive compilation of over 60 technologies currently available from CSIR-NML. The Division periodically organizes industrial/ business meetings and presentations with the aim of raising awareness among industries in different sectors about the technologies that are now accessible.

Intellectual Property Facilitation Center (IPFC)

IP Facilitation Centre of CSIR-NML, which is established in the year 2020. The center was founded under the aegis of Ministry of MSME, Govt. of India with an objective of "Building Awareness on Intellectual Property Rights (IPR)" for the MSMEs. The ambitious project has a budget of 100 Lakhs with an objective to bring awareness about IP and exploit IP for the MSMEs competitive business advantage. It's a project of national importance which would create a surge in IP based start-up eco-system in the country and eventually it leads to knowledge based thriving economy. The center is fully equipped with all the necessary amenities, infrastructure and manpower competencies to provide IP related services to MSMEs in a big way. Since Its inception, IPFC center has organized several webinars to bring awareness about IP and the importance of IP protection for a competitive business sustainability. As a part of this program, NML-IPFC organized 19 webinars and 02 seminars so far wherein around 1900 people were benefitted in the matters of IP. The center has already started providing IP related services like patentability, patinformatics, patent landscaping analysis, copyrights registration services, trademark & design registrations, and other techno legal advisory services. So far the center registered 18 trademarks, filed 05 patens, 03 industrial designs registered, and 01 copyright registered.

Team-RPBD

Empire State Building - New York

- Most iconic and amazing, the Empire State Building, was constructed in 1931.
- The building's steel frame weighs 57,000 tonnes, while the Art Deco exterior is composed of 200,000 cubic feet of limestone and granite, 10 million bricks and 730 tonnes of aluminium and stainless steel.

Sources: wikipedia

Administration

The Administration provides a variety of support services for conducting R&D in the laboratory. The division has aligned itself to realize the vision of CSIR-NML and facilitates the overall system towards meeting the set goals and targets. The division has significant roles to play in every facet of the career development of the staff as well as providing sustained support right from their recruitments to superannuation, and often, even after superannuation. The Administration connects all the staff and facilitates in fulfilling various vital needs of the employees, like, academics, career, housing and health in the following manner:

- Formulate and implement the policies concerning administrative procedure for smooth functioning of the Institute.
- Provide advice to the functional bodies (committees/ functional groups) within the organization.
- Maintain liaison with CSIR Headquarters on matters related to administration/vigilance/ legal.
- Provide healthy working conditions and atmosphere to Institute by correct interpretation as well as implementation of governing rules and regulations.
- The Administrative Head of the Laboratory advises the Director for decisions on administrative matters.
- Implement instructions of the Director/CSIR on various matters.

The division is presently headed by the Administrative Officer, who is over all In-charge of the activities and supported by the Section Officers, and a group of ASOs, SSAs, JSAs and other supporting staff. The division also coordinates the work of the Health care centers, security services and Rajbhasa cell. In the recent past, the Administration has undergone a major shift in terms of work culture, towards implementing paperless processes through e-Office. An improved work culture and decentralized leadership at all levels has been introduced to bring the desired changes. A sustained effort has been initiated to inculcate the passion to ensure faster service delivery system to match with the expectations of CSIR-Enterprise Transformation initiatives.

Team - Administration

Luis Bridge - Porto

- Spanning 172 metres.
- Constructed from iron and granite, the bridge weighs a total of 3,045 tonnes.

Sources: wikipedia

Engineering

The Engineering Division caters and co-ordinates the engineering needs, both R&D and infrastructural, of the laboratory, Large Scale Testing Facilities & Residential Complexes. Majority of the needs are non-repetitive in nature, though some are of routine type. The division has two groups called Works Services and Maintenance (WSM) group and Project Planning and Engineering (PPE) Group. WSM group include Civil Engineering Unit, Electrical Engineering Unit and Air-Conditioning Unit, while PPE group consists, central workshop and new projects unit. The type of activities performed by the Division include: Design and Development of prototypes, Project Engineering, Engineering Consultancy, Infrastructural Development, R & D activities of the core areas of the laboratory, Up-keeping of premises, In-house maintenance, Workshop facilities and support services.

Project Planning and Engineering Group :

The activities of the group in brief, divided into following categories:

1. Prototype/Product design and development
2. Research and consultancy
3. Setting up and operation of critical infrastructure
4. Finite Element and CFD Modeling
5. Maintenance and up-keeping of R&D equipment
6. Central workshop
7. Skill development
8. Technology up-scaling and detailed Engineering Packages (BEP/ DPR)
9. Pilot plant operation and maintenance

Prototype/ Product Design and Development :

In the reported period, the division has contributed to the requirements of several projects. Design and development of barrel electroplating system for coating Mg-based biodegradable implants is a major inhouse prototypes designed and developed during the period.

Research and Consultancy :

In the reported period, the division has undertaken the following major research projects as follows:

1. Numerical modelling of heat transfer and fluid flow in Selective Laser Melting (SLM) of SS316L.
2. Design and development of an in-house barrel electroplating system for coating Mg-based biodegradable implants
3. Near net shape 3D manufacturing of Inconel 718 by optimizing controlled parameters of wire arc additive manufacturing with Cold metal

Setting up and operation of critical infrastructure : In the reported period the division has been working on the following areas for critical infrastructure development:

1. Facility maintenance for 24×7 controlled atmosphere testing conditions for the Creep Laboratory.
2. Setting up of infrastructural requirements for the successful installation of following major procurements during the period: Rolling Mill and Inert Gas Atomiser.
3. Operations of 493KWP solar power plant for catering the electrical load requirement of Laboratory, due to which a saving of Rs.1,50,000/- per month in the running expenditure is observed.

Finite Element and CFD Modeling :

The division is actively contributing in process modeling activities. We are gaining expertise in Particle Image Velocimetry (PIV) technique, which can be used for studying insights of fluid flow systems and for validation purpose. Following are the major contributions :

1. Optimization of FBG sensors requirement for locating the critical zone of blow pipe by numerical simulation and ANN.
2. Numerical modelling of heat transfer and fluid flow in Selective Laser Melting (SLM) of SS316L.
3. Temperature mapping of GTG gas collector for assisting annealing cycle and furnace design.

Basic Engineering Packages:

The group has been involved in Preparation of Detailed Project Report(DPR) for the NMLS retort technology for magnesium metal production and for the upscaling of an energy efficient process for the recovery of metal value from spent NdFeB magnets

Pilot Plant Operation and Maintenance:

1. Construction of energy efficient brass melting furnaces in various clusters of Bengal, Jharkhand and Odisha, and demonstration to artisans to construct themselves.
2. Support in carrying out pilot scale campaigns.
3. Support in revival of critical R&D equipment's.

Maintenance and Up-keeping of Equipment:

The division has limited manpower but actively involved in in-house maintenance support to high value equipment of the laboratory. This will save a lot of AMC costs and will reduce breakdown time of the equipment's. During the reporting period the Surface grinder and Lathe Machine were serviced.

Skill Development:

Every year the division provides training to graduate and technician apprentices. In addition, training in the area of welding and carpentry is provided under CSIR skill initiatives.

Central Workshop:

Central Workshop receives jobs from various divisions, for specimen preparation of different materials, fitting, machining & fabrication of prototypes and repairing of miscellaneous jobs. All these jobs are completed in time to the satisfaction of the indenters. Major facilities available in the workshop are: CNC Lathe, Universal Milling, Shaper, Radial drill, Pillar Drill, Double column band saw, Shearing, Pipe bending M/C, TIG/ MIG welding, EDM wire cut machine. Major achievements made during the period are:

1. Job value of the services during the period 2022-23 is Rs. 46 Lakh. (upto January,31st 2023)
2. No. of job-sheets served is 624 in FY 2022-23.
3. Average time to complete a job also has come down with emphasis to complete the given job in less than a week of its requisition.
4. Upgradation of workshop facilities by utilization of Robotic MIG and CMM.
5. New Forklift has been procured for material handling purposes in workshop and for entire laboratory.

Works Services and Maintenance Group:

This group has diverse responsibility to upkeep infrastructure, create new infrastructure and renovation of facilities in 7 campuses (Main laboratory, 2 pilot plants, 4 residential campuses) of CSIR-NML. These services include civil engineering, electrical engineering and refrigeration & air conditioning, lifts, water supply etc. The work accomplished by the group can be categorized in 3 major categories namely- New infrastructure, renovation jobs and routine maintenance jobs. List of major works undertaken are enumerated below.

New Infrastructure:

The infrastructure management team has successfully completed new facilities creation jobs as per the requirements of the laboratory. In addition, we take annual Maintenance & Overhauling of infrastructure & maintenance jobs. Some of the new facilities developed are as following:

New thermal Laborataory

New rolling mill foundation

New security office under construction, Agrico Housing Complex

Renovation Jobs:

The infrastructure management team has successfully completed new facilities creation jobs as per the requirements of the laboratory. In addition, we take annual Maintenance & Overhauling of infrastructure & maintenance jobs. Some of the new facilities developed are as following:

Road carpeting and concrete pavement in residential complex

Renovation of Melting Bay

Routine Maintenance:

Maintenance of L.T Breakers

Team - Engineering

Cloud Gate - Chicago

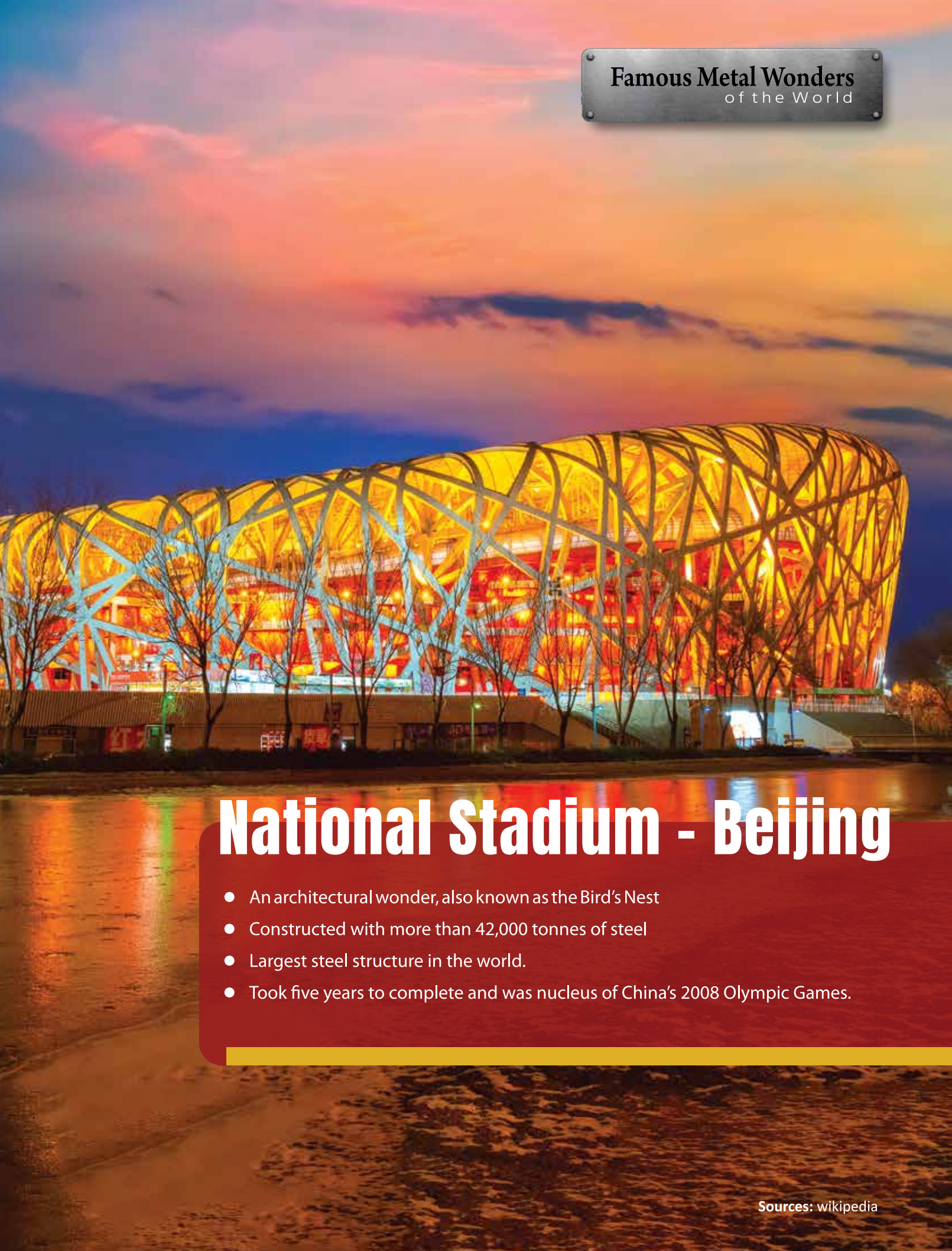
- Nicknamed 'the bean' because of its shape. Its design and was inspired by liquid mercury. Indian-born British artist designed it.
- Construction comprises of 168 stainless steel plates welded together and highly polished so that there are no visible seams. It measures 33 by 66 by 42 feet (10 by 20 by 13 m), and weighs 110 tonnes.

Sources: wikipedia

Stores & Purchase Division

CSIR-NML's Stores & Purchase Division is a committed team of dedicated officials who are primarily responsible for procurement of goods & services including imports from foreign countries. The team works as a support system to cater to the Research and Development (R&D) needs and also to meet the long term strategic goals of this Institute and also the team strive to keep the system of R&D and other supporting services running in smooth condition by taking care of procurement activities related to materials / services in time and within the ambit of public procurement.

Team - Stores & Purchase



National Stadium - Beijing

- An architectural wonder, also known as the Bird's Nest
- Constructed with more than 42,000 tonnes of steel
- Largest steel structure in the world.
- Took five years to complete and was nucleus of China's 2008 Olympic Games.

Sources: wikipedia

Finance & Accounts

Finance & Accounts Division of CSIR-NML is actively engaged in planning, organizing, directing and controlling the financial activities of the Lab including accounting of all the financial transactions of the year as per GFR and CSIR guidelines. This division provides a central accounting and financial information to Director, NML, CSIR Headquarters and other stakeholders through the management information system.

Following are the major activities of the Finance & Accounts Division.

- Preparation of Budget Estimate and Revised Estimate for CSIR-NML and submitting the same to CSIR for allocation of funds.
- To ensure that there are adequate funds available to acquire the resources needed to help the organization to achieve its objectives.
- To ensure cost control while facilitating adequate spending within laid down guidelines and procedures in the matter.
- To ensure adequate cash flow and proper management of funds through transfer of funds from CSIR.
- To provide appropriate financial information relating to different heads of accounts and projects to the Director, Project Leaders and other decision makers so that informed judgments and decisions are made. Posting of monthly progressive expenditure in NML intranet to keep all employees informed about fund position.
- To prepare financial documents such as Receipts and Payments account and Balance Sheet of the organization on a given date for submission to CSIR and decision makers including submission to CAG (Audit) for certification of accounts.
- Preparation and Submission of Utilization Certificate to sponsors of the projects as and when required.
- Pre-audit of all the bills before making final payment to avoid any irregularity or deviation from the financial Rules.
- Processing promptly all payment payable through Treasury Single Account (TSA) at RBI in PFMS system of the Government of India.
- Promptly, accurately and efficiently recording all the receipts and payments in the relevant ledgers and books of accounts.
- Closing of GPF/CPF accounts, remittance of funds to NSDL relating to National Pension Scheme and Professional tax, income tax, etc. within due date to appropriate authority.
- Accounting, processing and ensuring timely filing of various GST returns and payment of GST due to the Government.
- To provide progressive reports on monthly expenditure, OB, Bank reconciliation, Audit Paras, etc. to maintain transparency.

Performance Highlights for the Financial Year 2022-23

1. Utilized Budget Grant allocated by CSIR- Rs.7254.253 lakhs + Rs.5143.063 lakhs (pension)
2. Utilization from Laboratory Reserve- Rs.214.763 lakhs
3. Generation of interest by investment of surplus funds- Rs.634.268 lakhs
4. Generation of Lab Reserve - Rs.1239.375 lakhs.

5. Bank reconciliation of the Cash Book completed up to 31st March, 2023.
6. GPF Account as on 31-03-2023 has been reconciled, finalized and closed.
7. During the year new cases of 35 pension and 24 family pension cases have been completed with issuing of PPO and pension papers on time.
8. NML finance successfully switched over to PFMS system for payments out of Govt. grant, where payments are directly made to vendors by RBI under Single Treasury Account system.
9. Several CAG Audit para have been settled.
10. Accounts Division has been renovated for better ambience.
11. Provision of QR Code for online money receipt in the NML official Account.

Team - Finance & Accounts

Awards & Recognition

National/International Awards/Recognitions

TATA INNOVISTA Award 2022

As THE MOST INNOVATIVE PARTNER for the "Intelligent Billet Caster"

Team : Dr. Sarmistha Sagar, Chief Scientist, Dr. Tarun Kumar Das, Sr. Principal Scientist, Dr. Arpita Ghosh, Principal Scientist

MRSI Medal Lectures 2022

The award was conferred to eminent researchers for delivering MRSI Lecture.

Dr. Asit Baran Panda,
Principal Scientist

2nd prize

Presentation on topic of "**Development of Hydrogen CRMs in Steel (PIN)**" in 6th PTP/RMP Conclave 2022 during 25th - 26th August 2022, Bengaluru organized by NABL, QCI.

Dr. A. K. Upadhyay,
Principal Technical Officer & QM, CRM Unit

Recognition to CSIR-NML Scientists and their Mentorship

A web-article recognizing the role of CSIR-NML mentoring in shaping the career of a Nigerian researcher.
Link: https://twas.org/article/boosting-steel-industry-nigeria

Skoch Order of Merit 2023

e-Recruitment System

Team: Dr. Beena Kumari, Principal Scientist, Mr. Sudip Kundu, Principal Scientist and Mr. Kumar Rahul, Administrative Officer

Recognition and Felicitation of CSIR-NML Women Staff, NML on International Women's Day Celebrations 2023 in Various Forums for their Contributions in Different Fields of Work

Field of Work : Entrepreneurship & Skill Development

Felicitated and graced the chief guest in the function organized by CSIR-CMERI, Durgapur

Dr. Mita Tarafder, Chief Scientist

Field of Work : NDT

Felicitated and participated as one of the panelist's in a panel discussion organized by at LPSC, ISRO

Dr. Sarmistha Sagar, Chief Scientist

Field of Work : ICT Development and Digital Transformation

Felicitated in the function organized by CSIR-CIMFR, Dhanbad

Dr. Beena Kumari, Principal Scientist

Field of Work : Analytical Chemistry

Felicitated in the function organized by CSIR-CIMFR, Dhanbad

Mrs. Rupa Das Biswas, Sr. Technical Officer

Fellowships

INAE Fellowship 2022

Prestigious fellowship for the year 2022.

Dr. Sandip Ghosh Chowdhury, Chief Scientist

CSIR-NML Foundation Day Awards (26th November 2022)

V.A. Altekar Award for Best Technology developed and transferred,

Technology : "Fiber Optic Based Break Out Prevention Technology for Continuous Billet Caster"

Dr Tarun Kumar Das, Sr. Principal Scientist, Mr. Chandan Dutta, PA, Mr.Alok Kumar, PA and Dr. Sarmishtha Palit Sagar, Chief Scientist

B.R. Nijhawan Award for the Best Technical Paper published from laboratory, was awarded to the paper "Evolution of microstructure and deformation behavior in Al-Ni added medium- Mn Steel process through intercritical/ cold rolling and annealing".

Dr. Biraj Kumar Sahoo, Scientist, Dr. Vikas Chandra Srivastava, Chief Scientist, Dr. Avanish Kumar Chandan, Sr. Scientist, Dr. Sandip Ghosh Chowdhury, Chief Scientist

Professor Shilowbhadra Banerjee Award for the Best in-house project completed, was given to for the project "Preperation and Certification of Hydrogen Standard (CRM) in steel".

Dr. Ashok K

Dr. A K Upadhayay

Dr. A K Mohanty

Dr. K. Ashok, Scientist, Dr. Arvind Kumar Upadhyay, Principal Technical Officer, and Dr. Ashok Kumar Mohanty, Sr. Principal Scientist

Prof. S.P. Mehrotra Award for the Best Colloquium Speaker in 2022 was jointly shared

Mr. M. Ananda Rao, Principal Scientist and Dr. Rajen Kundu, Scientist

Prof. P. Ramachandra Rao Award for the Best Employees

Category : Technical

Mr. Dhani Ram Mahato, GrII/2 and Mr. Manoj Kumar Toppo , GrII/2

Prof. P. Ramachandra Rao Award for the Best Employees

Category : Non-Technical

Mr. Amod Kumar, ASO (G)-Admin

Mr. Md. Nayeem Ansari, ASO(G)-Admin

Meritorious Student Award-2022

Awards for scoring 90% or above marks in the Board Examinations (ICSE/CBSE/Jharkhand Board) in class 10th and 12th in the year, 2022.

Mr. Ayush Kumar
Mr. Chandresh Kumar, Section Officer
Class 10th , 96.00%

Miss Abhipsa Mishra
Dr. D. Mishra,
Senior Principal Scientist
Class 10th, 93.50%

Miss Stuti Das
Mr. Byomkesh Das,
Chief Scientist
Class 12th, 98.75%

Mr. Ankit Sahoo
Dr. K. L. Sahoo, Chief Scientist
class 10th, 98.75%

Miss Aditi Upadhaya
Dr. A. K. Upadhyay, Principal Technical Officer
class 10th, 98.25%

Miss Arpita Sahu
Dr. S. K. Sahu, Senior Principal Scientist
class 10th, 96.00%

Mr. Deepanshu Sau
Dr. D. D. Sau, Principal Scientist
class 12th 97.25%

Award for Scoring 100% Marks in any Subject in the 10th and 12th Class Examination held during the Year, 2022.

Mr. Anikt Sahoo
Dr. K. L. Sahoo, Chief Scientist
10th Mathematics

Miss Stuti Das
Mr. Byomkesh Das, Chief Scientist
12th Mathematics

Mr. Deepanshu Sau
Dr. D. C. Sau, Principal Scientist
12th Computer Science

Admission In Institutions of National Repute Through Competitive Examination Held during the Year, 2021 & 2022.

Mr. Ivan Jacob Thomas
Dr.(Ms.) Ansu J. Kailath, Senior Principal Scientist
2021 IIEST, Shibpur

Mr. Deepanshu Sau
Dr. D. C. Sau, Principal Scientist
2022
IIT, BHU

National / International / Committee Membership/ Editorial Board Membership

Dr. Sanjay Kumar, Chief Scientist	• Editorial Board Member of Transactions of Indian Ceramic Society for the third time, for 2023-25, a Tailor & Francis Journal with Impact Factor of 2.64 • Expert Advisory Committee Member for Technology Enabling Centre Program of DST, Ministry of Science & Technology from 29.04.2022. This program funds universities to establish Technology Enabling Centres at various part of country. • Screening Committee Member of prestigious National Technology Awards, 2023 given by Technology Development Board and DST, Ministry of Science & Technology from 06.02.2023. • Elected as Council Member of Indian Ceramic Society for the year 2023-24

 Dr. Trilochan Mishra, Chief Scientist	• Bureau of Indian Standards (BIS) for Inorganic Chemical Section Committee (CHD-1) • High level expert committee for environmental clearance of secondary metallurgical industries under Ministry of Environment, forest and climate change (MOEFCC) during Oct. 2021-Jan. 2022.
 Dr. Abhilash, Senior Principal Scientist	• Editorial Board Member, Mineral Processing and Extractive Metallurgy Review (Taylor Francis) • Editorial Board Member, Russian Journal of Nonferrous Metals (Springer) • Youth Editorial Committee Member, Journal of Central South University (Springer) • Review Editor, Frontiers in Chemical Engineering • Section Editor, Microbiology Insights (SAGE) • Academic Editor, International Journal of Analytical Chemistry (Hindwai) • Academic Editor, Journal of Chemistry (Hindwai)
 Dr. Pallab Bhattacharya, Senior Scientist	• Editorial Board Membership in Journal : Advances in Materials(AM) • Review Editor of Journal: Frontiers in Energy Research.
Dr. V Rajinikanth, Principal Scientist Dr. Sharma Paswan, Principal Scientist 	• MTD-6 Member, "The Pig Iron and Cast Iron Sectional Committee" in the panel as a convenor constituted for revision of standard Centrifugally Cast (Spun) Ductile Iron Pressure Pipes for Water, Gas and Sewage - Specification as per IS 8329.

High No. of Downloads of Research Publication

 Dr. Abhilash, Senior Principal Scientist Dr. Pratima Meshram, Principal Scientist	• Ata Akcil, Yahaya Alhaji Ibrahim, Pratima Meshram, Sandeep Panda, Abhilash; Hydrometallurgical recycling strategies for recovery of rare earth elements from consumer electronic scraps: a review • Pratima Meshram, Abhilash, Banshi Dhar Pandey; Advanced Review on Extraction of Nickel from Primary and Secondary Sources

High Impact Factor Journal Publication

 Dr. Abhilash, Senior Principal Scientist	Abhilash, Isiri Inamdar; Recycling of plastic wastes generated from COVID-19: A comprehensive illustration of type and properties of plastics with remedial options, Science of the Total Environment 838 (2022) 155895 Impact Factor- 10.753

Paper/Poster Awards

Receiver	Title	Description	Photo
Dr. Manis Kumar Jha, Sr. Principal Scientist	N.M.Sampat Award -2021	The award was conferred in the inaugural function of the national symposium on electrochemical science and technology (NSEST-2022) held in Indian Institute of Science Campus Bangalore, India organized by the Electrochemical society of India on (24 June 2022); Awarded Article: For the development of electro-leaching/ selective electro- leaching, electroplating, electro-winning of various non-ferrous, rare and precious metals from e-waste.	

Dr. Sanjay Prasad, Principal Scientist	Best Paper Award	Best Paper Award for the paper entitled "Zinc powder preparation for Zinc dross"; Presented in the technical session "Development of Materials and alloy for emerging applications" from 18th to 22nd April,2022.	

Invited Talks Delivered by Staff

Speaker	Topic/Event
Dr. Sandip Ghosh Chowdhury Chief Scientist	"Similar/Dissimilar Materials Welding of Automotive & Aerospace Sectors (WSM 2022)"; VIT Vellore; Indo-German Science and Technology Centre (IGSTC); 22 September 2022 to 24 September 2022.
Dr. Sanjay Kumar, Chief Scientist	"The Science of Making Artificial Stone"; Indian Ceramic Society, Jamshedpur Chapter; 19th November 2022.
Dr. Sarmishtha Palit Sagar, Chief scientist	NDT in AIMTEK-2022: One day Int. Conf. on Asset Integrity management"; 07th June 2022

Speaker	Topic/Event
 Dr. Ashis Kumar Panda, Senior Principal Scientist	"Rapidly Quenched Magnetic Materials for Sensor Applications"; K.L.University, Vijaywada; 21st February 2023
 Dr. Trilochan Mishra, Senior Principal Scientist	"Environmental Consciousness"; Atal Shodh Kendra, Kanpur; 6th June 2022
	5th International Symposium on hydrogen energy and Energy Technologies (HEET) seminar, Osaka, Japan; 18th -19th November 2022.
	"Material science and Nano Science"; SciWide; 29th – 30th July 2022.
 Dr. Sanjay Agarwal, Sr. Principal Scientist	• "Chromium partition studies in Al2O3-MgO-SiO2-CaO-FeO-Cr2O3 slag system for ferrochrome production", at Manganese/ Chrome Ores, EMD, EMM & Ferro-Alloy Summit, 3 - 4th January 2023, Kolkata, India. • "Utilization of low grade sukinda chromite fines for ferro chrome production" at Technological Advancement in Ferroalloys & Opportunities for Growth, Organized by STEEL TECH, on 11th April 2022, Kolkata, India.
 Dr. Ashit Kumar Pramanick, Senior Principal Scientist	"Defect Characterization of Ga2O3 Single Crystals by TEM and AFM Techniques"; EMSI-2023; 8th -10th February 2023.

Speaker	Topic/Event
 Dr. Abhilash, Senior Principal Scientist	• Invited Lecture at TATA STEEL on 21st June 2022 (Topic: EXTRACTION OF CRITICAL METALS FROM STEEL WASTES) • Invited Lecture at PESIT, Bangalore on 11th November 2022 (Topic : Application of Microbiology in Chemical, Mining and Environment Areas) • Invited Lecture at Karim City College, Jamshedpur on 5th September 2022 (Topic : Innovative Approaches to Remediate Issues in Basic Science Research & Education An Adaptive Competence Development Approach)
Dr. Premkumar Murugaiyan, Senior Scientist	"Development of High Induction Fe-Soft magnetic Nanocomposite alloys: Alloy design to Industrialization"; Central University of South Bihar; 20th March 2023
 Dr. Ajita Kumari, Scientist	International Womens Day 2022 Webinar, Organised by IIME Hyderabad Chapter; 08th March 2022
 Dr. Vinod Belwanshi Scientist	"Micro/Nanoelectronics Devices, Circuits and Systems (MNDCS) 2023"; National Institute of Technology, Silchar; 29-31 January 2023.

Books & Book Chapters

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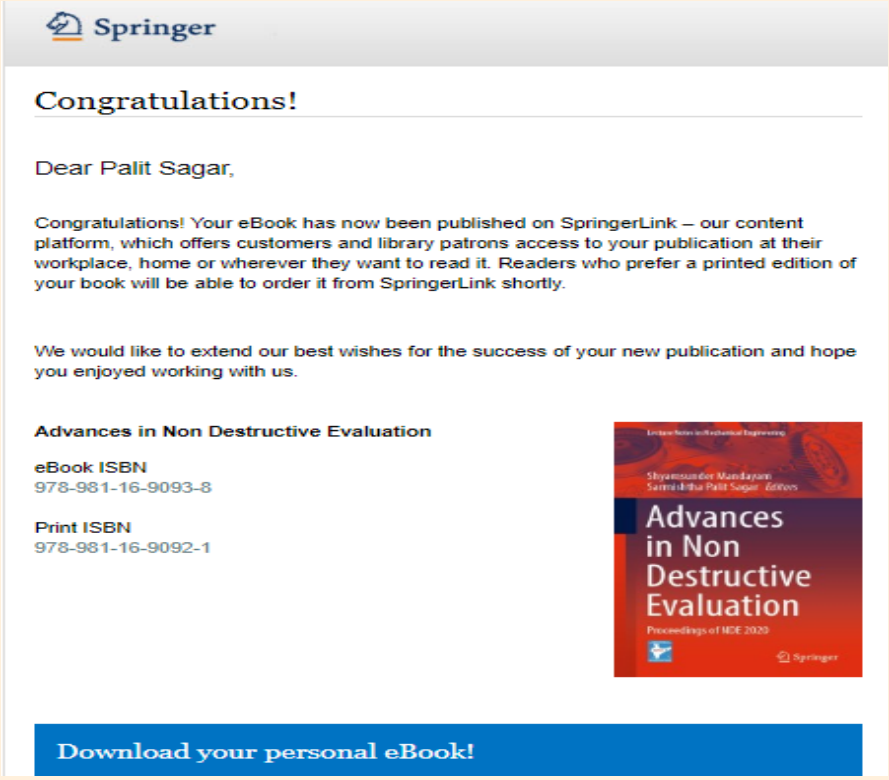
Dr. Sarmistha Sagar, Chief Scientist</td>
<td>Editor of e-Book

Co-edited an e-Book entitled as “Advances in Non Destructive Evaluation” Proceedings of NDE 2020.



Springer

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Congratulations! Your eBook has now been published on SpringerLink – our content platform, which offers customers and library patrons access to your publication at their workplace, home or wherever they want to read it. Readers who prefer a printed edition of your book will be able to order it from SpringerLink shortly.

We would like to extend our best wishes for the success of your new publication and hope you enjoyed working with us.

Advances in Non Destructive Evaluation

eBook ISBN
978-981-16-9093-8

Print ISBN
978-981-16-9092-1

Download your personal eBook!</td>
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Dr. Pratima Meshram, Principal Scientist

Dr. Abhilash, Sr. Principal Scientist</td>
<td>Material Recycling : Unearthing Metals from Anthropogenic and Industrial Resources. In: Shrivastava, A., Arora, A., Srivastava, C., Dhawan, N., Shekhar Singh, S. (eds) New Horizons in Metallurgy, Materials and Manufacturing. Indian Institute of Metals Series. Springer, Singapore. https://doi.org/10.1007/978-981-19-5570-9_5, pp. 69-89.</td>
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CSIR-NML Foundation Day Essay Competition

Somnath Das
Hindi (First)

Amit Prakash
Hindi (Second)

Rukhshana Parween
Hindi (Third)

Shilpa Bawkar
English (First)

Dr. Saswati
English (Second)

Sukalpan Nandi
English (Third)

CSIR-NML Foundation Day Quiz Competition

FIRST PRIZE	SECOND PRIZE
RR Srivastava and Roshan Kumar	**Vikas Kumar and Minati Sahu**

Vigilance Awareness Week Essay Competition

विषय : भ्रष्टाचार को रोकने के लिए सांस्कृतिक उपाय

Topic : Cultural remedy for preventing corruption

Roshan Kumar
(First)

Amit Prakash
(Second)

Abhishek Kumar Singh
(Third)

Vigilance Awareness Week Poster Competition

विषय : आज का सामाजिक परिवेश का भ्रष्टाचार में योगदान

Topic : Role of present social environment in corruption escalation

Rachit Ghosh (First)

Abhishek Kumar Singh (Second)

Pankaj Kumar (Third)

Vigilance Awareness Week Elocution Competition

विषय : भारत को भ्रष्टाचार मुक्त बनाने में सोशल मीडिया की भूमिका

Topic : Role of social media in making India corruption free

Roshan Kumar (First)

Shekhar Sanga (Second)

Hindi Week Dictation Competition for non-Hindi Speakers

C.R. Chakraborty (First)

Tapan Kumar Shankar (Second)

Mudila Dhanunjaya Rao (Third)

Suchitra Bhatt (Consolation)

Hindi Week Essay-Writing Competition for Hindi speakers

Rohit Mudi (First)

Amit Prakash (Second)

Somnath Das (Third)

Ajit Gangwar (Consolation)

Hindi Week Essay-Writing Competition for non-Hindi speakers

Tapan Kumar Shankar (First)

C.R. Chakraborty (Second)

Suchitra Bhatt (Third)

Rachit Ghosh (Consolation)

Hindi Week Hindi Noting and Drafting Competition for Hindi Speakers

Sudhir Kumar (First)

Rohit Mudi (Second)

Amit Prakash (Third)

Pankaj Kumar (Consolation)

Hindi Week Hindi Noting and Drafting Competition for non-Hindi Speakers

Rachit Ghosh (First)

C.R. Chakraborty (Second)

Tapan Kumar Shankar (Third)

Suchitra Bhatt (Consolation)

Hindi Week Poetry Recitation Competition for Hindi Speakers

Prem Vishwakarma (First)

Roshan Kumar (Second)

D. Bhaskar (Third)

Amit Prakash (Consolation)

Hindi Week Poetry Recitation Competition for non-Hindi Speakers

Tapan Kumar Shankar (First)

Sarita Kandeyang (Second)

Pinky Patra (Third)

Suchitra Bhatt (Consolation)

Special Appreciation Letter and Cash Award to the Personnel who Worked the most in the Hindi Language during the Year 2021-22.

Parmarth Suman

Sudhir Kumar

C.R. Chakraborty

Md. Naeem Ansari

Santosh Kumar Rai

Nandlal Paswan

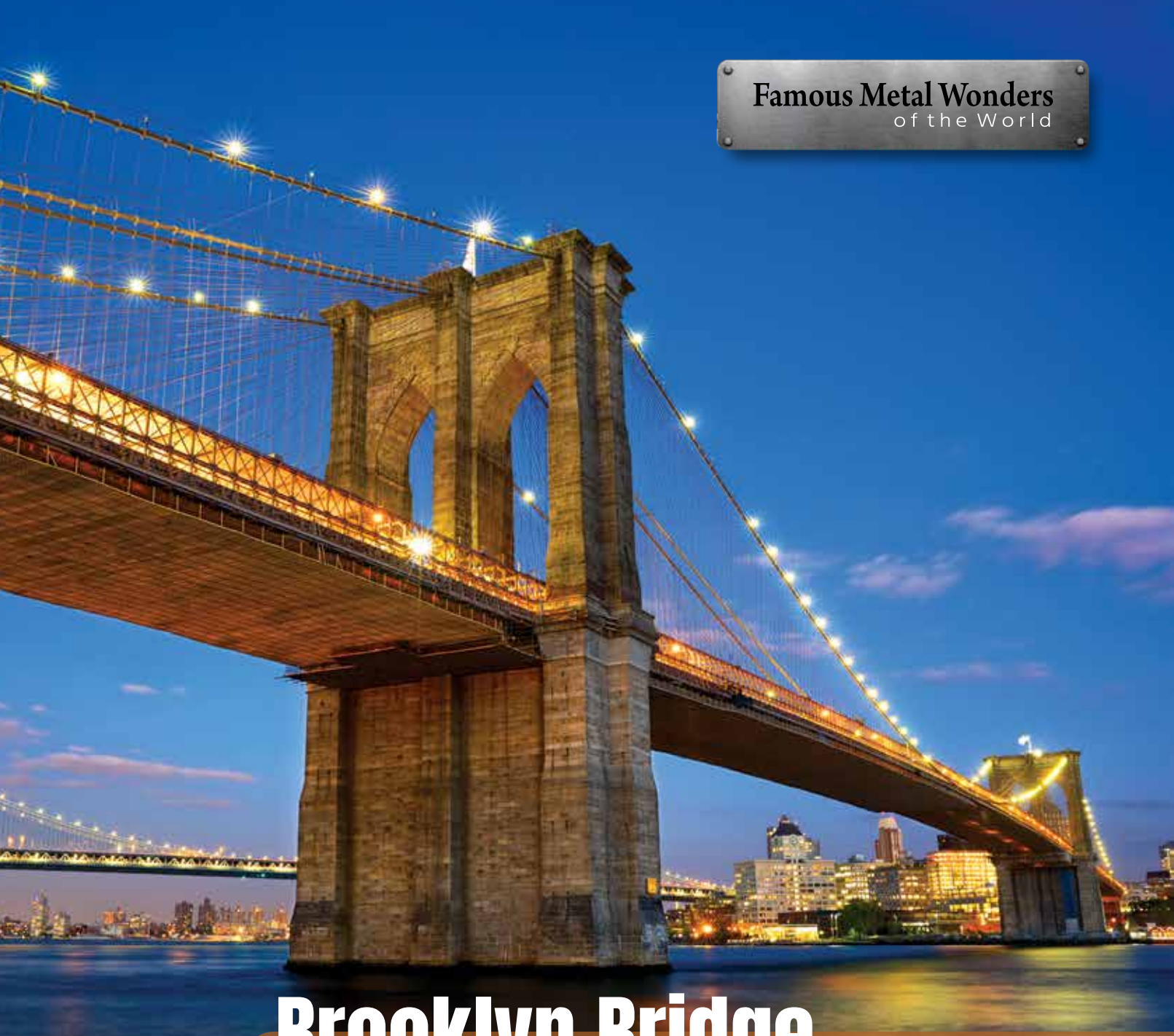
Anil Kumar

Jyoti Kumar

Ravi Ranjan Kumar

Rohit Mudi

G. Dharma Rao



Brooklyn Bridge

- It was the very first steel-wire suspension bridge built in 1869.
- The steel is so thick and construction so challenging, it took a decade to complete. It was also the longest suspension bridge in the world at the time of its opening, with a main span of 1,595.5 feet (486.3 m) and a deck 127 ft (38.7 m) above mean high water.

Sources: wikipedia

Special Days & Events

Cultural Night-n- Grand Feast (3rd April, 2022)

A number of cultural programs viz. Dance, Songs and Skit were organized in which the staff and staff children participated.

Visit of Reliance Industries Delegates (15th April, 2023)

Delegates from Reliance Industries visited various R&D facilities of CSIR-NML for future R&D collaboration.

Town Official Language Committee Meeting (25th & 27th April 2022)

Swachhata Pakhwada-2022 Celebrations (9th -13th May 2022)

A number of events like cleaning of all residential and office campuses, competitions for staff and staff children were organized as part of the celebrations like Sit & Draw, Essay writing and Extempore. The closing ceremony was graced by Mrs. Debarati Chattoraj and Mr. Sanjay Choudhury, Blood Bank, Jamshedpur as Chief guest and Distinguished guest respectively

National Technology Day Celebrations (11th May 2022)

The occasion was celebrated on virtual platform. The technological development of the laboratory was showcased and the success stories about reaching from laboratory to market, for the recently commercialized technologies were also presented during the ceremony.

International Day of Yoga-2022(21st June, 2022)

International Day of Yoga was celebrated at all campuses of CSIR-NML. A lecture was organized on the occasion. Mr. Rajeev Nair, Coach, Cricket, Tata Sports Complex, Tata Steel, Jamshedpur and Director Indian Institutte of Yoga and Management, Haryana delivered a lecture on “Importance of Yoga for a healthy life”.

Covid-19 Vaccination Drive @CSIR NML (1st-31st August, 2022)

Independence Day Celebrations 2022

The flag hoisting program was held at all official and residential premises of CSIR-NML. Various events for staff, staff children and staff families were organized to mark the event like poetry competition, competitions for ladies, drawing competition, football match, marathon and cultural events. The winners of various competitions were also awarded during the main function.

CSIR-Jigyasa Program- Virtual Lab Integration (18th August 2022)

NML visit by students of SSVM School Chandil

10th Prof. S. N. Sinha Memorial Materials and Metallurgy Quiz (SNSM3Q-2022)(23rd August, 2022)

The Indian Institute of Metals (IIM), Jamshedpur Chapter along with CSIR-NML organized the event titled "Professor S.N. Sinha Memorial Materials and Metallurgy Quiz (SNSM3Q-2022)". The primary purpose of this event was to create awareness about the role of materials science and metallurgy in industrial and technological developments amongst Standard XI and XII students of schools in and around Jamshedpur.

Inauguration of Technology Park for Women and Innovation Cell at NIAMT, Ranchi

Central Education Minister Honorable Madam Annapurna Devi was the chief guest. The centers have been opened jointly by CSIR-NML and NIAMT under the DST project on Women Technology Park.

एनआईएमटी - वीमेन टेक्नोलॉजी पार्क व इनोवेशन सेल का उद्घाटन

महिलाओं के लिए हर वर्ष दो नए शॉर्ट टर्म ट्रेनिंग प्रोग्राम शुरू होंगे

तीन वर्ष में 6 कोर्स के जरिए दी जाएगी महिलाओं को ट्रेनिंग

एनआईएमटी-एनएमएल मिल देंगे कौशल शिक्षा

अन्नपूर्णा ने कहा, महिलाएं ट्रेनिंग से आर्थिक रूप से आत्मनिर्भर बनेंगी

ऑफिसहुन या ऑनलाइन अलाई करने की सुविधा

महिला उद्यमिता को बढ़ावा देगा वीमेन टेक्नोलॉजी पार्क

स्टाफ रिपोर्टर • रांची

वह होगा खास

Healthcare Lecture (8th September 2022)

A lecture on "Breast Cancer: Self Examination & Early Detection" by Dr. Natasha Das, Cofounder and Director of Hazlo Consultancy Pvt. Ltd. was delivered at CSIR-NML in hybrid mode.

Contract Bridge Pairs Championship (11th September 2022)

Vishwa Hindi Diwas 2022 (14th September 2022)

Hindi Lectures were organized on the occassion of "Vishwa Hindi Diwas".

Hindi Week Celebrations-2022 (1st-7th September 2022)

Theme : Importance of Hindi language in the development of the nation.

A number of programs and events were organized during the program like Essay Competition, Poetry Recitation, Hindi Drama and Noting Drafting Competition.

CSIR Foundation Day Celebrations (26th September, 2022)

A number of events were organized to mark the 81st CSIR Foundation Day. The main function was celebrated at the laboratory having Prof. Tanusri Saha-Dasgupta, Director Satyendra Nath Bose National Centre for Basic Sciences as the chief guest. Dr. Indranil Chattoraj, Director-NML and Mr. Rajkumar Droach, Sr. CoFA were amongst the dignitaries present on dais. The chief guest delivered the CSIR Foundation Day Lecture along with presenting awards to the meritorious staff children and staff completing 25 years of service in the lab. The dedicated services provided by the superannuated staff to the laboratory, during last two years, were also recognized and appreciated. The CSIR-NML Annual Report 2021-22 was also released by the dignitaries, on the occasion.

Visit of Shri Chetan Prakash Jain, Financial Advisor, CSIR (28th September 2022)

Visit of Delegation from CSIRO, Australia

Vigilance Awareness Week 2022 (31st October - 6th November 2022)

The occasion was celebrated with many programs as essay, elocution and poster competitions on related topics. A lecture on "Corrosion free India for a developed nation" was also delivered by Mr. Binay Kumar Kar, Ex. Sr. COA, CSIR-IICB.

Ayurvedic Medical camp and lecture (14th October, 2022)

To commemorate the 7th Ayurveda Day, an Ayurvedic Medical Camp and free distribution of medicines was organized. The speaker of the lecture was Dr. Balaji Potbhare, R.O(Ay), Nodal Oflicer and the topic was "Ayurveda for mental well-being".

Fit India Freedom Run 3.0 (29th October, 2022)

The event was organized by the laboratory under the banner of Fit India Movement. Staff members and their families participated in a large number.

CSIR-NML Foundation Day Celebrations (26th November, 2022)

CSIR-National Metallurgical Laboratory celebrated its 73rd foundation day on 26th of November, Saturday. The main function started with the lamp lighting ceremony by the dignitaries on the dais. CSIR-NML song was also played on the auspicious occasion. Professor T N Singh, Director, IIT Patna graced the occasion as the chief guest. He delivered the Foundation Day Lecture on the topic E-Waste Recycling. A number of awards were customarily presented by the chief guest to the staff for their outstanding contribution in technical and non-technical areas as well as to the meritorious staff children for their various achievements in the year 2021. The awards included V.A. Altekar award for the best technology licensed or commercialized, B.R. Nijhawan Award for the best paper published, Prof. S.P. Mehrotra award for the best colloquium speaker and Prof. Shilowbhadra Banerjee award for the best in-house project completed during the year 2021, Prof. P. Ramachandra Rao award for the best employee in Technical/ Non-Technical Category during the year 2021 and several meritorious awards to NML staff children in various categories. The constitution day pledge was undertaken by the NML Staff and Guests on the day."

On the occasion, CSIR-NML signed MoUs with Industry and Academic institutions to carry out collaborative research in futuristic R&D areas and solving current & future industrial R&D problems. MoUs for academic collaboration were signed with IIT Patna and IIT (ISM) Dhanbad for enhancing joint student mentoring and undertaking joint R&D projects of mutual interest. This collaboration aimed to organize joint seminars/conferences/ workshops as well as to provide better exposure and access to available state-of-the-art equipment to the students to pursue their higher studies. This would also fulfil the Skill India objectives of Government of India. Industry partners including SAIL (Bokaro), NTPC, Vedanta Pvt Ltd, Jamipol (Jamshedpur) and Diva Envitech, Pune also signed MoUs with CSIR-NML to collaborate in various fields of mutual interest, to find novel solutions to the industrial problems and to develop technologies. CSIR-NML joined hands with NTPC to enable studies related to the residual life assessment of important parts of the boiler and turbines in power plants. Vedanta Pvt Ltd and CSIR-NML have agreed upon to work together for the development and scaling up of

the laboratory level technologies to industrial level. While the agreement with SAIL focused on developing technologies, which decrease the carbon footprint and greenhouse gas emission from steel plants. These collaborations will also ensure that research on sustainable technologies are also focused. The successful collaboration of CSIR-NML with academic and industrial partners is the need of the hour and will play a major role in the development of the nation.

General Collaboration with IIT, Patna

General Agreement with NTPC Limited (NTPC), New Delhi.

Collaboration for R&D in Mutual Interest Areas (Umbrella) with Vedanta Pvt. Ltd.

General Agreement with Steel Authority of India Limited-Bokaro Steel Plant, Bokaro.

General Agreement with IIT-ISM, Dhanbad.

R&D in the Areas of Mutual Interest With Diva Envitec Pvt. Ltd., Mumbai.

General R&D Collaboration with Jamipol, Jamshedpur

Republic Day Celebrations 2022

Visit of DG-CSIR (03rd March 2023)

Visit of Dr. N. Kalaiselvi, DG,CSIR and Secretary, DSIR .

Women's Day Celebrations @ CSIR-NML

The occasion was celebrated with many programs. A medical test camp was organized for the Janitorial and other Contractual female staff at the lab. In the main function distinguished ladies from various fields were felicitated and a Fun and Food fair was organized for staff and staff-families.

Technology Transfer and Memorandum of Understanding Signing Events (17th May 2022)

Transfer of Technology for Flawguard: A device for real time defect detection of high end wires. (//todo date)

Transfer of Know-How for the Recovery of Li, Ni, Mn, Co from spent Lithium-ion Batteries (Know-How Transfer) to ReCy Energy Pvt Ltd, Pune. (25th May 2022)

Development of optimized methodology for hot rolled TWIP steel plates (10mm thickness) (Sponsored) for Surgiwear Ltd., Shahjahanpur. (13th May 2022)

Collaboration for R&D in the areas of recycling with Vardhman Auto Recycling, New Delhi on 16th August 2022.

Webinars/Seminars/Conferences/Workshops

Webinar on "ROLE OF IPR IN INNOVATION ECOSYSTEM" (26th April 2022)

The Webinar was organized by CSIR-NML, IP Facilitation Center, Jamshedpur in association with CTTC-WIPO-TISC CENTER, BHUBANESWAR as a part of celebrations of the "World Intellectual Property Day".

Webinar on "Great Metallurgical Legacy of India through Ages" (26th May 2022)

"Azadi ka Amrit Mahotsav" was celebrated in association with Vigyan Bharti, Jharkhand Chapter. A number of experts on the subject participated in the event, to name a few Dr. Indranil Chattoraj, Director, CSIR-NML, Prof. Indranil Manna, Vice-Chancellor, BIT-Mesra, Ranchi, Prof. S. Basu, Director IMMT Bhaubaneshwar, and Dr. N. Ishwara Prasad, Director-DMSRDE.

Workshop on Matlab application (13th December 2022)

A workshop on MatLab applications by the representative from MathWorks was organized at CSIR-NML.

Workshop on "Materials for Energy and Sustainability" (20th January 2023)

The National Academy of Sciences (NASI), Jharkhand Chapter in association with CSIR-National Metallurgical Laboratory (CSIR-NML), Jamshedpur organized a one-day "Workshop on Materials for Energy and Sustainability" at CSIR-NML. The event has been envisaged to deliberate on the various frontiers of material types, property, structure, and applications in energy generation, storage and sustainability; and others.

International Conference on "Corrosion and Coating (i3C)" (7th-8th December 2022)

Indian Institute of Metals (IIM) Jamshedpur Chapter, in association with Tata Steel Ltd, CSIR-National Metallurgical Laboratory and NIT Jamshedpur organized the conference at CSIR-NML. Around 250 participants were present in the conference.

Trainings Organized

Corporate Skill Training Program (9th -13th May 2022)

"Exposure training on metallic pipes (ETMP)". A total of 10 Graduate Trainees attended the program.

Societal Skill training program (17th May - 16th June 2022)

Internship training on innovation productivity prototype making (IPPM 2022). A total of 46 Diploma students attended the program.

Corporate Skill training program (23rd - 26th May 2022)

Minerals & Coal Characterization (MMC 2022). A total of 6 Graduate Trainees attended the program.

Societal Skill training program (28th June - 01st July 2022)

Training on "Animation Video Making". A total of 32 participants attended the program.

06th June 2022- 05th July 2022

Internship Training on Innovative Product Prototype Making (IPPM 2022) Batch II for Graduate. A total of 146 participants attended the program

14th June 2022- 30th July 2022

Industrial R & D Training on Materials and Metallurgical Engineering (ITMME2022) for Undergraduate. A total of 70 participants attended the program

Popular lecture series

A lecture on decontamination of drinking water was organized on 25th August 2022 by CSIR-NML.

Trainings Organized by CSIR-NML

Jigyasa 2.0 (Integrated Skill Development):

The Integrated Skill Initiative Program, Jigyasa 2.0 - (Computer 3D Printing product development (C3PD)/ Handmade Paper Products) under project DST Women Technology Park was held from 10-Sep, 2022 to 02-Feb, 2023 and 14-Nov, 2022 to 13-Jan,2022 for 10th students (number of trainees = 60).

Jigyasa (Skill Development)

The Internship/ Summer Training was held under the Project "CSIR-Integrated Skill Initiative" from 1st March 2023 to 30th April, 2023 for B.Tech students.

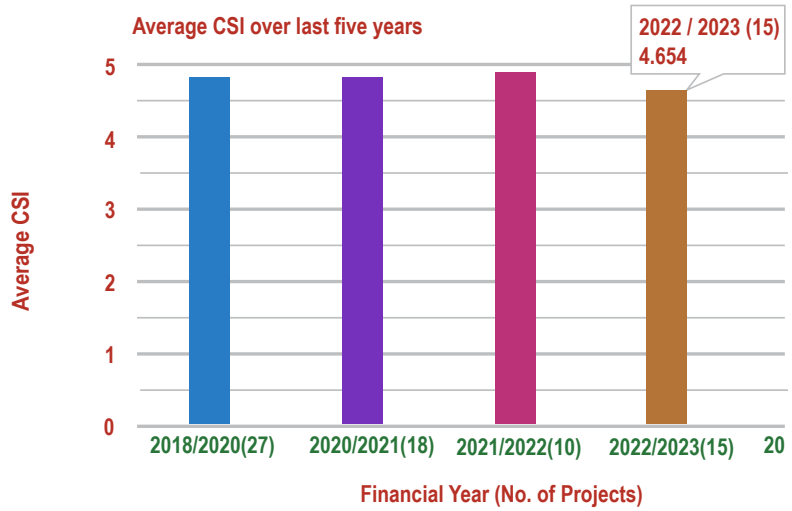
Jigyasa 2.0 (Integrated Skill Development)

The Integrated Skill Initiative Program, Jigyasa 2.0 - (Hands on experiment on water splitting for green hydrogen production / Innovative Product prototype making) was held from 28-Dec,2022 to 27-Jan,2023 and 04-Jan,2023 to 03-Feb,2023 for (B.Sc / B.Tech) students (number of trainees = 25).

Jigyasa 2.0 (Integrated Skill Development):

Jigyasa 2.0 Programme: Virtual Lab Integration - One Day NML Visit by (S.E. RLY Mixed High School, St. Jhoshep High School, Buddha Academy School students) was held on (10-Jan / 12-Jan / 18-Jan,2023) (number of trainees = 154).

Customer Satisfaction Evaluation & Feedbacks



Good support from PL;

Very Good;

Very satisfied with the overall output, Good work done, just delayed due to COVID situation.

Excellent team work Special thanks to Dr. Abhilash and team.

-Tata Steel Ltd. (SSP 1244, SSP 1291, SSP 1225, SSP 1176)

The testing live pictures and other videos shall be shared with report for better understanding of procedures and equipment availability very supportive team

-Arcelor Mittal Design and Engineering Centre Private Ltd. (SSP 1295)

Very Good

-Uttam Value Steels Ltd. (SSP 1324)

Excellent NML stands to its mark.

-Godawari Power and Ispat Ltd. (SSP 1331)

The R&D results reported have met expectations of the Company

-Sandur Manganese & Iron Ore (SSP 1330)

The project was executed in a very professional manner.

- ECOLAB (SSP 1289)

We are happy with the tests being carried out in NML and hope to carry out more in future It will be better, if we can carry out tests for protective coating as per ISO 12944-6-2018 and ISO 20340.

- Vision Craft Industries India Pvt. Ltd. (SSP 1239)

The project to recover valuables from waste PCB in an organized and environment friendly manner is commendable. We are overall satisfied with the process.

-M/s. Metaroe Recycler Private Ltd. (SSP 1273)

Excellent

-MOIL Ltd. (SSP 1180 & SSP 1179)

It was an excellent experience with Dr. Jha and his team. The technology transfer went smoothly. Every aspect of the technology was explained to us in details to help us commercialize this technology with confidence. We are certain that we will sign new MoUs, for other technologies.

-Recyclib Private Limited (SSP 1309)

The overall experience was very good. We are already running one more project with this team and are expecting to have more collaborations in coming future. Great work team NML!! Special thanks to Dr. K. D. Mehta jee and Dr. Ranjeet !! Great support. Thanks and Regards Piyush

- ECOLAB (SSP 1276)

Everything satisfactory only due to some issues there was delay in few sample reports.

-SGS India Pvt Ltd (SSP 1166)

Fortune 1000 and ET 500 Clients (2022-2023)

TATA STEEL

GEOLOGICAL SURVEY OF INDIA

DRDO

Coal India Limited
A Maharatna Company

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MINISTRY OF SCIENCE AND TECHNOLOGY

INDIAN RAILWAYS

इस्पात मंत्रालय
MINISTRY OF STEEL

सेल SAIL

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KMML
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भा प अ कें BARC
ATOMS IN THE SERVICE OF THE NATION

GMDC
FUELING THE GROWTH

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MoU signed between CSIR-NML and Recyclib Pvt. Ltd.. Delhi for e-waste recycling technology

JHARKHAND'S OWN ENGLISH DAILY

THE AVENUE MAIL

CSIR-NML inks 7 MoUs with industry and academia on 73rd foundation day

Five day Corporate Training Programme by CSIR-NML gets underway

Recyclib inks MoU with NML for e-waste recycling tech transfer

Mail News Service

Jamshedpur, Feb 28: Recyclib Private Limited, New Delhi signed an MoU with CSIR-NML for recycling technology of electronic waste.

The MoU will facilitate technology transfer of recycling of lithium ion batteries (LIBs) to recover metal or salts of Li, Co, Mn, Ni, Cu, Al, graphite and valuable plastics.

Technological know-how is a chemical design to recover Li, Co, Mn, Ni, Cu, Al, plastics and graphite from black cathodes material of spent LIBs. Developed process flow-sheet to recover Li, Co, Mn, Cu, Ni as metals salts and graphite from spent LIBs will be fine tuned by the samples supplied by the PARTY. The party will commercialize the technology as per the mutualized Know-How of CSIR-NML.

It is well known in past, CSIR-NML has transferred a number of technologies to a national mineral industries and research organizations. M/s Recyclib Pvt. Ltd., Delhi will process the LIBs and extract the non-ferrous metals viz Li, Co, Mn, Cu, Al, Ni, etc. and a part of that they will recycle all the materials present in it based on zero waste concepts.

On this auspicious occasion, Dr. Sudhan O Chatterji, Director CSIR-NML, Dr. Manoj Kumar Jha, Project Leader, e-waste recycling activities, Dr. Sanjay Kumar, Head MER, and a group of researchers Dr. Pankaj Kumar Choubey, Dr. Rabita Pandey, Mr. Om Shankar Dinkar, Ms Bakshima Parveen and from the RPHD side, Dr. S. K. Pal, Head, RPHD and Dr. Barun Kumar, were altogether present. Dr P.N. Mishra actively participated to bridge the NML with the media for advertisement and dissemination of e-waste recycling technology to the society.

Mohit Garg, Director, M/S Recyclib Pvt. Ltd. Company, Delhi has entered into a technology transfer MoU with CSIR-NML, Jamshedpur concerning the improvement of LIBs recycling in the present scenario. The recovered metals will fulfill the demand-supply gap of Li, Co, Mn, Ni, Cu, etc. Statement of Mohit Garg, "Pan-very pleased to be a part of CSIR-NML by taking the LIBs recycling technology to serve the nation by making pollution free society as well as conserve the natural resources for generations to come".

The NML director said, "In the recent past, NML has transferred a number of technologies to Indian companies and hope in future we can transfer more to make India an e-waste free society".

On this occasion, Dr. Sanjay Kumar, Head MER division expressed his disappointment and said, "NML will transfer more technologies in near future"(IW-an

गोवा के विद्यार्थियों ने किया एनएमएल विजिट

एनएमएल की तकनीक से बनेगा ई-वेस्ट रिसाइक्लिंग प्लांट

MNPS students visit NML, gain firsthand experience of research environ

एनएमएल में मनाया गया अंतर्राष्ट्रीय महिला दिवस

CSIR-NML initiates two day training on welding and non-destructive evaluation of joint quality

एनएमएल और रीसाय एनर्जी के बीच हुआ करार

खराब मोबाइल से सोना-चांदी निकालने की तकनीक जानी

CSIR-NML MoU with Recy Energy Pvt Ltd for recycling scrap, used LIB

एनएमएल व रीसाय एनर्जी प्राइवेट लिमिटेड के बीच एमओयू

Five day Corporate Training Programme by CSIR-NML gets underway

एनएमएल में रिसाइक्लिंग के साथ किया ई-वेस्ट रिसाइक्लिंग पर काम

A Workshop on VIDEO conf... by CSIR-National Metallurgical Laboratory, Jamshedpur

एनएमएल एवं एनएसआई ने राष्ट्रीय विज्ञान दिवस समारोह मनाया, शिक्षक पुरस्कृत

एनएमएल म मनाया गया अतर्राष्ट्रीय महिला दिवस

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Giving us feedback, keeping in touch :

We want to hear from you, whether it is a constructive suggestion or a critical observation or any other feedback that you have about this Report.

Please contact us at +91-657 2345209/ director@nmlindia.org

Or stop in at CSIR-National Metallurgical Laboratory,
Jamshedpur, Jharkhand, India-831007.

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सीएसआईआर
CSIR
भारत का नवाचार इंजन
The Innovation Engine of India

CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, India

Phone : 91-657-2345028 /2345000-001, Fax : 91-657-2345213

e-mail : director@nmlindia.org, Website : www.nmlindia.org

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