वार्षिक प्रतिवेदन
Annual Report
21 22

CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, India

Indian Women Achievers
(Padma Awardees 2022)








Padma Awards - one of the highest civilian Awards of the country, are conferred in three categories, namely, Padma Vibhushan, Padma Bhushan and Padma Shri. The Awards are given in various disciplines/ fields of activities, viz.- science and engineering, trade and industry, art, social work, public affairs, medicine, literature and education, sports, civil services, etc. 'Padma Vibhushan' is awarded for exceptional and distinguished service; 'Padma Bhushan' for distinguished service of high order and 'Padma Shri' for distinguished service in any field. The awards are announced on the occasion of Republic Day every year. These awards are conferred by the President of India at ceremonial functions which are held at Rashtrapati Bhawan usually around March/April every year.

India has a rich cultural heritage and historically women of India have always shown excellence in whatever they do. In the year 2022 a total of 128 Padma Awards were conferred. Out of which, 34 were women awardees. This book recollects a few of such inspiring and extraordinary achievers and salutes to their exemplary contributions towards the progress of nation in various domains .

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Contents

Appreciation Message (excerpted)

We are pleased to inform you that 3751 metric tonnes of sillimanite mineral worth around Rs. 5.63Cr. was produced from heavy mineral beach sand during the financial year 2020-21 which is a record in the KMML's history. It is also a major and significant contributor to the earnings of our Mineral Separation Plant during this period. This was made possible by adoption of 'Column Flotation Technology' developed by CSIR-NML and executed jointly by M/s. McNally Sayaji Engineering Limited (MSEL), Bengaluru. I take this opportunity to profusely thank the contribution made by the team members of CSIR-NML and M/s MSEL led by Dr. T. V. Vijaya Kumar and Mr. Murali, respectively.

At Tata Steel- Wire Division, we make Tyre Bead wire of 1.6 mm, which is used in radial tyres meant for trucks & buses. ……. Any defect in wire ……. leads to breakage of wire at customer end, ……. Thus, the customer desires wire to be free from any such defects. To achieve such reliability in every wire coil of approx. 30 km length, Tata Steel thought of inspecting the wire surface on-line as it gets drawn. However, detecting defects at high drawing speed of 10 m/s was a challenge.

A team of CSIR-NML led by Dr. Sarmishtha took up the challenge …… for detecting defects at such high drawing speed. Their team came up with a sensing system using eddy current principle coupled with high- speed data acquisition and analysis …….. One system was tested at our wire drawing unit in Tarapur and was found to be suitable for detecting flaws in real time. After proving the concept with the first system, order has been placed for one more system. The cost-effective nature of the solution makes it eminently suitable for its implementation in a large number of wire drawing lines. …….

Given the high quality standards of automobile industry customers, any defect experienced at their shop floor leads to potential rejection of entire lot supplied. Therefore, every defect detected prevents a potential loss of Rs. 5 to 10 lakhs …… More lasting impact is in terms of the rising customer confidence in our product and the competitive edge.

Tata Steel Wire Division congratulates the team for this cost-effective solution supporting the "Make-in-India" mission. It is at par with the imported system for same purpose. Some of the new features customized to our requirements have made it a system of choice. We certainly look forward for further collaborations with the CSIR-National Metallurgical Laboratory.

Client/ Collaborator

For Kerala Minerals & Metals Limited

22nd April, 2021

KMML
Spreading Splendour

Mr. Shishir Desai
Head- Wire Technology Group
18th May 2021

TATA

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

Prof. Suddhasatwa Basu
Director
CSIR – Institute of Minerals & Materials Technology, Bhubneswar

Dr. Debashis Bhattacharjee
Vice President
(Technology & New Materials Business)
Tata Steel, Kolkata

Dr. Indranil Chattoraj
Director
CSIR – National Metallurgical Laboratory, Jamshedpur

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

Dr. R.M. Mohanty
Principal Scientist,
TMD (SEMI)
CSIR, New Delhi

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

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

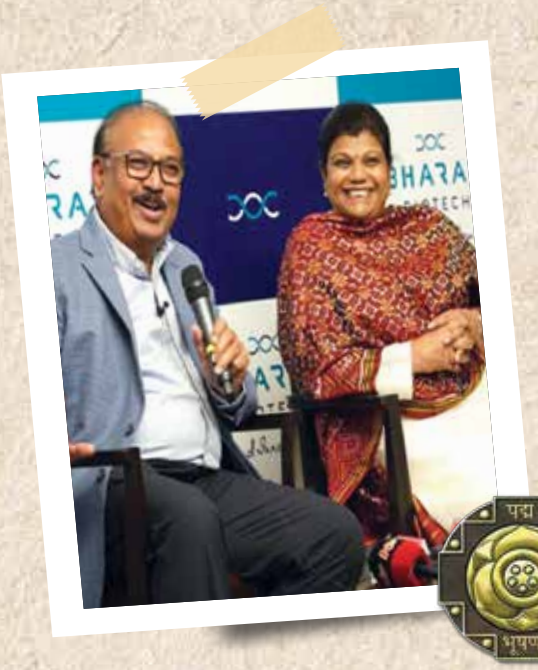
Dr. Beena Rai
Chief Scientist and Head,
Tata Consultancy Services,
Mumbai

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

Prof. Rajiv Shekhar
Director,
Indian Institute of Technology (IIT –ISM),
Dhanbad

Indian Women
Achievers

Trade & Industry



KRISHNA ELLA & SUCHITRA ELLA

FOUNDERS-BHARAT BIOTECH (Telangana)

Pioneering development of several vaccines - including Covaxin, India's indigenous COVID-19 vaccine

PADMA BHUSAN 2022

MUKUTMANI DEVI

Entrepreneur (Manipur)

Exporting & Popularizing Handcrafted Woolen Shoes in Manipur, India.

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Foreword

Hello everyone!

In the past fiscal (2021-2022), the nation and the world was trying to come out of the debilitating pandemic. There were signs of recovery but financial participation in research was low key. Consequently, our ECF generation (₹22.05 Crores) was only slightly higher than the previous fiscal and below our projected target of ₹ 25 Crores. There was insignificant inflow through Grant-in aid projects, due to financial constraints of most governmental funding agencies. In spite of the severe limitations on industrial productions and therefore on the industry's desire for research sponsorship, our ECF generation from Industrial sponsors was significant, making up more than 90% of the total ECF generated.

We could initiate and sustain a number of very important activities in 2021-22. The program on "Technology development for holistic utilization of red mud for extraction of metallic values and residue utilization", has started and is continuing at full flow. This initiative catalyzed by Nitiayog, and sponsored by the top three Aluminum producers of the country and CSIR, is a very important project in industrial wastes valorizations. Another high impact program was a part of CSIR mission on "Bulk Chemicals". One of the work packages, with CSIR-NML in the lead, aimed at developing a technology to dismantle spent LIBs, extract all metals from the electrode material, and demonstrate the technology at a 1 kg product level.CSIR-NML has developed CSIR's first complete and holistic TRL-4 process for the extraction and separation of Lithium, Nickel, Cobalt, Manganese, Iron, Aluminum, Copper and for the recovery of graphite from spent Lithium batteries of mixed origin. The pilot plant, slated to be commissioned at CSIR-NML, will be the first of its kind Hire-Operate-Transfer (HOT) platform for MSMEs and entrepreneurs in India. Currently, CSIR-NML has signed agreements with four Indian firms with whom technology transfer is on the anvil, and more interested entrepreneurs are in the queue. In a connected development a project on recycling of graphite from spent lithium-ion batteries for high energy Li-ion capacitors, funded by DST, was initiated. The urban ore recycling center, established in CSIR-NML in 2019, is doing brisk technology transfers to a large number of MSMEs. A project to develop a process for producing electrolytic Manganese from MnSO4 liquors, sponsored by MOIL was initiated. Ministry of steel, approved and funded the pilot scale technology development for production of medium carbon Ferromanganese.

Installation and commissioning of 200 tonnes per day flotation column for fine coal flotation at Belatinda Coal Preparation Plant of Tata Steel, is under progress, using CSIR-NML's column flotation technology. Industry scale trials (5 tonnes per hour) of the newly developed environment friendly flotation reagent for sillimanite is in progress at Kerala Minerals and Metals. A project that was successfully completed was the development of geopolymer cement for immobilization of radioactive waste; 100 kg of cylinder samples were prepared and supplied to BARC for evaluation. The processes to reduce mineral matter in coking and non-coking coals through oil agglomeration was developed through two R&D projects sponsored by Coal India (CIL) and Mahanadi Coalfields (MCL). GSI has sponsored a project to quantify the rare-earth and trace elements in soil and sediments samples, which requires sustained and detailed chemical

analysis. In another project, production of 50 tons of briquette from scraps was completed and supplied to FSNL for carrying out trials at Bhillai Steel Plant.

In a niche research for the Indian space programme, the effect of processing parameters on cryo impact properties of cast alloys was carried out. CISR-NML is also responsible for generating forming limit diagram (FLD) of welded and non-welded aluminium sheets for space applications. CISR-NML has strengthened its ties with the Indian navy and is involved in qualifying materials and components in use for the aircraft carrier Vikramaditya. We have also completed material analysis and reclamation of gas collectors for INS Ekshila. Various RLA studies, failure investigations and root cause analyses were carried out for diverse sectors including Railways, Petrochemicals, Chemicals, Power and other sectors. SAIL has entrusted CISR-NML with assessment of the corrosion behaviour of different rail steels, taking into consideration the operating environments. The fatigue behaviour of primary piping vessel material, used in nuclear power plants was evaluated in a project sponsored by BARC.

Our non-financial outcome and output were quite satisfactory. The laboratory earned the high satisfaction ratings from most of our important stakeholders, the average customer satisfaction index, like the previous year, was 4.8 out of 5. Our SCI publications were reasonable in terms of numbers (119) but the significant improvement in quality noted in the previous year was maintained with the publications having an average impact factor of 3.3. We could file 12 patents and 1 copyright. Three technologies were developed in the reporting year and five technologies were transferred. One technology developed by CISR-NML has been selected as a finalist in the prestigious Tata Group Innovista awards (Innovative partner category).

Aligning with the government policy on Skill Mission, CSIR, in its Platinum Jubilee Year launched a major programme on “CSIR Integrated Skill Initiative”. These training programmes vary from 1 days to 1 year in duration. The focus is to develop skills in the area of metals, metallurgy, manufacturing, waste utilization, soft skills and entrepreneurship development. In 2021 - 2022, CISR-NML trained 1444 participants, through corporate training programmes, professional training programmes, and students’ trainings. CISR-NML, in association with the National Institute of Advanced Manufacturing Technology (NIAMT), Ranchi is establishing a Women Technology Park (WTP) through a project sponsored by the Department of Science and Technology (DST). The focus of this endeavor will be to empower women, especially of the weaker sections, through skilling, enhancing their employment potentials and inculcating entrepreneurship zeal. Another important development in the techno-social sphere was the creation of the Intellectual Property Facilitation Centre (IPFC). This was established in 2020 through funding from the Ministry of MSME, with the objective of building awareness on Intellectual Property Rights (IPR) for the MSMEs. The IPFC has organized 15 webinars so far, through which around 1200 people got trained in the matters of IP. Additionally, the centre has registered 18 trademarks, 3 industrial designs and one copyright; and has filed 5 patents on behalf of the MSMEs.

To address the critical issue of depletion of manpower due to superannuations, CISR-NML has completed the recruitment of 14 Scientists, who are expected to join soon. Similar efforts are being made to recruit a security officer, Gr II and Gr III staff and clerical staff.

This will be my last foreword in an CISR-NML annual report as I will be superannuating in 2022. It is only appropriate that I express my gratitude to all who have contributed to make CSIR-NML a well-recognized and well regarded laboratory. I am extremely grateful to our former Director General, Dr. Shekhar Mande, for his continuous encouragement, advice and support. The vision he charted out for CSIR was instrumental in fine tuning the vision of this laboratory as well. Our Research Council has been a motivating as well as guiding force, many of the course corrections were based on their kind inputs. Our collaborators, customers and clients, kept us on our toes as well as provided us the necessary financial support as well as technical guidance, which enabled us to complete most of our projects on time and successfully. There are a number of other well-wishers of CISR-NML including our retired personnel, to whom we are grateful. The success and consistent performance of this laboratory is largely due to the diligence of its employees. I thank the employees who either through direct research or through excellent back-end support, contribute to enhance the image of CSIR-NML. I wish CISR-NML a very successful future aligned to the growth of our nation.

(Dr. Indranil Chattoraj)
Director, CSIR-NML

Performance Targets Achieved in 2021 - 2022

	Objectives	Planned	Achieved
1.	Total External Cash Flow (ECF)^	25.0 Crores	22.05 Crores
2.	Industrial ECF (a part of ECF)	20.0 Crores	21.024 Crores
3.	Customer Satisfaction Index	4.8	4.9
4.	SCI Publications	124	119
5.	Patents	25	12
6.	Copyrights	5	1
7.	Technologies Developed#	5	3
8.	Technologies Transferred*	5	5

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

Technologies Developed :

1. FOBOP : Fibre Optic based Break Out Prediction technology for Billet Caster (TRL 8)
2. A Process to improve the corrosion resistance of steel rebar (TRL 6)
3. A Process to clear ball jam in ball pen tips (TRL 6)

* Technologies Transferred :

1. Know-How for the magnetostrictive sensing (MsS) device for pipe inspection (MagStrics) to *Accelor Microsystems, Mohali*.
2. Flaw Guard ; A device for real time defect detection of high end wires to *Sanielectronics, Mumbai*.
3. Process to clear ball jam in ball pen tips to *CRI Limited, Kolkata*.
4. Recycling of Lithium ion batteries (LIBs) to recover Li, Co, Mn, Cu, Al as metals/salts, saleable graphite and plastics to *Recyclib, Delhi*.
5. Closed loop Know-how to recycle Lithium ion batteries (LIBs) to produce value added products of Li, Co, Mn, Cu, Ni, saleable plastics and graphite to *NILE Li-Cycle, Hyderabad*.

Major Technological & Scientific targets Planned and Achieved in 2021-2022

Planned	Achieved
• Installation and Commissioning of 200 tons per day flotation column for fine coal flotation at Belatinda Coal Preparation Plant of Tata Steel	• In progress, to be commissioned in 2022-23
• Industrial scale trials (5 tonnes per hour) of newly developed environment friendly flotation reagent for sillimanite	• In progress at Kerala Minerals and Metals; trials are planned for April, 2022
• Band by band coal core chemical characterization for geo-chemical mapping of coalmines sponsored by CMPDIL, Ranchi.	• Carried out through 11 industrial projects.
• Rare earth and trace element analysis of sediment & rock samples supplied by Geological Survey of India	• In progress
• Lab Scale Study on reducing ash content from washery grade coking coal and high ash non-coking coal through oil agglomeration	• Process developed through projects sponsored by Coal India (CIL) and Mahanadi Coalfields (MCL).
• Preparation of BEP for Li extraction on 1 kg scale from end-of-life batteries	• Pilot plant setup and BEP preparation under progress
• Production of 50 tons of briquette for carrying out trials at Bhillai Steel Plant	• Produced and supplied to FSNL, Bhillai, for carrying out the trials
• Installation of FOBOP: Fiber Optic based Break Out Prediction technology	• Installed at the billet caster of Tata Steel and detected breakout apriori
• IoT based system for health assessment of blowpipe to avoid sudden failure	• IoT based Technology developed and tested at the plant
• Improve corrosion resistance of the developed zinc and magnesium alloy as bio-implant	• Corrosion resistance of biodegradable Mg alloys is improved by multilayer Zn electrodeposition
• Improve the purity of Ti3AlC2 (MAX) to >95% with an indigenous process	• Indigenous process for Ti3AlC2 (MAX) to yield >95% purity is developed and patent filed.
• Development of geopolymer cement for immobilization of radioactive waste	• Prepared 100 kg cylinder samples and supplied to BARC for evaluation.
• Benchmark data generation for HCF and LCF for No base alloys	• In progress
• Rejuvenation of Gas collector for Indian Navy	• In progress

Technologies Profile

Technologies Developed

FOBOP : Fiber Optic based Break Out Prediction technology for Billet Caster (TRL 8)

Breakouts are containment losses of liquid steel from the solidifying steel cast product before full solidification. They are the major contributors to loss of productivity and loss of equipment life in a continuous caster. These often lead to long outages, which may involve laborious equipment cleaning with lancing and gas cutting and/or change of mold assembly/segments. Breakout detection systems are a mandatory part of most commercial slab and thin slab casters. For billet and bloom casters though, they are almost completely absent. This could be due to the size and shape of the billet mold, which impose restrictions in installing temperature sensors on a commercial billet caster. Thus, the breakout detection in the billet caster remains a challenge. CSIR-NML in collaboration with CSIR-CGCRI provided an innovative solution of using Fiber Bragg Grating (FBG) as a temperature sensor, for a steel major. Multiple sensors were assembled on a single optical fiber and embedded along the length of a billet mould. The "interrogation" of these sensors allowed for temperatures to be obtained along the length of the mold using a single strand of the optical fiber. In addition to the development of the FBG sensor, its installation in the harsh conditions (high temperature, high pressure, restricted space) of an operating caster called for considerable engineering ingenuity. Two instrumented moulds were installed in one of the casters of the sponsor and the sensor output has helped to detect the breakout well in advance. This is the First Time in the world, that a breakout has been detected a-priori in a billet caster. It holds tremendous potential to save costs and improve the productivity of billet casting plants.

A Process to Improve the Corrosion Resistance of steel Rebar (TRL 6)

Rusting of rebar during transit (time between rebar production and consumption by the end user) is a major problem for rebar manufacturing industries. This is because rusted rebar has low consumer acceptance. Moreover, the use of rusted rebar in concrete manufacturing is not recommended as it reduces the bonding of concrete with rebar and may cause delamination and failure of the concrete. CSIR-NML has developed a process to improve the corrosion resistance of the rebar through chemical treatment. The chemical treatment of the rebar can be carried out offline at room temperature, or in-situ in the rebar production line at high operating temperatures (500-550 oC) after the water-quenching step. The chemical treatment solution (NML DeRust) contains active ingredients that reacts with the oxide layer on the rebar surface and forms a phosphate type conversion coating, thus improving its corrosion resistance. It provides a dark grey look to the rebar and makes it corrosion resistant for a period of 3-4 months in the outdoor atmosphere. The treatment process involves contacting the rebar surface with the treatment solution for duration of 1-2 seconds by spraying or dipping. This results in formation of an invisible conversion coating of less than 1 µm on the rebar surface, without impacting the bond strength of rebar with concrete. The chemically treated rebars passed 72 hours of salt spray test without formation of red rust, and, 4 months of outdoor exposure test at Jamshedpur without formation of red rust. The process is scalable and economical.

Schematic diagram of rebar chemical tretment process (batch process)

A Process to Clear Ball Jam in Ball Pen Tips (TRL 6)

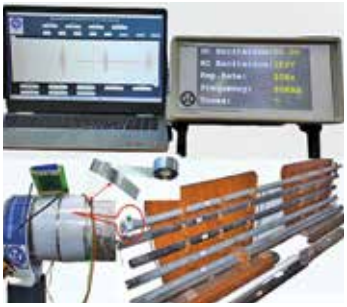
Ball pen tips are generally made from alloys of copper such as brass and nickel silver (alloy of copper and nickel) primarily due ease of mechanical fabrication of these alloys. Although these alloys are fairly corrosion resistant, jamming of the ball in pen tips is often encountered in hot humid climates. CSIR-NML has developed a chemical treatment process to clear the ball in jammed pen tips, making it free from defects. In addition, the brass and nickel silver pen tips are chemically polished to enhance the glitter and improve customer acceptance. The water based chemical treatment process is carried out at room temperature in ultrasonic bath for durations of 10-15 minutes. The batch process restores tip functionality. The treatment process involves contacting the jammed ball pen tips with the treatment solution for duration of 1-2 minutes by dipping. The chemical treatment is done at ambient conditions in an ultrasonic bath. The chemical treatment removes the corrosion products around the jammed ball and forms a conversion coating of less than 10 nm thickness on the tip surface to protect it from further corrosion. The treatment improves the appearance of the tips and does not alter the writing performance of the ball pen tips. The process is scalable and economical

Chemical cleaning of jammed ball pen tips

Technologies Transferred

Magnetostrictive Sensing (MsS) Device for Pipe Inspection (MagStrics)

CSIR-National Metallurgical Laboratory, carried out a project "Development of Magnetostrictive Sensing Device for Structural Integrity Evaluation of Pipes" sponsored by Department of Science & Technology (DST), New Delhi. Through this project, a Magnetostrictictive Sensing (MsS) device for pipe inspection was developed by CSIR-NML in collaboration with M/s. Accelor Microsystem, Chandigarh. The device coined as "MagStrics" is based on the principle of generating ultrasonic waves using magnetostrictive element. MagStrics is a portable equipment that can be used for assessment of ferrous as well as non-ferrous pipes. The sensor element used in this device is amorphous/nanostructured ribbons prepared at the CSIR-NML by melt spinning. The prepared sensor element displays high saturation magnetostriction at much lower magnetizing fields compared to crystalline materials conventionally used in MsS sensors. The sensing device was tested at the laboratory for detection of defects (holes, saw cuts), corrosion, welds, etc. The device can detect MsS Signals from surface as well as embedded pipes. The technology was transferred to M/s. Accelor Microsystem, Chandigarh.



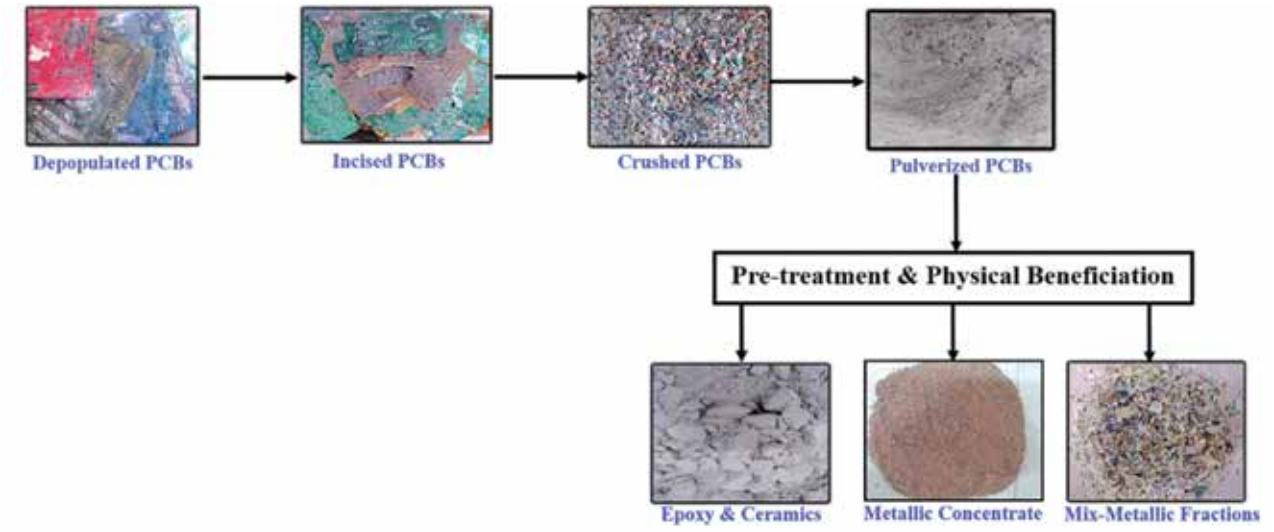
Development of Close Loop Process for the Recycling of Metals/Materials from e-Wastes

CSIR-NML has developed a simple, complete and novel process for the production of non-ferrous, precious and rare earth metals as value added products (metal/salts) by recycling spent lithium ion batteries (LIBs) and printed circuit boards (PCBs). The major processing steps are physical beneficiation, leaching, solvent extraction, precipitation and electro-winning processes. Systematic laboratory scale leaching studies have been carried out and scientifically validated. Technology for the extraction of precious metals from PCBs of electronic wastes has also been developed. Implementation of these processes at larger scales can help in maintaining clean and green environment. The extraction of Co and Mn along with plastics from LIBs is of much interest for the industrialists and the process has proven to have potential for industrial exploitation after scale up/ pilot studies. Recently, several technologies have been transferred to Indian recycling companies under the aegis of Urban Ore Recycling Centre at the CSIR-NML premises. The summary of industries and MoUs signed with them for e-waste recycling during this period are as follows:

M/s Metaore Recycler Pvt. Ltd., Kolkata: CSIR-NML signed MoU's for two technologies:

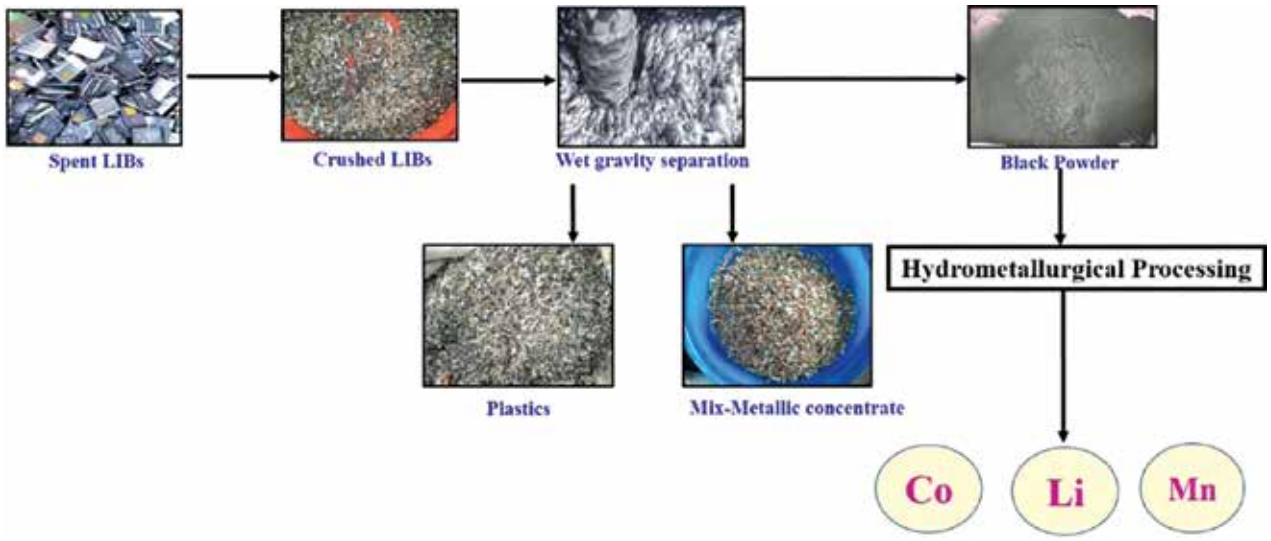
1. "Know-How (Laboratory Scale) transfer for recovery of Co, Li and Mn from lithium ion batteries (LIBs) with fine tuning".

The technology mainly involves dismantling of the e-waste to separate the PCBs from other components. The PCBs are further pre-treated using scutter cutter and pulveriser followed by physical beneficiation using wet gravity separation technique to separate the non-metallic and metallic fractions. The metallic concentrate obtained is further processed using hydrometallurgical route to recover Cu, Al and Au as salt/metal using precipitation, evaporation and electrowinning techniques.



2. "Transfer of Know-How for the recovery of Cu, Au and Al from printed circuit boards (PCBs) with fine tuning".

The technology mainly involves pre-treatment followed by hydrometallurgical processing to get Co, Li, Mn, Cu, and Ni as salts/ metals and saleable graphite. Initially the LIBs were discharged, shredded and processed for the separation of black powder, plastics and metallic fractions using wet gravity separation techniques. The leaching of metals from the black powder was carried out. The leach liquor generated was filtered using filter press to separate the solution from the slurry. The leached residue, i.e. graphite, was treated further and washed to make saleable graphite. The obtained leach liquor was then processed for the recovery of Co, Li, Mn, Cu and Ni using advance separation techniques (solvent extraction/selective precipitation). From the purified solution, salts/metals of Co, Li and Mn could be obtained using precipitation, evaporation and electrowinning techniques.



M/s Recyclib Pvt. Ltd., Delhi:

CSIR-NML has signed an MoU with M/s Recyclib Pvt. Ltd., Delhi for "Recycling of lithium ion batteries (LIBs) to recover Li, Co, Mn, Cu, Al as metals/salts, saleable graphite and plastics"

M/s NILE Li-Cycle Pvt. Ltd., Hyderabad:

CSIR-NML has signed an MoU with M/s NILE Li-Cycle Pvt. Ltd., Hyderabad for "Closed loop Know-how to recycle lithium ion batteries (LIBs) to produce value added products of Li, Co, Mn, Cu, Ni, saleable plastics and graphite".

Science and Engineering

SANGHAMITRA BANDOPADHYAY

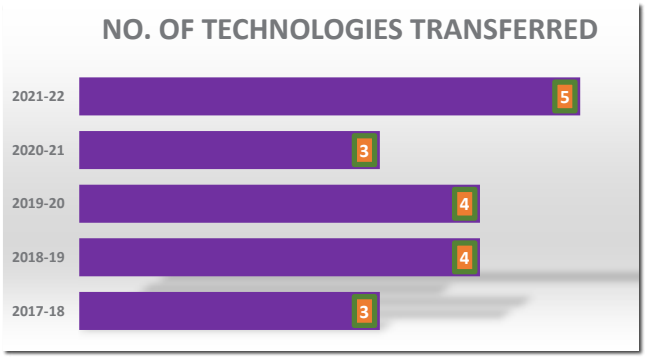
SCIENTIST (West Bengal)

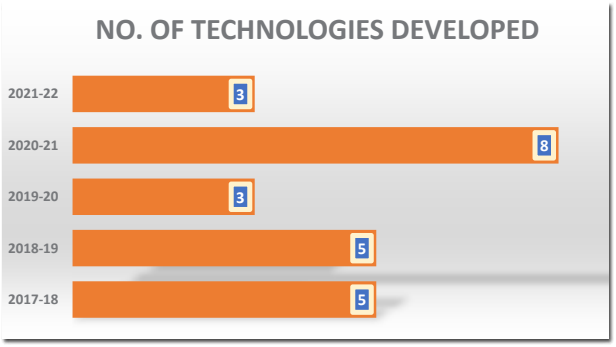
Eminent Computer Scientist and Machine Intelligence Expert-
First Woman Director of the Indian Statistical Institute

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

R & D Output


NO. OF TECHNOLOGIES TRANSFERRED
2021-22
5
2020-21
3
2019-20
4
2018-19
4
2017-18
3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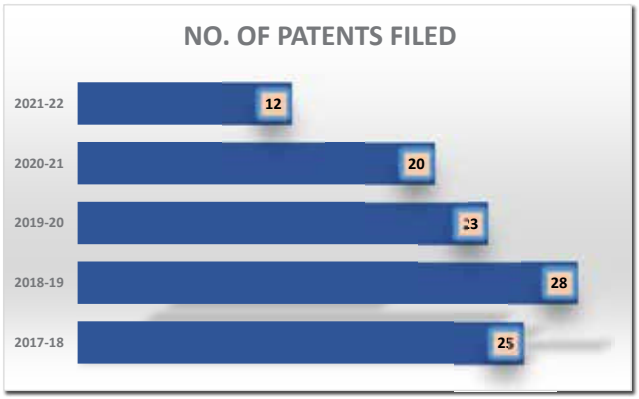
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2017-18
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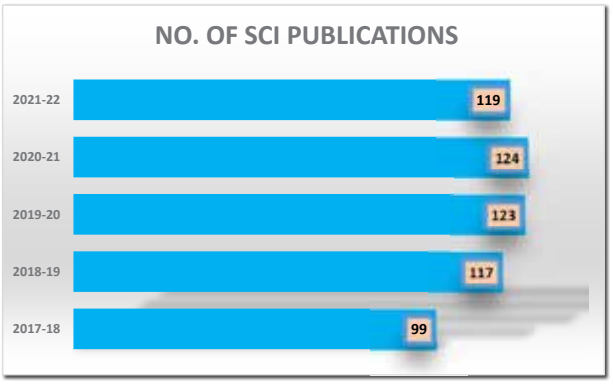
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2017-18
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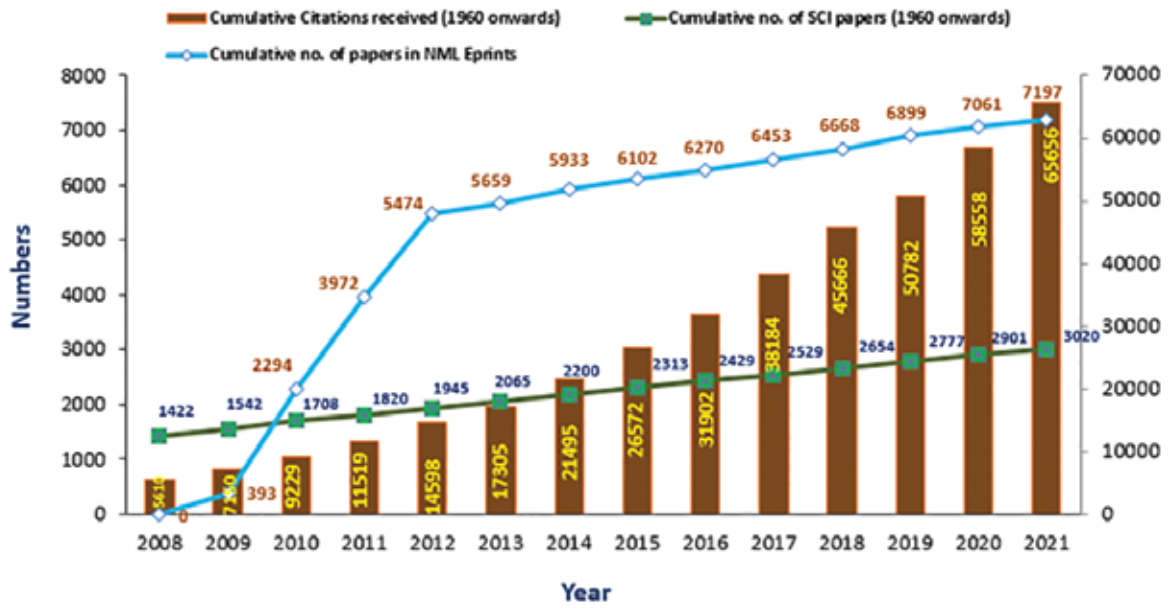
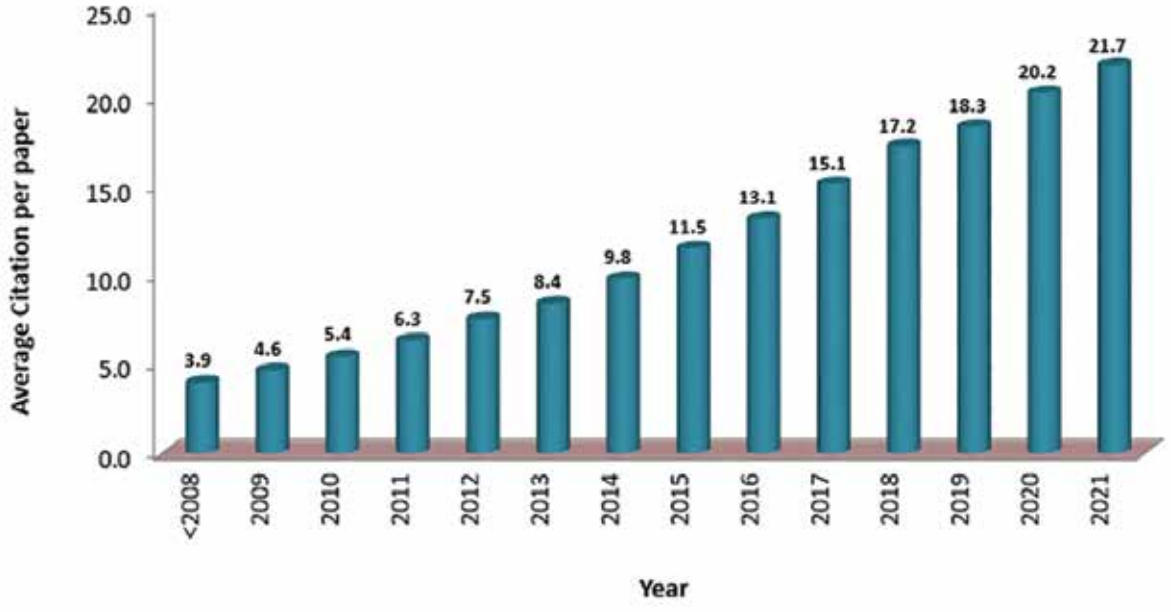


Source: Web of Science / Google Scholar as on 31.12.2021



Source: Web of Science / Google Scholar as on 31.12.2021

Impact Making Technologies

Real Time Zinc Coating Weight Measurement Sensing Device for Hot-Dip Galvanizing Lines : Zincometer

CSIR-NML has come up with a sensing device "Zincometer" which is a sensing coil based technology for real-time Zinc coating weight measurement of moving galvanized wires in the commercial pad wiping (thin coating) as well as N2 wiping (thick coating) lines.

Impact : Absence of Zinc control system leads to huge financial losses due to over coating. Market survey shows commissioning of the Zinc control system will help in saving approximately 100 crores to the largest GI wire manufacturer of India. This "Make-in-India" technology "***ZINCOMETER"*** will help to overcome the stated problem of commercial GI lines and can also serve as an **import substitution** for Zinc weight control systems available for Nitrogen wiping GI lines. Zincometer was benchmarked against the existing imported sensing system in the N2 wiping lines and a *two channel system along with two sensors* are recently commissioned and installed at the wire plant hot dip galvanising line of a steel major (Figure 1).

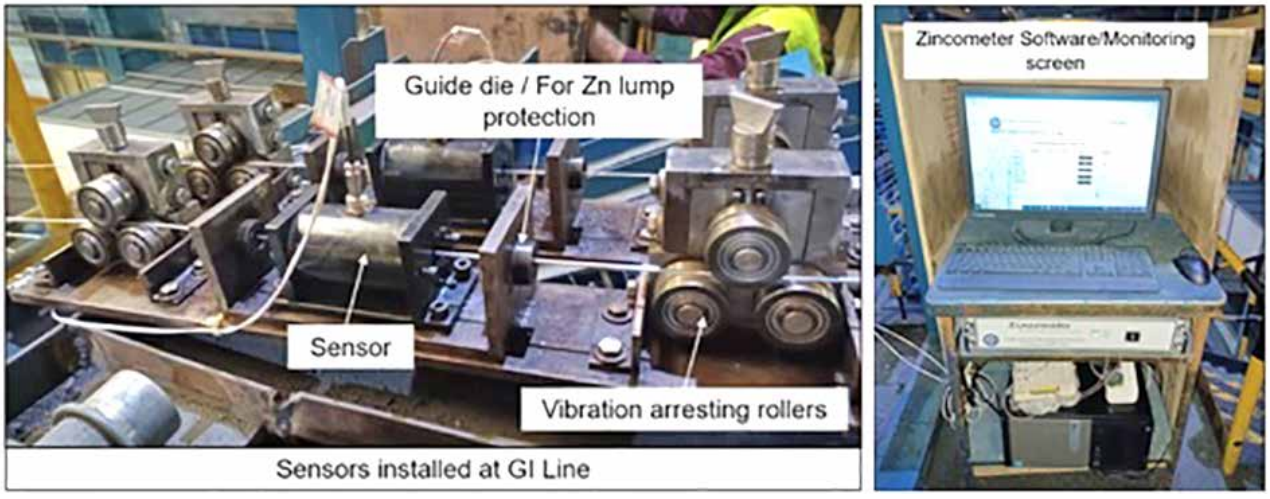


Figure 1: Zincometer set-up

Consultancy on design, erection and commissioning of flotation column for Coal Preparation Plant

The supply and installation of commercial plant scale flotation column of 2.0m diameter and 9.0m height, at a coal washery of a steel major, is being executed in collaboration with M/s MSEL, Bengaluru, for 200 tpd fine coal processing (Figure 2). Under the scope of an MoU between CSIR-NML and M/s MSEL, this project pertains to providing consultancy services for supply and installation of commercial flotation column and necessary accessory equipment. The consultancy involves providing details for column design, formulation and drawing of accessory equipment specifications. It would be followed by assistance in erection, commissioning of flotation column, process stabilization using flotation column and guidance in preparation of operation manual.

Figure 2: CSIR NML flotation column (2.0m diameter and 9.0m height) in the Coal Preparation Plant

Impact on Society

Detailed Project Report (Dpr) on Common Facility Center for Silver Cluster Artisans

India is one of the world's largest silver markets, with a very traditional core in a diverse market. The artisans are still following age-old traditional processes (Figure 1) for making ornaments. Lack of innovation and modernization has resulted in a variety of problems ranging from raw material sourcing to the marketing of products. Government and non-government organizations are coming forward to guide and assist the sector. Directorate of MSME, Government of West Bengal, with the aim of helping the silver clusters, has sought NML's expertise for the artisanal cluster "Jafarnagar Astha Silver Ornaments Artisan's Welfare Foundation". Based on the inputs from the General Manager (GM)/ Industrial Development Officer (IDO) of District Industry Centre (DIC) and the artisans of the cluster, as well as site surveys and discussion with vendors, a Detailed Project Report (DPR) has been prepared. The DPR contains the basic details of the cluster, benchmark surveys, proposed business model, machinery required, bill of quantity for civil estimation, commercial viability and demand and scope for diversification.

Figure 1: Silver thali and ornaments developed in the cluster

Energy Efficient Brass Melting Furnace for Odisha Artisans

India has a legacy in brass making and brass handicrafts and is one of the leading brass handicrafts manufacturer. This fine art has been traditionally handled and has produced excellent handicraft products. The melting furnace is heart of the process. The coal fired furnace is an age-old and simple brass melting method. These traditional furnaces are found to be energy inefficient and less productive. To resolve these challenges, CSIR-NML developed a brass-melting furnace, which reduces energy consumption by 20-40%, melting cycle by 25-50%, increases productivity by 30% and reduces metal loss during melting (60%). It also helps to reduce pollution including emission of harmful Zn vapours. CSIR-NML has installed and successfully demonstrated the energy efficient brass-melting furnace at IMMT Bhubaneswar. This will enable CSIR-NML to showcase its furnace to Odisha's local artisans.

Demonstration of Energy Efficient Brass Melting Furnace at CSIR-IMMT, Bhubaneswar

DST-Women Technology Park

CSIR-National Metallurgical Laboratory (NML) in association with the National Institute of Advanced Manufacturing Technology (NIAMT), Ranchi is establishing a Women Technology Park (WTP) project sponsored by the Department of Science and Technology (DST).

The objectives of the program are:

- To offer a six-month certificate entrepreneurship development Train the Trainers (TTT) programme on innovative product development to create a pool of competent women trainers
- To train women in the areas of waste management and carpentry for capacity building resulting in the enhancement of their employment potential
- To carry out need assessment study for women-centric product innovation for developing innovative machines and tools for improving the working conditions of women through S &T
- To establish an incubation centre for women entrepreneurship development focusing on rural India
- To create common facilitation centres for women entrepreneurs

CSIR Jigyasa Virtual Laboratory Project

CSIR Jigyasa program, was an initiative taken by CSIR during its Platinum Jubilee year, which was inspired by the Honorable 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 and to create innovative learning tools and contents through Virtual Laboratory (VL) utilizing advanced digital technology focusing on the areas of minerals, metals, materials, and metallurgy. The targeted beneficiaries under this project are school students from Std. VIII to XII, focusing on Government-funded schools located in rural areas.

In FY21-22, CSIR-NML organized the following scientist interaction programs for school students and teachers:

- Visit of scientists to schools
- Scientists and science teachers' conclave
- Teachers training on innovation
- Mentoring of Atal Tinkering Labs (ATL) schools
- Popular lecture series
- CSIR-NML science club

For the "Teachers' training on innovation" more than 120 teachers from all parts of India joined online. The "Scientists and science teachers' conclave" was attended by more than 100 participants.

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, nail and battery, which will help students to understand the concept of 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.

CSIR Integrated Skill Training Initiative

Aligning with the government policy on Skill Mission, CSIR in its Platinum Jubilee Year launched a major programme on "CSIR Integrated Skill Initiative". The purpose of CSIR Integrated skill initiative is to encapsulate all CSIR skill/training programme under one umbrella, which will cater to diverse cross section of people at various levels beginning with school dropouts to Farmers to ITI diploma holders to graduates.

From 2017 to 2022, CSIR-NML received funding support of around Rs. 150 Lakh under this network scheme to provide skill training ranging from basic training for rural youths, summer/winter internship for undergraduate students, M. Tech/PhD dissertation guidance for post graduate students, apprentice training for ITI/Diploma/Graduate engineers and specialized training for professionals from industry. These training programmes vary from 1 days to 1 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 2021 - 2022, CSIR-NML trained 1444 participants, through corporate training programmes, professional training programmes, and students' trainings.

Exposure Training on Metallic Pipes for CIPET Officials

National Skill Competition for Best of the Best Welders 2021

Performance Targets Planned for 2022-2023

SL. No.	Objectives	Planned
1.	External Cash Flow (ECF)	30 Crores
2.	Industrial ECF (a part of ECF)	24 Crores
3.	Customer Satisfaction Index	4.9 (Max 5)
4.	SCI Publications	125
5.	Patents	25
6.	Copyrights	5
7.	Technologies to be Developed	5
8.	Technologies to be Transferred	5

Human Resource Targets Planned for 2022-2023

- Recruitment in 15 Scientist positions
- Recruitment of Security Officer

Major Technological & Scientific Targets Planned for 2022-2023

- Benchmarking of zinc coated magnesium alloy as bio-implant
- Scale up of Ti_3AlC_2 (MAX) with purity ≥95% with our indigenous process to 100g scale
- Magneto-Impedance Array sensor based device
- Multi-channel coating weight measurement sensing device
- Scale-up of sol-pre-coating based universal HDPS process for AHSS
- Production of ferrochrome at pilot scale using 500 KVA submerged arc furnace
- Technology transfers in the area of E-waste management
- Production of magnesium metal (kg scale) using Pidgeon process
- Benchmark data generation for HCF and LCF of Ni based alloys
- Piloting Armour steel development, aiming for 2GPa strength and minimum fracture toughness of 50MPam$^{1/2}$
- Study on Performance Improvement of coking coal washery through modelling and simulation
- Effective utilization of middling and fines of coking coal washery for recovery of carbon values
- Studies on processing of iron ore sample for beneficiation plant of sponsor

- Piloting coal with oily bubble flotation
- Processing of hydrocyclone underflow of grinding circuit towards recovery of silver through advance gravity separator
- Pelletization of iron ore concentrate using organic binder.
- 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 at 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 at 7 kg scale.*
- Certified reference materials (CRM) production and proliferation
- Online chemical treatment of rebar to improve corrosion resistance
- Preparation of Detailed Project Report on modernization and improving mineral recovery in mineral separation plant of sponsor
- Preparation of Detailed Project Report on wet concentration plant No.1 up-gradation and separating sillimanite-rich fraction from wet concentration plant No.1 & 2 for sillimanite recovery circuit in mineral separation plant of sponsor
- Feasibility studies on flotation of high-silica limestone from Rajasthan and high-magnesia limestone from Maharashtra

Flagship Projects

Technology Development for Holistic Utilization of Red Mud or Extraction of Metallic Values and Residue Utilization

In order to make India self-reliant in REEs, it is envisaged to establish a technology for holistic utilization of red mud that caters to extraction of REEs, iron, alumina and titania present in red mud. The project is motivated by NITI AAYOG directives and is formulated as a six-party jointly funded project of NML, IMMT, JNARDDC, NALCO, HINDALCO and VEDANTA. The project aims to develop processes for beneficiation of red mud for REE enrichment, for dissolution and recovery of alumina values, for recovery of iron values from red mud, for extraction and separation of Ti, REEs (especially Sc), and, final residue utilization in cementitious products/ building materials. It is also planned to provide master flowsheet for selected grades of red mud along with energy and material balance, and techno-economic feasibility assessment, at 100kg/batch scale.

The work flowsheet has been developed as given below, with the work elements for the respective organizations indicated in colored boxes (**Figure 1**):

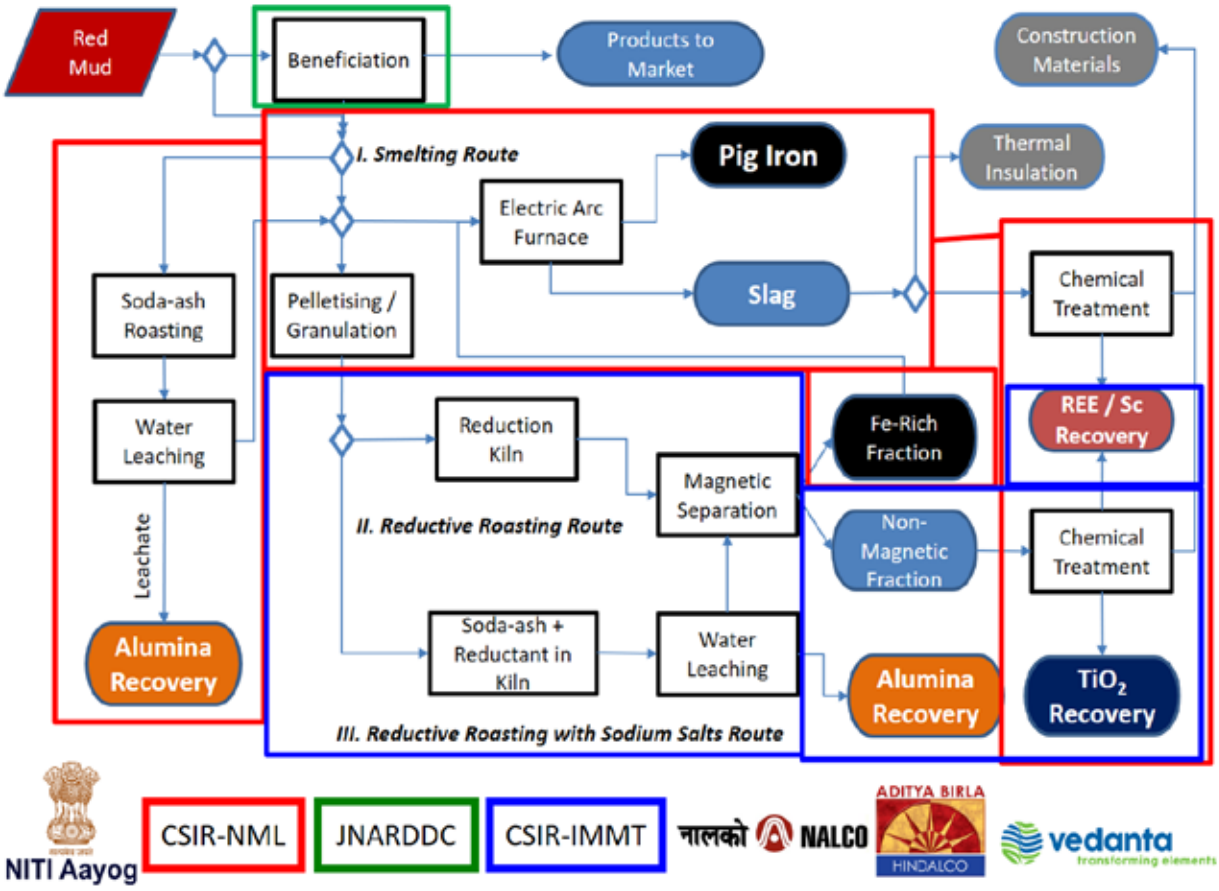


Figure 1 : Work Flow for holistic red mud utilization

Recycling and Valorization of Urban Ores

The generation of electronic waste (e-waste) is increasing at a disquieting rate worldwide. About 80% of the valuables present in these wastes end up in landfills. Despite strict regulations for the proper treatment of these electronic scraps, only 20% of it is getting recycled in an organized manner by the formal sector. Recycling is the most effective and essential solution to the growing problem of e-waste. Due to the presence of several valuable metals/materials, recycling of e-waste has become a significant economic activity. The major fraction of e-wastes comprises of personal computers, mobile phones, batteries, magnets, fluorescent tubes, etc. Printed circuit boards (PCBs) of personal computers contain Cu, Ni, Sn, Pb, Au, Ag, Pt, Pd, etc., whereas, PCBs/connectors of mobile phones contain mainly precious metals (Au, Ag, Pt, Pd and Cu). The magnets present in different electronic items contain rare earth metal Nd, whereas the lithium-ion batteries (LIBs) is composed of rare as well as strategic metals like Co, Li, Ni, etc., which should be recovered in an eco-friendly manner. Recycling of e-waste requires pre-treatment (physical / pyrolysis / chemical) followed by processing using advanced separation techniques to recover value added products (salts/metals). Keeping in view of the above, CSIR-NML has developed application oriented, novel, feasible and scientifically validated hybrid pyro-, chemical and hydrometallurgical processes to recover rare, earth, and precious metals and other non-ferrous metals from varieties of e-wastes fulfilling zero waste concepts through collaborations with national and international research institutes and industries. A center dedicated for the development of feasible technologies to recover non-ferrous, precious and rare earth metals from secondary resources has been established. Dr. Shekhar C. Mande, Director General of CSIR and Secretary of the Department of Scientific and Industrial Research (DSIR), inaugurated this center named as Urban Ore Recycling Centre (UROC) at CSIR-NML, on 20th April 2019 (Figure 2). The developed processes are fully indigenous, economically feasible, less energy intensive and recover high values of metals and materials (Figure 2).

Figure 2: Urban Ore Recycling Centre (UORC) and its activities

Mission Program: Production of Lithium from Ores

Lithium finds use in various commercial applications due to its low density, electrochemical activation, high redox potential and high specific heat capacity. With the emergence of renewable energy technology, portable electronics, and electric vehicles, lithium demand for energy storage systems has increased. Globally, lithium is produced from brines through preconcentration and by hydrometallurgical extraction from spodumene/petalite concentrate. In global trade, spodumene concentrate with 5-6% Li_2O is traded as a mineral commodity and highly pure Li_2CO_3 (purity 95%) is marketed for lithium ion battery (LIB) application.

India has a limited deposit of lithium, but there is neither mining nor extraction of lithium, making it a critical metal, that may become strategic on global supply chain failures or compelling geopolitical situations. An endeavor was made for 'Production of lithium from ore' through one of the work component of *CSIR-Mission Mode Program on 'Bulk Chemicals' led by CSIR-National Chemical Laboratory* in which CSIR-IMMT and CSIR-NML are working in collaboration.

For this research, Spodumene ore was sourced from Atomic Minerals Directorate for Exploration and Research (AMDER, DAE), and Lepidolite bearing pegmatite/aplite was sourced from Atomic Minerals Directorate for Exploration and Research (DAE) and through procurement. The study aimed at developing beneficiation flowsheet for mineral concentrate, developing process flowsheet for hydrometallurgical extraction, purification and production of lithium salt/ Li_2CO_3. The Lepidolite bearing pegmatite contained lepidolite/muscovite, quartz, albite and minor amount of calcite (Figure 3). The spodumene bearing pegmatite contained spodumene, quartz, albite, muscovite/lepidolite, calcite and trace amount of columbite (Figure 3). CSIR-NML's beneficiation process led to the upgradation of spodumene ore with 4.48% Li_2O to a spodumene concentrate with 5.8% Li_2O through flotation. CSIR-NML's second beneficiation process leads to upgradation of Lepidolite bearing pegmatite with 1.98% Li_2O to a lepidolite concentrate with 4.06% Li_2O through flotation.

Innovative hydrometallurgical processes through roasting and leaching of lepidolite- and spodumene bearing pegmatites were developed resulting in 99% Li recovery in leach liquor. Hydrometallurgical parameters were established through laboratory scale experiments. Novel precipitation route was developed wherein impurities of Al, Fe, Mn, etc. were selectively precipitated thereby improving Li-recovery to 91% in purified leach solution and lowering Li loss to <10%. On precipitation of purified leach solution, Li could be recovered as highly pure Li_2CO_3 (purity >93%). The study led to filing of two patents.

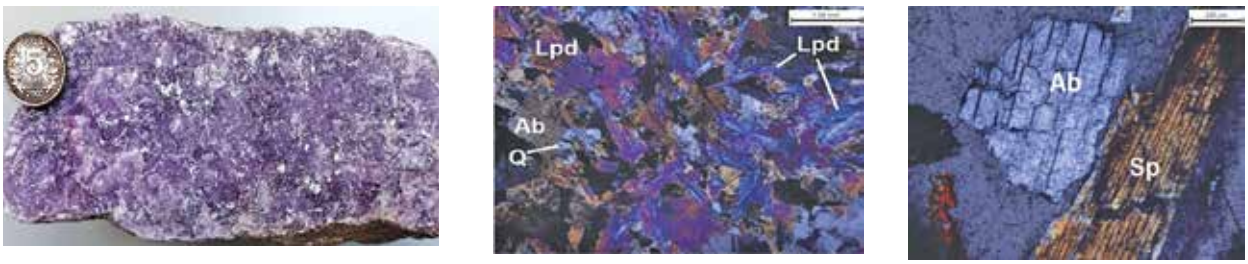


Figure 3 : Lepidolite bearing pegmatite (a) hand specimen; (b) Under Optical Microscopy, Lpd= Lepidolite, Ab= Albite, Q= Quartz; (c) Spodumene Bearing Pegmatite Under Optical Microscopy, Sp= Spodumene, Ab= Albite

Mission Program : Extraction of Critical Metals from used Li -ion Batteries

As another work package of the *CSIR-Mission Mode Program on 'Bulk Chemicals' led by CSIR-National Chemical Laboratory*, and with the aim to make India self-reliant in resources for Lithium battery manufacturing, secondary resources were targeted. The primary objective of this work was to develop a technology to dismantle spent LIBs, extract all metals from the electrode material, and demonstrate at a 1 kg product level. CSIR NML has developed CSIR's first complete and holistic TRL-4 Process (Figure 4) for Extraction and Separation of Lithium, Nickel, Cobalt, Manganese, Iron, Aluminum, Copper and Recovery of Graphite from spent lithium batteries of mixed origin, i.e., LCA, LMO, LCO, NCA, NMC (Patent Application No.

202111040164 dated 16.09.2021). Additionally, a process for selective extraction and separation of lithium and iron salts from spent LFP batteries (Patent Application No. 202111040165, dated 16.09.2021), has also been developed. The pilot plant is slated to be commissioned at CSIR-NML, which shall be the first of its kind Hire-Operate-Transfer (HOT) platform for MSMEs and Entrepreneurs in India. Currently, it has signed agreements with four Indian firms with whom technology transfer is on the anvil, and more interested entrepreneurs are in the queue.

Figure 4. Values recovery from LiBs

Materials for Advanced Ultra Supercritical Power Plants : Investigation of Creep Crack Growth Rate and Damage Micro-Mechanism of New Generation High Temperature Material (IN617)

The assessment of creep crack growth rate (through C* parameter calculation) and understanding the mechanism (from microstructural characterization) are critical for IN617 alloy, a potential candidate material for the A-USC power plants. Considering the microstructural instability at the AUSC power plant operating temperature (~700^{o}C), the present study carried out (i) microstructural characterization of as-received and aged alloys; (ii) creep crack growth rate measurement; (iii) a path-independent fracture mechanics parameter (C*) calculation as per ASTM-1457 standard; (iv) understanding the influence of initial microstructure on the creep crack growth rate.

IN617 sample in solution treated condition showed bimodal grain structure consisting of fine grains (avg. dia. ~50 mm) and coarse grains (avg. dia. ~ 150 mm) with prominent presence of annealing twins. Twinning is a primary deformation mechanism of the IN617 alloy owing to its lower stacking fault energy (~ 35 kJ/m^2). A few (Cr, Mo) based $M_{23}C_6$ types coarse carbides are found at the grain boundaries and Ti(C,N) and other particles are also observed in the grain interiors (Figure 5) with the help of energy dispersive x-ray spectrometry (EDXS) technique. As a result of ageing treatment, the (Cr, Mo) based $M_{23}C_6$ types primary coarse carbides were decomposed and precipitated out as secondary fine carbides at the grain boundaries. EDXS elemental maps (Figure 5) showed Al enrichment adjacent to these secondary carbides, which is suggestive of an ordered L_{12} type γ' phase precipitation during ageing treatment. However, substantiation through TEM investigation is required. The effect of initial microstructure on the creep crack growth rate (da/dt) is visible in the (da/dt) vs. C* plot of the as-received (ASR) and 1000 h aged (1k-aged) samples in Figure 6. It is evident from the plot that for similar amount of crack growth rate the C* values are lower for 1000 h aged sample than that of the as-received (solution treated) condition. It appears that the IN617 alloy is more resistant to creep crack growth after ageing treatment.

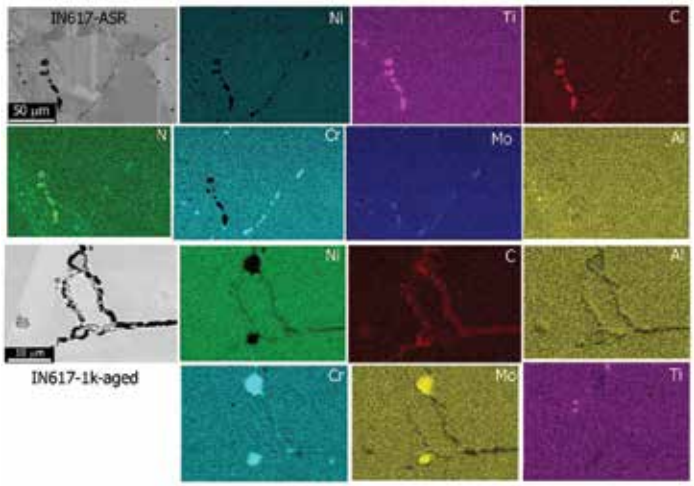


Figure 5: SEM images and corresponding elemental EDXS maps of ASR and 1k-aged IN617 samples showing the microstructural evolution because of ageing treatment.

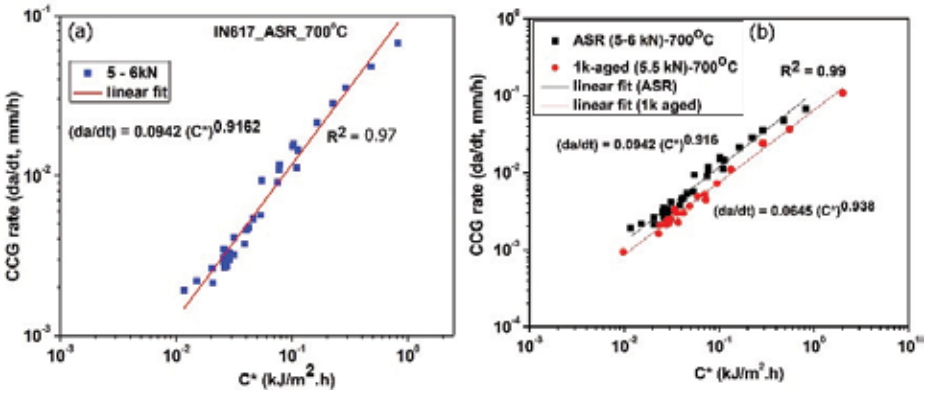


Figure 6: Creep crack growth rate (da/dt) vs. C* plots of ASR and 1k-aged IN617 samples.

Research & Development for the Strategic Sectors

Aerospace Sector

Generating Forming Limit Diagram (FLD) of Welded and Non-welded Aluminum sheets

An aerospace organization approached NML to generate forming limit diagram (FLD) of non-welded and welded aluminum sheets. The thicknesses of the aluminum sheets were 1 and 2 mm for both welded and non-welded samples. Nakajima tests were carried out as per ISO standard in universal sheet metal forming machine with varying blank widths to construct the forming limit diagram. Figure 1(a) shows the picture of Erichsen universal sheet metal testing machine available at CSIR-NML. Waisted blanks with parallel shaft (dog bone shape) were used as specimen, as shown in the Figure 1(b). Regular square grids of 1 mm dimensions were generated on the aluminum surface, as shown in Figure 1(b), by electro-chemical etching for in-process measurement of major and minor strains during deformation using four cameras integrated with the machine. A drawing punch of 100 mm diameter with punch velocity of 60 mm/min was used for testing. After the test, the in-process captured images were analysed by AutoGrid® strain analyzing system to determine the strain paths and to subsequently draw the forming limit diagram.

Effect of Creep-fatigue Interaction on Disk Forgings

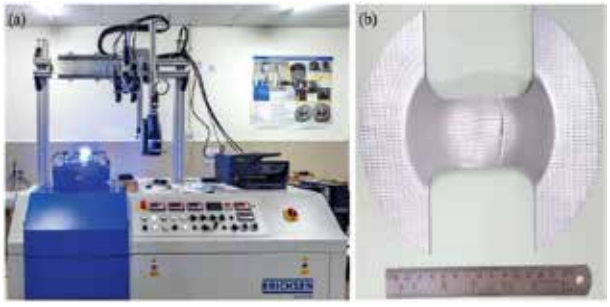


Figure 1: (a) Erichsen sheet metal testing machine, (b) grids generated on aluminium sheet.

Aero engine manufacturers are continuously striving for higher efficiency and therefore, temperature capability of disc alloys is of paramount importance, particularly for the 1st stage disks, where stress and temperature are the highest. 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 for operation 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 g¢¢. SU 720, which is strengthened by g¢ phase, has greater temperature capability and can be processed by conventional forging route. The latter makes this alloy a cost effective alternative for application up to 650°C (Figure 2). Extensive experiments on thermal fatigue and creep fatigue interaction behavior of alloy SU 720 vis-à-vis SU 718 was carried out and shared with the design team of the sponsor. The fatigue life of SU 720Li alloy is almost 45% higher compared to its predecessor alloy SU 718 at 650°C.

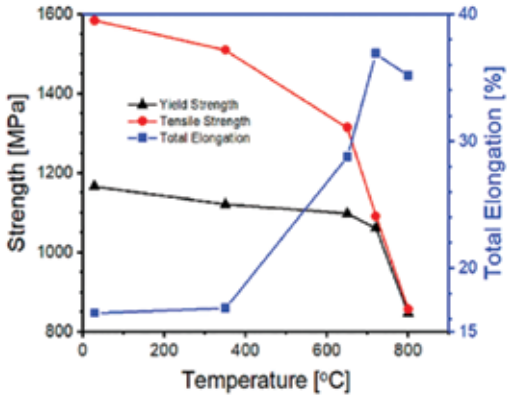


Figure 2: Variation of tensile properties of SU 720 with temperature.

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

Spacecraft propellant gauging is one of the important activities that allows 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 sponsor, is attempting to fabricate four systems using flight-qualified electronics for on-board propellant gauging of spacecraft based on a CSIR-NML technology on 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 developments of pulser, receiver, onboard storage and signal processing, to enable acquisition, analysis and delivery of data from spacecraft to the ground stations. Design and components for the master module has been firmed up, and the fabrication of the master module has been completed. Trial of the master module is in progress at the sponsor's premises.

Defense sector

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

The Indian Navy has entrusted CSIR-NML with Life Assessment of GTG 1250 2E Gas Turbine under their Life Extension Program. CSIR-NML has conducted a comprehensive study of the various components of the GTG and submitted an exhaustive material health analysis. Gas collector, one of the critical components, was also subjected to a critical material health examination. In the course of this analysis, it was realized that service-retired gas collectors can be subjected to a process of reclamation/rejuvenation. With the knowledge gained during the interactions with Indian Navy, CSIR-NML proposes to develop a rejuvenation process protocol for gas collectors of GTG for extending their service lives and to explore the enhanced performance of new gas collectors.

Nuclear Sector

Geopolymerization 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 with low aqueous solubility materials 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 an 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 endeavor. Among the several geopolymer matrices developed, the matrices with fly ash (FA) in combination with ground granulated blast furnace slag (GGBFS) were found to have 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 (sulfuric acid, hydrochloric acids, nitric acids). The samples also conformed to the standard water penetration tests

and hydraulic conductivity tests. The leachabilty 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 5 kg monoliths initially and then to 100 kg monoliths (Figure 3). The up-scaled products are being evaluated. Based on the results, the end user will carry out immobilization of various nuclear waste streams at their facilities.

100 kg casts

Core drilling

Drilled cores

Figure 3: Geopolymerized casts for Immobilization of nuclear wastes, and drilling cores for testing

Metallurgical and Fractographic Examination of 304LN and Its Weld under Cyclic and Monotonic Loading in Air/Water and Air Environment

Corrosion fatigue is one of the degradation mechanisms in the piping of nuclear power plants. In order to understand the mechanisms of fatigue and corrosion fatigue, stainless steel pipe and its welds have been used for carrying out tests under simulated reactor water environment at operating temperatures and pressures. Fatigue crack growth (FCGR) tests have also been carried out on virgin base and weld materials of the piping. The outcome of the investigation as follows. Strain induced martensitic phase transformation was observed during fatigue loading. The increment in microhardness value with respect to virgin alloy, along the growing crack near the fracture location endorsed the presence of martensite. The volume fraction of martensite was in the range of 58-90% as revealed by X-ray diffraction; the dissolved oxygen quantity in the water did not have any direct correlation with the fraction of martensite. At elevated temperatures the volume fraction of martensite was reduced drastically, perhaps the rise in temperature influences tempering of martensite as well as affects the stacking fault energy of the material. Irrespective of environment and dissolved oxygen concentration, fast fracture zone revealed ductile dimple fracture for all specimens. Striation spacings on the fracture surface changed marginally along the growing crack. Increment in test temperature or increase in dissolved oxygen triggered oxide scale formation. Oxide scale thickness was more at the crack tip compared to adjacent areas. The change in the waveform during FCGR did not produce any significant qualitative / quantitative changes. Increase in test frequency changed striation spacing marginally; higher strains possibly caused more adiabatic heating and suppressed martensitic transformation. Severe oxidation occurred during the tests at elevated temperature, as well as in tests in water environment. The major oxidation components were Fe_3O_4 and $FeCr_2O_4$.

Fatigue Behavior of Primary Piping/ Vessel Materials of Indian NPPS under Multiaxial Cyclic Conditions

The objectives of this project were evaluation of piping materials used in nuclear power plants with specific aims of (i) generation of reference

fatigue life curve in cyclic tension and cyclic torsion for SA508 steel, (ii) investigation of the effect of phase shift angle, equivalent strain amplitude, shear to axial strain ratios and loading waveforms on fatigue life for both SS304LN and SA508 steel, (iii) investigation of the cyclic response of the materials under different multi-axial/ non-proportional loading scenarios. This was to be supplemented with microstructural investigations of gauge region of tube specimens for both the materials. Cyclic, completely reversible, tension and torsion tests were performed in a 100 kN axial-1000 N-m torsional bi-axial fatigue testing system. Tests were carried out for various equivalent strain amplitudes ranging from 0.25% to 1.0% using triangular waveform for both axial and torsional tests in SA508 steel. Cyclic frequency was suitably altered for different strain amplitudes to maintain a constant strain rate of 10-3/s. The stress response (hardening and softening behavior) of pure axial and pure shear tests at various equivalent strain amplitudes are given in Figure 4.

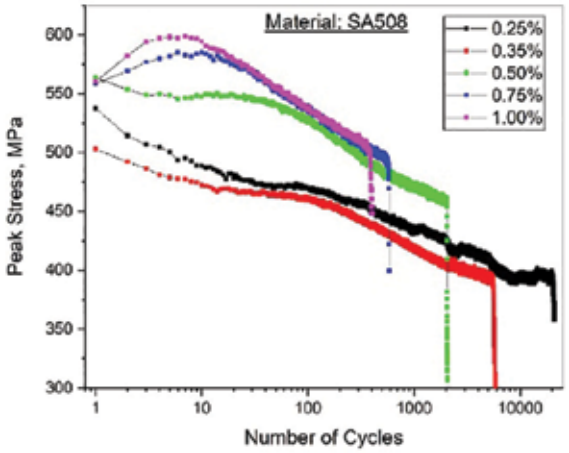


Figure 4: Peak Stress response in different equivalent strain amplitude

Indian Women
Achievers

Literature & Education

PRATIBHA RAY
ODIYA AUTHOR

Internationally-acclaimed Odia Author-popularly known as the Queen of Odia Literature

PADMA BHUSAN 2022

NAJMA AKHTAR
AUTHOR AND EDUCATIONIST (Delhi)

1ST Woman Vice Chancellor of Jamia Milia Islamia

PADMA SHREE 2022

VIDYA VINDU SINGH
AUTHOR AND EDUCATIONIST (Uttar Pradesh)

Renowned Hindi Author from Lucknow-with over 3000 works to her credit in folk and children's literature

PADMA SHREE 2022

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Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Advanced Materials Processing

Sensors and Devices for Metallurgical Industry

Real-time structural health monitoring (SHM) of components is one of the crucial and important components of Industry 4.0. CSIR-NML has established itself in the areas of component integrity assessment and sensors and devices, for over two decades. Our work on sensors and devices for structural health monitoring are categorized under the following sub-heads: ***Thermal sensing in Harsh Environment, Sensors for inline quality assessment of wires and rods and Sensors for Remaining Life Assessment***.

Thermal Sensing in Harsh Environment

Industrial ducts and pipes carrying fluids at high temperatures are refractory lined for protection. In many cases, these pipes are several meters long, nearly a meter in diameter and often located at a height. Failures of these structures can be catastrophic. A crack in the refractory exposes the pipes to high temperature and thus the monitoring of the thermal condition of these structures is essential. 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, manual and intermittent, many areas of the structure would not be accessible to thermal scanning. Embedded temperature sensors (thermocouples, FBGs etc) are a viable alternative. The feasibility of the embedded Fiber Bragg Grating (FBG) sensor has been successfully demonstrated through real time trials at a blast furnace of a Steel Multinational, but embedded sensors sense temperature only at discrete points and not at all locations in a large structure. Hence, there is a need to develop an understanding of the thermal conditions of the entire structure albeit with limited temperature measurements. Two projects were initiated to develop an ANN based trained system to predict the location of critical hot zone from the output of optimum number of sensors; one for the blowpipe through which hot air blows to the tuyer of the blast furnace and the other for the down comer of the pellet plant. A complete simulation for blowpipe was done using the plant operating data. ANN based system was developed for the blowpipe. A real time trial was conducted on a blowpipe of blast furnace by fixing sensors along the length and circumference. The instrumented blow pipe and the real time temperature data are shown in Figures 1 and 2 respectively.

Figure 1: Instrumented Blow pipe installed at the Blast Furnace

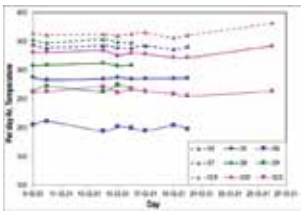


Figure 2: Real time temperature data

Sensors for Quality Assurance of Products (Wires/Rods)

Wire diameters by definition are small and their lengths are in kilometers when manufactured, therefore, detection of defects on the surfaces are difficult to spot. Often the defects are revealed during the processing of the wire at the customer end. Depending on the application, the presence of defects in the wire could cause failure during service with serious repercussions. Thus, detecting the defects and isolating the spools, which have defects, during manufacturing, is important. Wires of diameter 1.5 mm to 2 mm are used in tires of trucks and buses to hold the rubber tyre against

the wheel rim. Such high-end applications need wires free from any surface cracks. As there are several wire drawing lines, it is necessary to have the system on each of the lines. CSIR-NML "Make-in-India" technology, "FlawGuard" made it possible to identify fine cracks during drawing of wires of diameter ranging from 1.5 mm to 13 mm. It is a cost effective, smart sensing system for real-time defect detection and identification in wires drawn at speeds as high as 12-15 m/s. It is capable of working in harsh environments while providing immediate feedback on product quality during production. Under a sponsored project, one system has been installed and commissioned at the MTB-212 line of the sponsor (Figure 3). The technology has been transferred to an Indian MSME company M/S Sanielectronics, Mumbai.

Figure 3: Flaw Guard installed at sponsor's wire mill

Zinc coating is the most effective and widely used process to prevent corrosion and to increase the longevity and performance of steel wire. Zinc coating is generally applied to steel wire by hot dip galvanizing (HDG) process. The process involves two wiping technologies; Nitrogen (N2) wiping for thick coating lines (100-500 GSM) and pad wiping for thinner coatings (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 real time automatic control system in the pad wiping line. The 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 occasionally in either over-coating or under-coating of GI wires. CSIR-NML has developed the technology for coating weight measurement of GI line in thin coating line (Patent Application No.: 202111002156). Successful trials were made in the thin as well as thick coating GI lines of the most renowned wire mill in India. The sensing device, Zincometer, was benchmarked with respect to the existing imported device in the thick coating line and it was found to be at par with the imported system. A two-channel system along with two sensors have been installed and commissioned in the HDG lines of the sponsor. Sensing device along with the sensors in GI lines are depicted in Figure 4. The device and sensors are in use since February, 2022.

Figure 4: Zincometer installed at sponsor's GI line

In order to provide an adherent, defect free and long lasting galvanized coating on the steel surface, the pretreatment of surface is an important aspect. In all the galvanizing lines, the pickling and rinsing of the surface is carried out to remove oxides scales. Pickling involves use of hydrochloric acids and acid disposal are severely discouraged through various environmental norms. To address these issues, under a collaborative project, Ultrasonic

Assisted Electrochemical Technique (UAET) has been developed. The technique, combines high intensity ultrasound and an electro-chemical process with alkaline electrolyte to remove the oxide scale of wires. A real time UAET setup has been manufactured with the help of an Indian manufacturer. The UAET setup is shown in Figure 5. Optimization of ultrasonic parameters and chemical solution needs to be done for the fast removal of oxide scale in-line.

Figure 5: UAET for oxide scale removal of moving wires

Sensors for Remaining Life Assessment

The life of engineering components is affected by various damage mechanisms such as creep, fatigue (mechanical and thermal), corrosion, erosion, etc. The damage assessment consists of specialized metallurgical inspection on samples taken from the structure. It is often important to know what fraction of the life span has been consumed and how much life still remains, in a non-invasive way. CSIR-NML is working on the development of various non-destructive evaluation (NDE) techniques and methodologies for remaining life assessment of different engineering components, such as, power plant components, pipes, reactors, and components for space crafts.

The Department of Science and Technology (DST), has sponsored a project titled “Development of Magnetostrictive Sensing Device for Structural Integrity Evaluation of Pipes”. The research on laboratory based sensors including prepared amorphous/nanostructured ribbon as sensing element, resulted in the development of a prototype Magnetostrictive Sensing (MsS) Device “MagStrics” for the assessment of damage in long pipes. MagStrics has been developed by CSIR-NML in collaboration with M/s. Accelor Microsystem, Chandigarh. CSIR-NML has also transferred the technology to M/s. Accelor Microsystem, Chandigarh on a non-exclusive basis. The device is a computer controlled portable unit with software console and suitable hardware unit for the generation of magnetic fields in the probes (cables) placed around the sensing element (ribbon). The device has a software panel for incorporating appropriate input parameters for operation as well as for detection of defects. The device along with the wrap around MsS sensors and the amorphous ribbons prepared at CSIR-NML is shown in Figure 6.

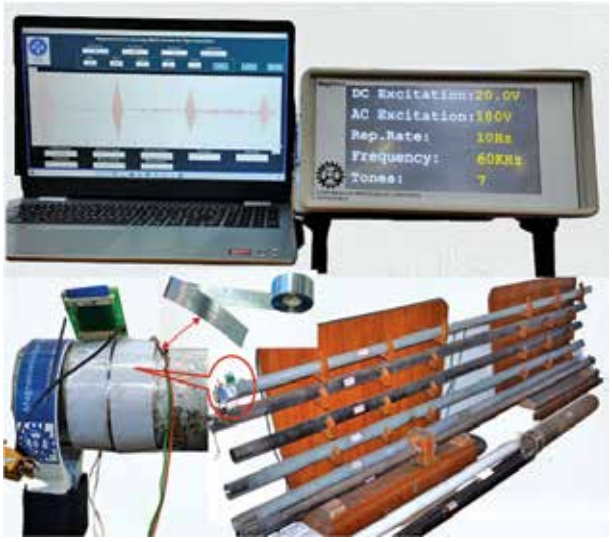


Figure 6: Magstrics; a device for the health monitoring of long pipes

Under the Fast Track Translation (FTT) program of CSIR, development of an advanced giant magneto-impedance (GMI) based sensor for structural health monitoring of engineering structures with enhanced area coverage, is being pursued. Magneto-impedance sensors are gaining ground in industrial applications due to enhanced sensitivity and portability. These sensors typically contain amorphous/ nanostructured soft magnetic microwires, about 120 microns thick, as the sensing element. These wires reveal a significant change in their impedance in the presence of a low or feeble magnetic field. CSIR-NML has already delivered a device (MagSys-2) for an Oil Company, wherein the sensor comprised of a single element. As the interrogating area was reduced due to small diameter of the sensor microwire, a project was undertaken to enhance the area coverage of inspection with the incorporation of an array of such sensor elements. Single and dual arrayed sensor elements were used to obtain magneto-impedance output from a Johnson screen used in a petrochemical refinery unit. Sensor probe was placed at different locations in between the fins of the screen. Figure 7 shows the enhancement in Magneto-impedance output from a Johnson screen using dual arrayed sensor elements vis-à-vis the single element sensor.

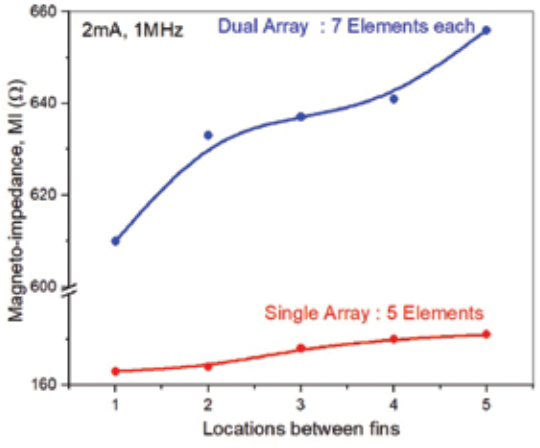


Figure 7: Enhancement of sensor output of array sensor over a single element sensor

Most component damage evaluations are based on periodical inspections during shut-down. Non-availability of sensors functional at high temperatures and pressures, is a crucial handicap for in-situ assessment and monitoring of such degradation during operation. Efforts are being made to address this handicap by developing application specific high-temperature sensors. In this work, a low temperature co-fired ceramics (LTCC) technology is being used to develop a planar eddy current (EC) sensor in order to improve the feasibility and reliability of the condition monitoring of the components in harsh and high T environments. The sensor consists of a micro-fabricated primary (drive) winding, and a secondary winding adjacent to the primary, for sensing the response to a material under test. Multiple coils are cascaded/stacked together to increase the SNR and sensitivity of the sensor. A finite element (FEM) based simulation model was developed over COMSOL Multiphysics simulation software for sensor parameter optimization prior to final fabrication. Based on the result of simulation, 32 layers' planar sensors shown in Figure 8 (a) were fabricated with enhanced quality factors suitable for defect detection in a harsh conditions (high temperatures). The dynamic thermal loading test was carried out from room temperature (RT) to 800°C. Figure 8 (b) shows the electrical parameters characterization of the fabricated sensor up to 800°C. Development and installation technology of these sensors will be useful to assess the remaining life of power plant components in real time.

Figure 8 (a): 32 layers' palnar sensor fabricated through LTCC route

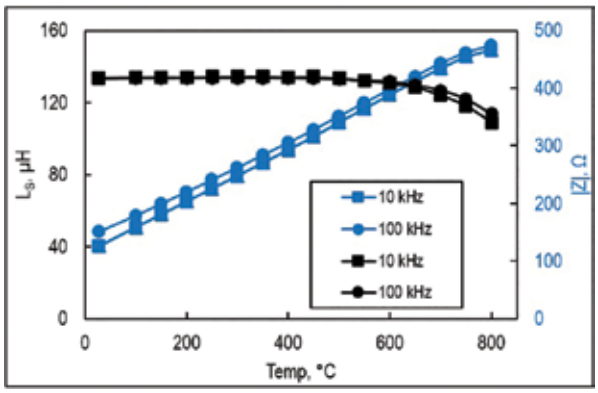


Figure 8 (b): Electrical parameters up to 800°C

Advanced Materials and Coatings

Materials/alloys for energy storage applications

Amorphous metallic alloys are widely identified as potential candidates for hydrogen storage and membrane applications and the majority of those are based on noble or critical elements like Pd, Nb, Ni, and Co. Literature on the usage of Fe-amorphous alloys are scarce. CSIR-NML in collaboration with a sponsor, has successfully prepared a series of Fe-based glassy/amorphous alloys utilizing industrial high-phosphorous pig iron as input material. The prepared alloys are $Fe_{80}C_{14}P_2Mn_{0.5}Si_{3.5,}$ (Alloy-1), $Fe_{68}C_{5.5}P_{11.5}Mn_{0.5}Si_{2.5}Cr_2Mo_{1.5}B_{8.5}$ (Alloy-2) and $Fe_{67.5}C_9P_{12}Mn_1Si_3Nb_2Cr_{0.5}B_{5,}$ (Alloy 3). The developed alloys show better glass forming ability (GFA), attractive functional and tribological properties coupled with use of inexpensive raw material. A feasibility study to understand the hydrogen permeation characteristics of developed Fe-amorphous alloys were carried out in the present project. The hydrogen permeation behavior is characterized using Devanathan-Stachurski electrochemical cell. To facilitate the test, defect free amorphous alloys of diameter 22-26 mm were required. Large scale- planar flow casting (PFC) process was adopted for the wide amorphous strips having thickness of 30 microns. However, the impurities associated with commercial raw materials, elimination of surface to surface defects, uniform thickness requirement and retaining uniform amorphous microstructure posed critical challenges. The as-cast wide ribbons of the developed composition were highly brittle and were prone to crack during electrochemical sample fixture. Simultaneously, well-known highly ductile $Fe_{80}Si_{12}B_8$ wide ribbons were prepared; and their permeation characteristics show promising properties. Suction casting technique using specially designed water cooled Cu-mould was used to obtain 25 mm diameter coin samples of 0.5 and 1 mm thickness. The die cavity and melt parameter optimization were carried out and defect free coin samples were prepared (Figure 9). A number of coin samples, surface polished, were supplied for the test and it was found that the closed casting defects inside the core offers difficulty in ascertaining the permeation behavior due to local thickness variation. A detailed study involving minor compositional and process optimization, suggests that Fe-amorphous/glassy alloys made from less purity materials are prone to mechanical brittleness and are not suitable for wide ribbon/coin casting. The results suggest consideration of modified alloy system or the use of high-purity input material.

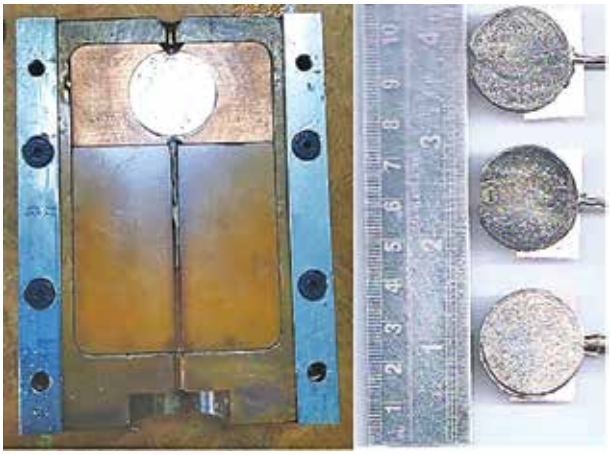


Figure 9: Suction casting mould assembly and 1 mm thick coin samples

Materials for Green Hydrogen

Efficient and cost effective production of pure hydrogen using anion exchange membrane (AME) based water electrolyzer is gaining importance, due to the applicability of abundant transition metal-based catalysts and the high cell durability for used dilute alkaline medium. The development of highly active transition metal-based electrocatalysts and scale-up is critical and also challenging. In this direction, under a DST sponsored project, CSIR-NML developed simple and scalable spray drying followed by calcination for the synthesis of bare (NiCo) and rGo incorporated porous NiCo alloy (rGo-NiCo) hollow spheres as an efficient bifunctional electrocatalyst, without using any template and/or organic substrate as structure directing agent. The synthesized rGo-NiCo showed superior bifunctional electrocatalytic activity. The synthesized rGo-NiCo requires a relatively low over potential of 183 mV to reach the current density of 10 mA/cm^2 and the Tafel slope of 94 mV dec^{-1} in 1.0 M KOH for HER. In the same time, the rGo-NiCo can provide a current density of 10mA/cm^2 in 1.0 M KOH at a low over potential of 400 mV and Tafel slope of 62 mV dec^{-1}. The catalyst showed excellent stability towards water electrolysis. SEM images of bare NiCo (a) and rGo-NiCo (b-c); TEM image of rGo-NiCo (d); XRD pattern (e); polarization curves and the corresponding Tafel Slopes (inset) for HER (f) and OER (g); electrocatalytic stability of rGo-NiCo for OER (h) are provided in Figure 10.

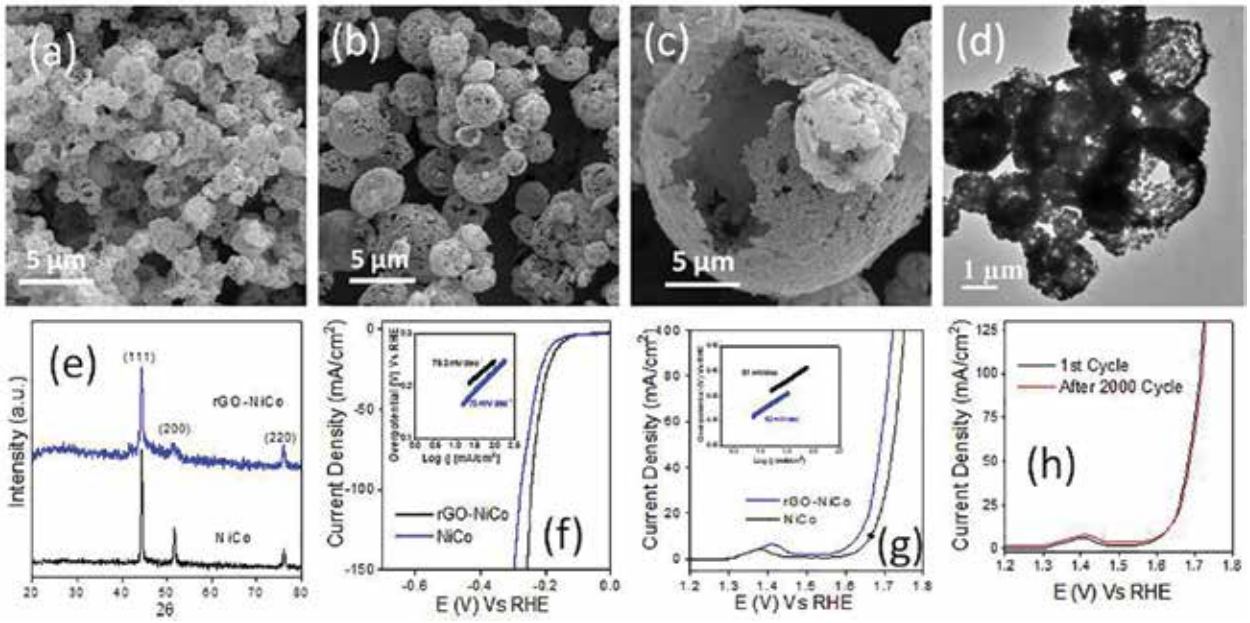


Figure 10: SEM and TEM images

Process Development for Layered Transition Metal Carbides/Nitrides/Carbonitrides (MAX)

MAX materials are the only precursor of 2D-MXenes which have high demand in energy applications. MXenes have very high electrical conductivity, high hydrophilicity, diversity in redox centers and many other interesting properties. High quality MAX phase is not commercially available in India and thus, researchers procure it from overseas at a very high price. Through a CSIR sponsored FBR project, an advanced Ti containing MAX material has been developed (shown in Figure 11). A low-

temperature pressure-less synthesis process was evolved to develop a Ti containing MAX phase with purity of more than 97%. A patent application is submitted for filling on the simple and economic process development of Ti containing MAX phase material with high crystallinity and purity. NML has derived the MXene from the developed MAX and has applied it for energy storage application which shows promising result.

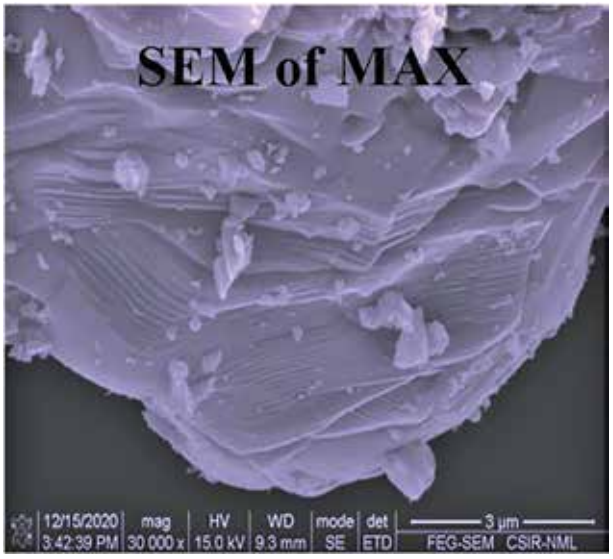


Figure 11: SEM of MAX

3D Architecture with Hierarchical Porosity for Energy Storage Application

Super capacitors are important for energy storage. Unlike batteries, super capacitors are known for their high power density, safety and long cycle life. However, their energy density is not adequate for many practical applications. Under a DST sponsored project, CSIR-NML is working on the development of various electrode materials based on MXenes, chalcogenides, metal oxides, metal sulphides, polymers and carbons for green energy storage system like super-capacitor. Work is also going on to explore the formation of different MXene and metal oxide based composites and their energy applications.

Development of Tin-Selenide Based Thermoelectric Thin Films on Harvesting The Waste Heat in Metallurgical and Other Industries

Thermoelectric materials are required to tap the waste heat energy in different industrial processes. The suitability of material in thermoelectric devices is dictated by high Seebeck coefficient, high electrical conductivity, and low thermal conductivity to maintain high efficiency. Several materials have been studied for thermoelectric device applications, such as Bi_2Te_3, Bi_2Se_3, PbTe, $PbTe_{1-x}Se_x$, $A_8Ga_{16}Si_{30}$ (A= Sr, Ba), $Ba_8Ga_{16}Ge_{30}$, Mg_2B^{IV} (B^{IV}=Si, Ge, Sn), $Mg_2Si_{0.55-x}Sn_{0.4}Ge_{0.05}Bi_x$, $Ba_{0.08}La_{0.05}Yb_{0.04}Co_4Sb_{12}$, $Sr_{0.07}Ba_{0.07}Yb_{0.07}Co_4Sb_{12}$, $Zn_{1-x}Ni_xO$, Na_xCoO_2, XNiSn and XCoSb (X = Ti, Zr or Hf), Si-Ge alloy, etc. It was seen from various reported literature that compared to other thermoelectric materials, layered materials had better properties due to their unique structure. Recently, single-crystalline layered tin selenide (SnSe) thermoelectric material has shown the highest efficiency. However, the single crystal of SnSe is brittle and has a narrow temperature zone where the efficiency is the highest. Moreover, the low carrier concentration and low doping efficiency, limit the use of single-crystal SnSe commercially. Efforts are on to improve the performances of these materials in the form of thin or thick films, which will be ultimately required for making devices. The current CSIR funded research focuses on developing Tin Selenide (SnSe) thin films by different PVD processes (thermal evaporation and electron beam evaporation) to know the effect of substrate temperature and the structure-property correlation of the SnSe thin films.

Thermoelectric polycrystalline SnSe thin films were deposited by various PVD processes in the present work. Prior to depositing the SnSe thin films, the polycrystalline SnSe pellets were also fabricated

by optimizing the sintering temperatures. The SnSe thin films were deposited on glass, silicon, and steel substrates at various temperatures using thermal evaporation and RF magnetron sputtering techniques. The microstructure, morphology, mechanical, and thermoelectric properties of the deposited SnSe films were studied. The deposited SnSe thin films exhibited a single-phase orthorhombic structure. The magnetron sputtered SnSe thin films showed an increase in power factor values with increasing substrate temperature, and a maximum value of 2.4 μW/cmK^2 was achieved at ~700K. Whereas, the thermally evaporated SnSe thin films deposited at 300°C substrate temperature showed the highest power factor value of 2.2 μW/cmK^2 at 778K. The p-type and n-type polycrystalline SnSe pellets were also fabricated by optimizing the sintering temperatures. The highest power factor value of 2.5 μW/cmK^2 with 0.03% Zn was obtained at 778K. Depositions of n-type and p-type SnSe thin films using PVD processes are in progress.

The power generation from the fabricated single-cell p-type and n-type SnSe (bulk) thermoelectric generator is promising. The schematic of the thermoelectric generator and the voltage generation at various temperatures are shown in Figures 12 and 13. It is expected that the optimized p-type and n-type SnSe thin films will improve a thermoelectric generator's performance.

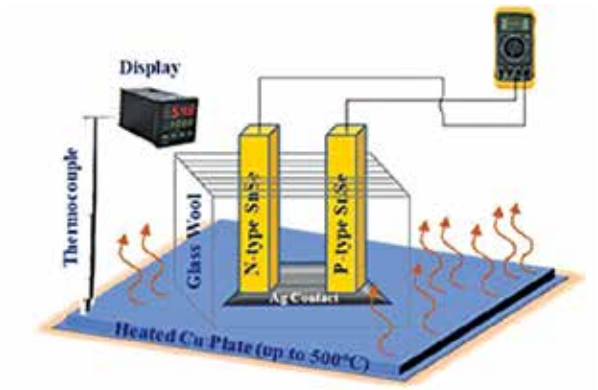


Figure 12: Schematic of Thermoelectric generator

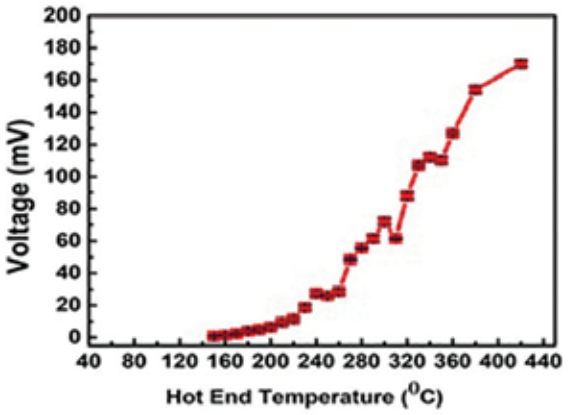


Figure 13: Thermoelectric power generation from single cell at different temperatures

Development of Mg/Zn based Biodegradable Implants for Orthopedic Applications

This project was executed as a work package of the Advanced Materials Mission (AMM) project of CSIR. Permanent metallic implants used for temporary fracture fixation needs to be removed through revision surgeries. However, biodegradable metallic implants eliminate revision surgeries. Biodegradable metallic materials are expected to provide adequate mechanical support to the bone and should have excellent biocompatibility and controlled degradation rate. This project aims to develop biodegradable Mg/Zn implants for orthopedic applications. Mg alloys exhibit high specific strength, low elastic modulus close to human bone, and low density minimizing the risk of stress shielding. However, Mg alloys have fast degradation rate in biological fluids leading to the release of hydrogen. Therefore, development and commercialization of biodegradable Mg alloys remain a challenge. Recently, Zn and Zn-based alloys have been proposed as a promising substitute for biodegradable Mg alloys as the degradation of Zn alloys does not evolve hydrogen. However, Zn has low strength and poor plasticity. This project

has three objectives: (i) develop a process for the preparation of surface modified in-vitro stable Mg-based biodegradable alloys, (ii) develop a process for the preparation of high strength Mg/Zn-based biodegradable alloys, and (iii) fabrication of Mg-/Zn- based biodegradable orthopedic implants.

Different surface modification approaches have been attempted on high strength Mg-alloys. Amongst all, the pulse electrodeposited Zn multi-layer coating with intermediate buffer layers on MgZnMn alloy exhibited corrosion rate of 0.04 mm/year. This coating has survived for 99 days in SBF, which was one of the prime objectives. Different Mg and Zn alloys have been prepared in electric resistance furnace under protective atmosphere. The as-cast alloys have been homogenized and subsequently hot extruded to get the alloys with a strength > 300 MPa and elongation > 10%, which is another important objective. Some prototype implants have been fabricated (Figure 14).

Figure 14: Fabricated Mg alloy and Zn alloy Pins

Indian Women
Achievers

Sports

AVANI LEKHARA

RIFLE SHOOTER (Rajasthan)

India's First Female Paralympic Gold Medalist - Winner of 2 medals in Air Rifle Shooting at Tokyo 2020

PADMA SHREE 2022

VANDANA KATARIA

HOCKEY PLAYER (Uttrakhand)

India's Top Goal Scorer in Hockey in the 2020 Olympics-First India Women to score a hat-trick

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Applied and Analytical Chemistry

The focus of Analytical and Applied Chemistry Division (AAC) is ascertaining the chemistry of metallurgical products and application of chemistry for improvement of metallurgical processes. Basic and applied research projects are executed in the areas of Analytical chemistry, Mineral and Materials chemistry, Corrosion protection, and Coal chemistry. AAC division also produces Certified Reference Materials (CRMs) for metallurgical products like ores, minerals, Coal, Steel, Ferro-alloys and other metallic alloys. AAC division is accredited as a reference materials producer (RMP) by NABL as per ISO/IEC 17034:2016. The division is fully equipped with state of the art analytical instruments to provide analytical support to the ongoing R&D projects of CSIR-NML and provides analytical testing service to outside agencies. AAC Division of CSIR-NML is also an NABL accredited Laboratory for chemical testing as per ISO/IEC 17025:2017. Below are some of the major achievements/activities of AAC Division in the year 2021-22.

Process to Produce Coke from Non-Coking Coal

Through a CSIR sponsored niche area creation project (NCP), researchers of AAC division are working on an alternative process to produce coke from non-coking coal. India's steel industry is heavily dependent on import of coking coal to meet its coke demand. Absence of thermal plastic properties (coking property) in non-coking coals is the prime hindrance for coke making. To address this issue, coking component from semi-coking coals was isolated and used as an additive to prepare coke from non-coking coal. An Indian patent has been filed for the process. A process flowsheet has been developed to produce coke from non-coking coal in 7 kg scale through carbonization at 1100 ^{0}C in a Carbolite oven (Figure 1). The coke produced using 20% non-coking coal and 80% active coking component isolated from semi-coking coal of Indian origin produced coke having CSR 61% and CRI 23%. CSIR-NML is looking for industrial partners for piloting and commercializing the process.

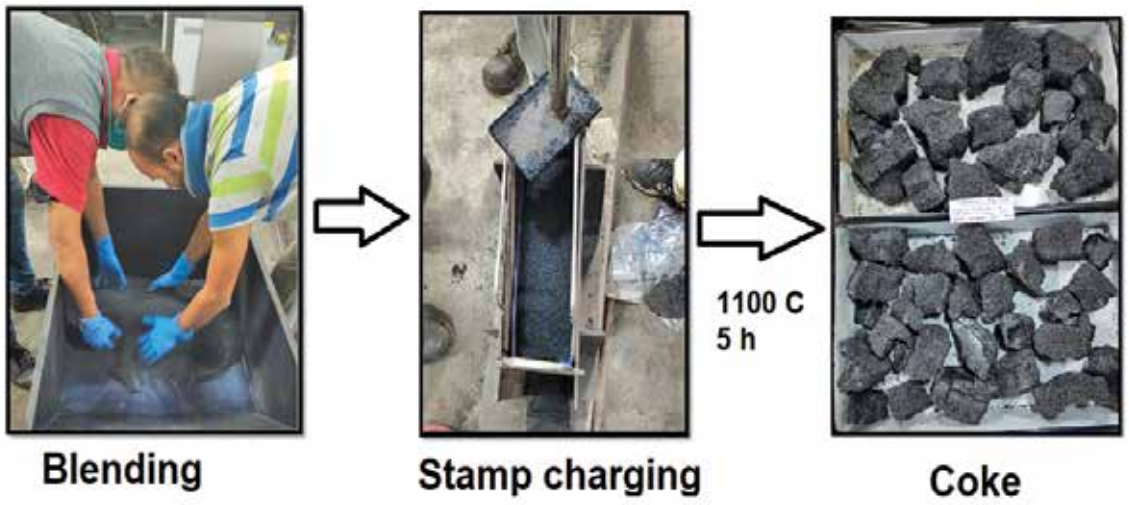


Figure 1: Coke from Non-coking Coal

Oil Agglomeration to Demineralize High Ash Coal

The high ash content in Indian coals makes its utilization in industries considerably challenging. The biggest drawback of such coals lies in their high surface hydrophilicity, which poses difficulties in beneficiation. Oil agglomeration has been demonstrated to be superior compared to other beneficiation processes owing to its simplicity, suitability towards coal fines with high combustible recovery. Nevertheless, finding suitable bridging liquid possessing economic yet industrially viable process parameters is especially challenging in the Indian scenario. Recently, the research team at AAC Division successfully completed two projects sponsored by Coal Industries. The beneficiation parameters of seven low-grade non-coking coals and three coking coals were optimized at 1 kg scale. A pictorial representation of the process of agglomeration is shown in Figure 2. The ash content in Rajrappa coking coal was reduced from 36.7% to 17.8% after oil agglomeration. Similarly, reduction of ash content was more than 50% for all the coking and non-coking coals studied.

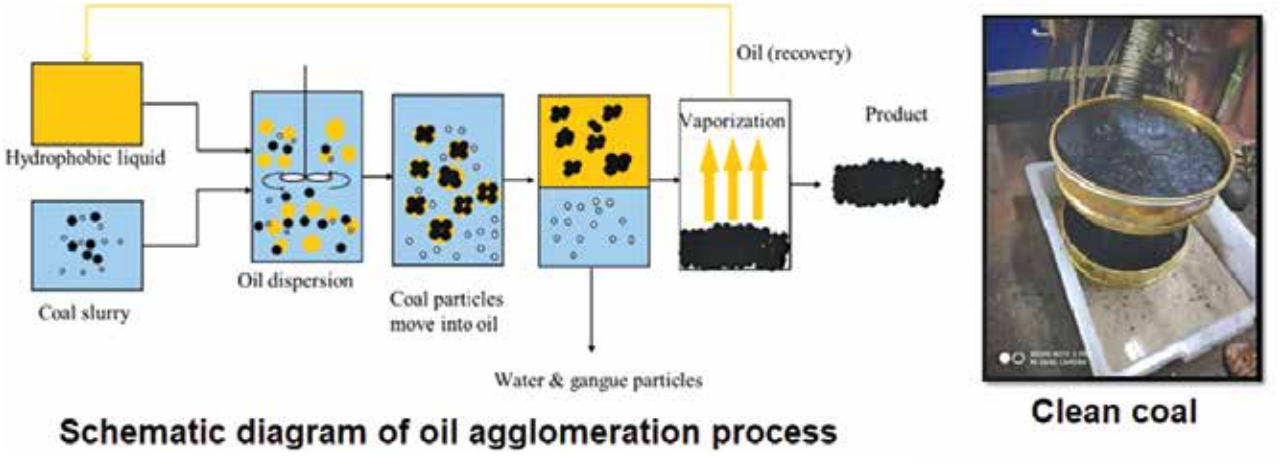


Figure 2: Schematics of oil agglomeration of coal

Technology for Production of Corrosion Resistant Brass Ammunition

An Indian Ordnance Factory, manufactures 7.62mm M-80 SA Ammunition, 7.62mm A-7 SA Ammunition, 5.56mm SA Ammunition, and 12.7mm API/APIT SA Ammunition. It has received a number of complaints from the customer about the blackening of Cartridge SA 7.62mm Ball M-80/M-62 Sequence belt Ammunition and 12.7 mm API/APIT ammunition. To address the problem, the factory approached CSIR-NML for the process improvement in the brass cartridge case manufacturing line. CSIR-NML has developed the chemicals for degreasing, brightening and passivating, which can be used during the brass cartridge case production process (Figure 3). This can ensure proper quality control and long-term economic benefits. A passivation test procedure was recommended to check passivation layer on the brass cartridge cases using ammoniacal silver nitrate test. ISAT trials of the passivated cartridge cases were conducted at the ordinance factory with acceptable results. A modification in the drying process for the brass cartridge cases after passivation, was also recommended.

Figure 3: Brightening of cartridges

Certified Reference Materials (CRMs)

AAC Division of CSIR-NML is involved in production of Certified Reference Materials (CRM) for the last 50 years. CRM is one of the most critical requirements to obtain accurate chemical analysis results and to maintain traceability of the results. CRMs are required to calibrate instruments and to validate the accuracy of analytical results. Under the missions of "Atmanirvar Bharat" and "Make in India", CSIR-NML is manufacturing 39 CRMs in the areas of ores, minerals, coal, steel (gaseous, spectrographic standard and chip/turning standard) and Ferro alloys (Figure 4). Standard procedures and strict quality control processes are followed to make the CRMs and the analytical values are certified through Inter Laboratory Comparison (ILC) and Proficiency Testing (PT) programs. CRMs of CSIR-NML has created its own brand value and has more than 600 Industrial users across India. In 2021, AAC Division has received NABL accreditation as a reference materials producer (RMP) as per ISO/IEC 17034:2016. Two CSIR sponsored FTT projects were executed to develop CRMs for Hydrogen in Steel and C, S in Steel.

Certified Reference Material (CRM) produced by CSIR-NML

National Accreditation Board for Testing and Calibration Laboratories

CERTIFICATE OF ACCREDITATION

CRM UNIT, AAC DIVISION, CSIR-NATIONAL METALLURGICAL LABORATORY

ISO 17034: 2016

"General Requirements for the Competence of Reference Material Producers"

REFERENCE MATERIAL PRODUCER

Figure 4: CRMs of NML and Accreditation

Coal Quality Assessment

India produces about 700 MT of coal annually and quality assessment of the coals produced is a job of national importance. AAC Division carries out quality assessment of both coking and non-coking coals through chemical characterization using its state-of-the-art coal characterization laboratory (Figure 5).

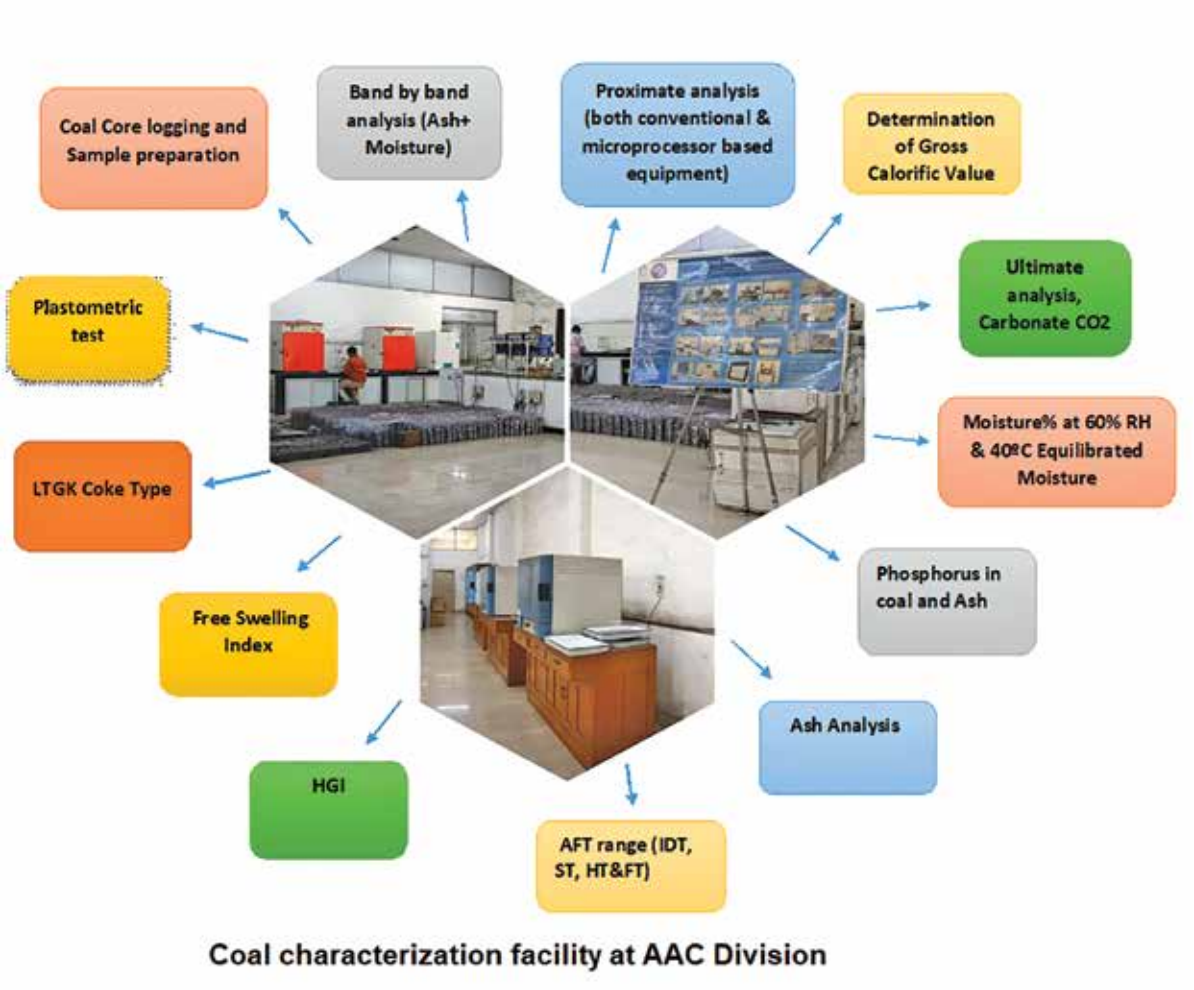


Figure 5: Coal Analysis Laboratory

Materials Engineering

Materials Engineering Division works in four research verticals: Corrosion Engineering, Materials Mechanics, Materials Processing and Microstructural Engineering. The goal of the division is to develop metallic materials, provide technical support to various industries in materials property evaluation, in critical testing, and in root cause analysis for component failures. The division has several state of the art infrastructure, including Creep facilities (2nd largest in South Asia in terms of number of testing points), Fatigue-fracture evaluation 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.

The research by the division during the reporting period is categorized below according to the material domain or service domain.

Line Pipe Steels

Effect of Weld Heat Affected Zone Microstructure on Fracture Toughness of API Steel

The heat affected zone (HAZ) simulation of X80 and X70 line pipe grade steels were carried out in the Gleeble 3800 Simulator considering a weld heat input corresponding to t8/5 of 20 °C/s. The phase transformation temperatures of the steels were determined by using dilatometry studies. Based on that, the different HAZ zones like Coarse Grained (CG) HAZ, Inter-Critical (IC) HAZ and a dual cycle comprising both CG and IC-HAZ cycles were simulated on the fabricated samples for dynamic fracture toughness (K_{ID}) evaluation and fracture toughness (JIC) evaluation. The HAZ cycles were also applied to dilatometry samples to evaluate the phase transformation and microstructure (Figure 1).

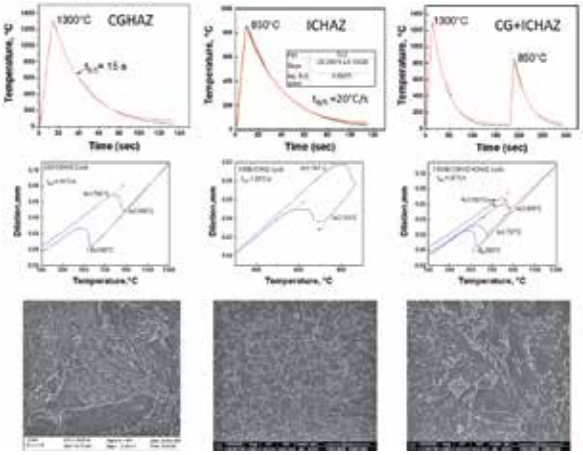


Figure 1: Different HAZ cycles and corresponding phase transformation and microstructure

Table 1 Dynamic Fracture Toughness of X80 linepipe grade steel

Sample condition	Dynamic Fracture Toughness, KJD* (MPa.m^ 0.5)
Parent	402
CGHAZ	137
ICHAZ	422
CG + ICHAZ	267

The dynamic fracture toughness of the simulated samples for X80 grade is shown in Table 1. Fine-grained intercritical HAZ zone comprising ferrite shows similar KJD values as that of the parent material. The coarse-grained HAZ zone comprising bainite showed the least fracture toughness; intercritical treatment (i.e., dual cycling) lead to improvement in its fracture toughness values. The notch bend fracture toughness was also least in the case of coarse-grained HAZ. Fractography studies revealed complete cleavage pattern in the case of CG HAZ and dimple shear in the case of ICHAZ condition, while the dual cycle showed mixture of both.

Investigation on Hydrogen Trapping Characteristics of Precipitate/Matrix Interface in Microalloyed Steel

Hydrogen can enter materials from many different sources. Hydrogen is well known for its deleterious effect on the mechanical properties of high strength steels. One way of preventing hydrogen-induced attack is the addition of microalloying elements such as Nb, Ti, and V, so as to obtain fine carbides and nitrides that act as irreversible hydrogen traps and impart high precipitation strengthening to the alloy. The carbides and carbonitrides have high binding energy for atomic hydrogen and lock them in the lattice rendering them immobile. The trapping capacity of the precipitates can be further maneuvered by altering their coherency with the matrix phase, their morphology and their distribution in the matrix phase, and by altering the type of interfaces. The present work investigated the ability of niobium (Nb) and vanadium (V) based precipitates (carbides/carbonitrides) to act as the trapping sites for the hydrogen in API grade micro-alloyed steels. The microstructural factors such as precipitate type, size and volume fraction, which influence the strain field around the precipitate particle, were varied in order to obtain maximum trapping of hydrogen. Hydrogen was charged in the sample using a laboratory hydrogen charging setup. Figure 2 presents the TEM micrographs showing variation in the size of the Nb(C,N) precipitate in a Nb containing alloy. The volume fraction was varied using alloys containing increasing Nb/V content (0.05 and 0.1 wt. % in the present study). Thermo-mechanically processed (TMP) tensile specimens having different size and volume fraction of precipitate were hydrogen charged employing a laboratory setup. Tensile tests were performed in the specimen in both uncharged and hydrogen charged conditions. The extent of the deleterious effect of hydrogen was quantified by an embrittlement index.

It was found that fine Nb(C, N) precipitates having size less than 5 nm were most effective in terms of hydrogen trapping and thereby preventing hydrogen-induced degradation. The fracture appearance of the hydrogen charged tensile specimen remained full of dimples, which was similar to the uncharged tensile sample (Figure 3). The primary reason for low degradation in the Nb alloys with finer precipitate size is that the binding energy (-Eb) of the Nb based precipitates for hydrogen is greater than 50 kJ/mol leading to irreversible hydrogen trapping. The trapping efficiency remained nearly similar with the increase in the volume % of the Nb based precipitates. V containing alloys showed least resistance to the hydrogen-induced attack, irrespective of the size and volume fraction of the precipitates in various alloys. The size of the V(C,N) precipitates was varied from 3.5 nm up to 35 nm. No improvement in the embrittlement index was observed with the variation in the precipitate size and with the volume fraction of the precipitate, owing to the low binding energy of V based precipitates for the hydrogen entrapment. The fracture appearance of the hydrogen charged tensile specimen of a V containing alloy changed from full of dimples in the uncharged specimen to brittle fracture appearance containing cracks and facets (Figure 3). An industrial sample provided from Tata Steel also performed optimally in presence of hydrogen. TSL samples possessed ultrafine (size ~ 2-3nm) complex precipitates of Ti and Nb. The binding energy associated with the Ti precipitates for hydrogen atoms are highest of all the type of microalloying precipitates and therefore are strongest hydrogen traps.

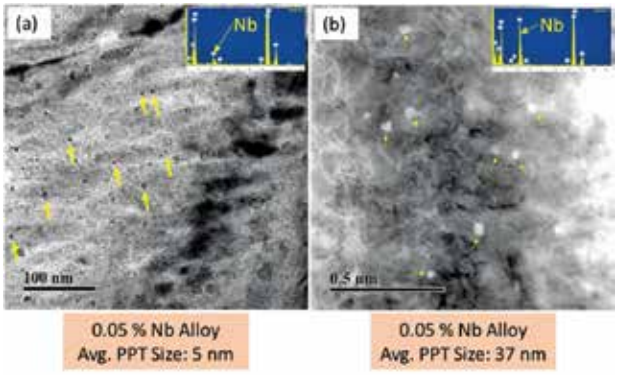


Figure 2: Distribution of precipitates in the 0.05 % Nb alloy (a) TEM bright field micrograph (b) STEM HAADF micrograph

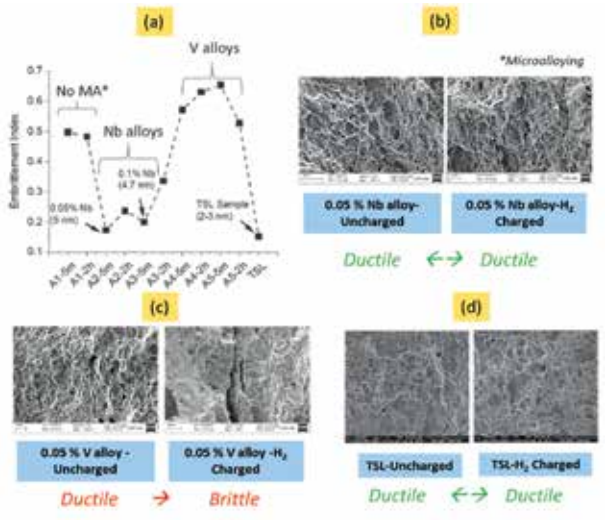


Figure 3: (a) Embrittlement index in various alloys; (b-d) Fracture surface appearance before and after hydrogen charging in different alloys

Materials with Enhanced Performance

Development of High Ballistic Strength Armor Steel With 2 GPa Tensile Strength And 50mpam$^{1/2}$ Fracture Toughness

NML aims to develop an indigenous technology for armor steel with enhanced ballistic performance, which will be extremely useful for Indian Defense. The steels will have higher strength to reduce the thickness of steel plates, for light-weighing. The developed technology will be cheap as it will not require tempering, it will eliminate isothermal holding required in conventional Q & P process, and, alloying additions will be minimal. The steel compositions were designed with minimal alloying additions. A novel processing scheme was used to achieve a multiphase microstructure, with due considerations to industrial feasibility and adaptability of the scheme. Two new alloys have been designed based on theoretical simulations, literature review and patent search. These alloys were processed by (i) 'continuous cooling' to room temperature at various cooling rates and (ii) 'quenching and non-isothermal partitioning' in the bainite and martensite regions, thus eliminating the isothermal holding. The microstructure of the steel shows the presence of martensite, bainite and retained austenite, with varying fractions (Figure 4). The results indicate the achievement of tensile properties close to the project targets (Figure 4). Based on these lab scale findings/optimizations, one of the best alloy will be chosen for large/pilot scale processing. The medium carbon low alloy steel through energy-efficient quenching and non-isothermal partitioning route and an optimized process methodology to achieve advanced high strength combined with good ductility and impact toughness are the deliverables achieved until now.

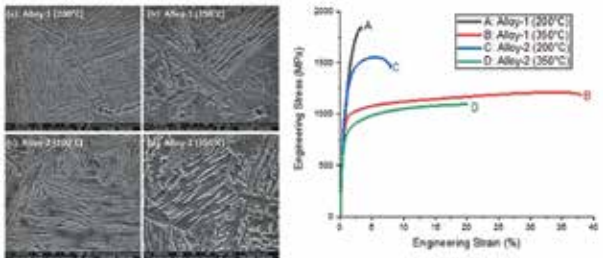


Figure 4: Microstructure and tensile of plots for some of the heat treatment conditions

Effect of Processing Parameters on CRYO-Impact Properties of Cast Alloys

The objective of this work was to investigate the phase evolution with different heat treatment conditions, and their effect on cryo-impact properties of the existing grade "08x as cast" alloy (14 Cr-8 Ni wt.% super-martensitic stainless steel). This would provide an understanding of the influence of heat treatment parameters on cryo-impact properties of the in-use alloy, as well as provide insights for designing new alloy composition and processing schemes that would provide better cryo properties. A super-martensitic stainless steel with 8 wt.% Ni, and with Ti as a microalloying element, was designed with the help of thermodynamic and kinetic simulations. The as-cast alloy after homogenization and solutionizing treatment was subjected to tempering treatment

at different intercritical temperatures. The scanning electron microscope (SEM) images of the as-solutionized and tempered samples are shown in Figure 5. The micrographs show martensite-retained austenite structure; the retained austenite content was found to increase with increase in tempering temperature. The partitioning behavior of the alloying elements was also studied. Ni showed significant partitioning to austenite during tempering treatments. The mechanical property tests (tensile tests, Charpy impact tests) have also been carried out; the designed alloy with suitable tempering shows promising mechanical properties. Further optimization of the tempering parameters is in progress, for enhancing the toughness of the alloy at cryo temperatures.

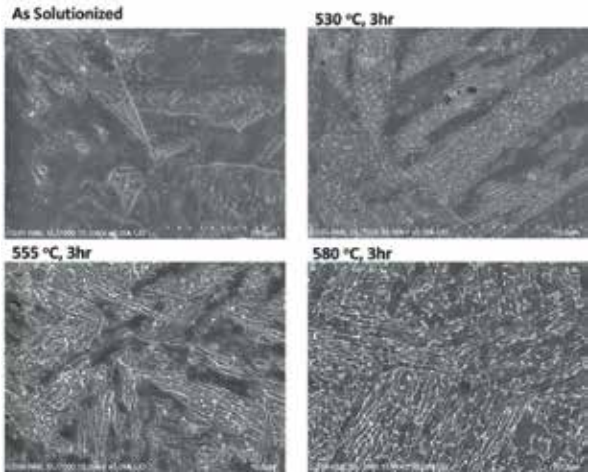


Figure 5: SEM micrographs of the as-solutionized and tempered samples showing martensite-retained austenite microstructure

Development of Thicker Section Abrasion Resistant Steel with Relatively Higher Coiling Temperature

This work was carried out to develop thicker section abrasion resistance grade steel (thickness: > 6 mm). The various processing routes to produce hot rolled steel are shown in Figure 6. The conventional processing routes require an additional heat treatment facility, which is difficult to introduce in a continuous hot rolling mill. As an alternative to isothermal holding, the remaining heat with the hot rolled coil was found to be sufficient to stabilize some amount of retained austenite (Figure 6). Therefore, this energy-efficient quenching and non-isothermal partitioning process was chosen for this project. Two new alloys were designed based on patent and literature search, theoretical calculations, etc. The steel samples were hot rolled to a thickness of 18 mm, followed by machining to 15 mm such that the surface scale was completely removed. This 15 mm thick plate was sectioned to investigate the heterogeneities, if any. The micrographs showed the presence of martensitic laths separated by thin films of retained austenite. In some regions, iron carbides were observed. The XRD analysis of the samples showed austenite retention up to 10 vol.%. Interestingly, both the alloys did not show any variation in the microstructure at different sections. The hardness and mechanical properties were also evaluated at different sections and showed uniform behavior against deformation. The targeted mechanical properties were achieved at a higher coiling temperature of 350oC, which affords easy industrial implementation.

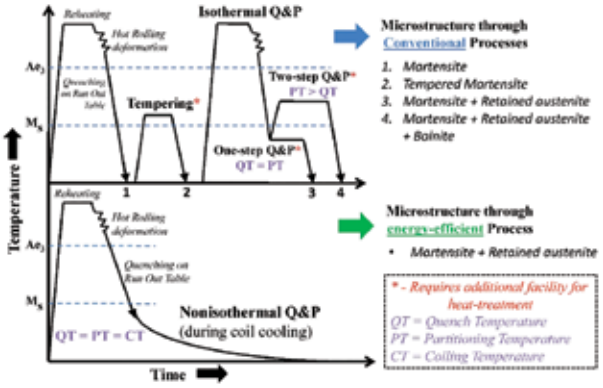


Figure 6: Schematic of the applied processing schedule on designed alloys

Thermodynamic and Kinetic Assessment of Interfacial Equilibrium Conditions in Multi-Component Based Bulk Nano-Pearlitic Steels (FBR)

Bulk nano-pearlitic steels are now widely attempted by various steelmakers across the globe, as they possess excellent combination of strength and

toughness thereby finding application in many areas. Usually these steels are prepared by non-equilibrium processing wherein it may undertake various thermodynamic paths. Various thermodynamic models (viz. ortho-equilibrium (OE), para-equilibrium (PE), no-partitioning local equilibrium (NPLE), partitioning local equilibrium (PLE)) have been theorized to predict kinetics of phase transformation under such non-equilibrium processing. The present work aims at developing a thermodynamic framework with the help of which the operational local equilibrium mode and the corresponding tie-line during pearlitic transformation can be determined. The obtained information will aid in predicting the attainable extent of refinement and growth rate of pearlite. The objective of the project is the development and validation of a thermodynamic and kinetic framework for prediction of interfacial equilibrium conditions during nano-pearlite formation in multi-component steels.

The results showed that second order truncation of Unified Interaction Parameter Formalism (UIPF) has been proven thermodynamically consistent for its application in evaluating excess Gibbs energy contributions in multicomponent systems. Interaction parameters and standard Gibbs energy change for different components (Fe, C, Mn, Cr) along with corresponding dependence upon temperature have been determined. Metastable ferrite/austenite and cementite/austenite phase boundaries along with demarcation between no-partitioning and partitioning local equilibrium regions has been done for Fe-Mn-C and Fe-Cr-C systems. Different ternary alloys (Fe-Mn-C and Fe-Cr-C) with compositions in specific local equilibrium regimes were cast followed by suitable post processing and isothermal heat treatments for obtaining fine pearlitic microstructure. Microstructural characterization of designed and processed alloys for determination of growth rate and interlamellar spacing has been carried out. Transmission electron microscopy based characterization of interfacial conditions (in terms of compositional assessment) have been carried out for Fe-Cr-C systems (Figure 7), and it has been shown to validate the predictions as per the UIPF simulations.

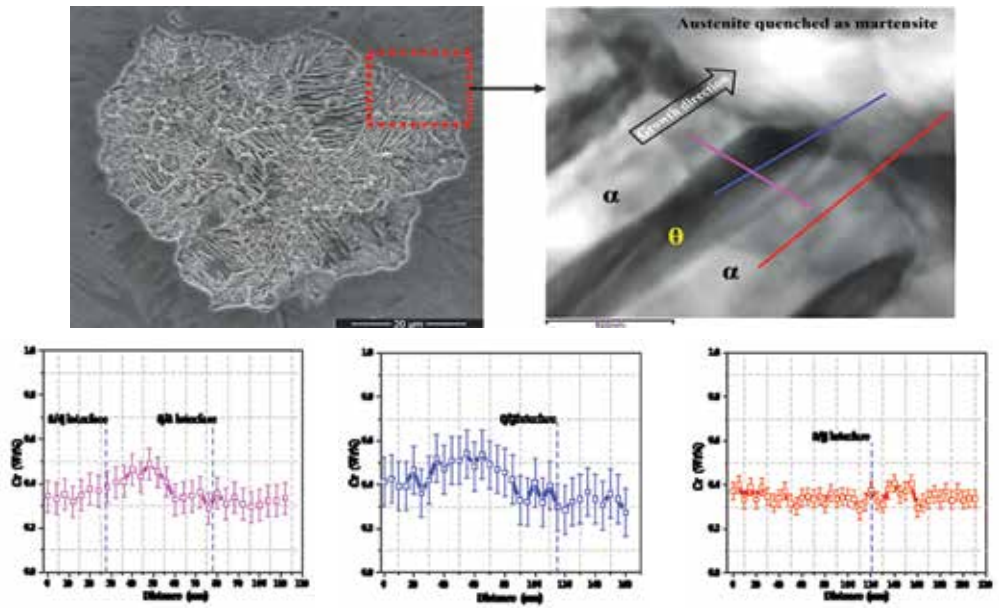


Figure 7: STEM based energy dispersive x-ray spectroscopic analysis across the pearlite/austenite growth front for a Fe-Cr-C specimen undergoing steady state pearlite growth at 670oC

Materials Processing

Thermo-Mechanical Processing and Cold Rolling of Medium Carbon High Manganese Alloy Steels

The objective of this project is optimization of rolling, forging and heat treatment process parameters with and without salt bath furnace for medium carbon high manganese steels. Medium carbon high manganese steels of different composition in the form of ingot supplied by a steel major is being used for the current project. The project involves the process optimization of forging, rolling and heat treatment parameters. Rolling mill, forging hammers and salt bath furnaces were employed to carry out the secondary processes, and different heat treatment processes for the medium carbon high manganese steels with different alloying elements was carried out. The quality of the steels in terms of the chemistry and mechanical properties will be assessed, so that the sponsor can take an informed decision on the suitability of medium carbon high manganese steels for structural applications.

Evaluation of materials

Creep-Fatigue Interaction Behavior of ODS-Austenitic Steels and ODS-iron and Nickel Aluminides

Oxide Dispersion Strengthened (ODS) iron based alloys are light materials. An effort has been made to use the alloy for high performance power generation systems and other high temperature applications. This requires thorough evaluation of their properties. This project has studied creep-fatigue damage accumulation in ODS-Fe3Al-Zr at 600 – 700 °C, evaluated the influence of dwell times on damage accumulation, and, examined the applicability of various creep-fatigue (CF) damage assessment models.

The low cycle fatigue (LCF) and creep-fatigue (CF) interaction tests were carried out in strain controlled mode using a servo-electric machine at a constant temperature. A series of LCF and CF interaction tests were performed in the temperature range of 600 – 700 °C with an interval of 50 °C, using different strain/time waveforms. The dwell time at maximum strain was varied to evaluate the CF interaction behavior of the investigated ODS alloy. The ODS alloy does not reveal any remarkable cyclic softening at 600°C (Figure 8), which is desirable. Once all the tests are completed, empirical relations will be constituted to compare the LCF and creep-fatigue properties of the ODS steel, with advanced ultra-super critical material, such as 304HCu, IN617 or IN625 alloys.

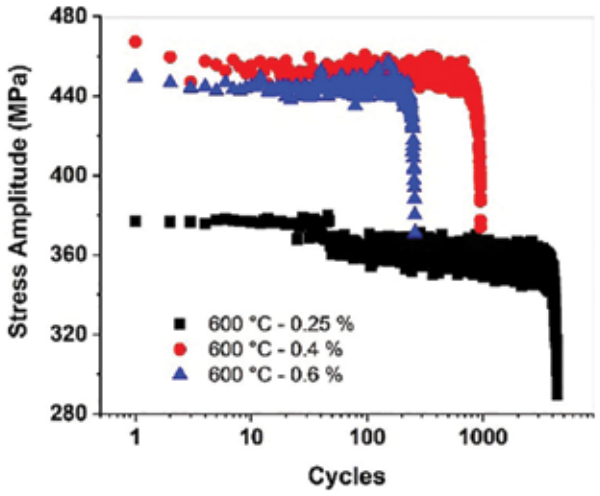


Figure 8: Plot depicting stress amplitude against number of cycle at 600 °C at different strain amplitudes

Big Data Assimilation and Synthesis for Materials Creep Degradation

Estimation of creep properties of steels is time consuming. A combination of simulation methodologies and machine learning approach has been employed to understand creep. In this project, linkage between chemical compositions, microstructural features and their evolution during creep deformation is studied. Multi-scale simulations

to investigate creep properties of steel at various loads and temperature conditions have been carried out. Multi-scale simulation consists of quantum, nano and meso- length and time scale simulations. At nano-scale, the molecular dynamics simulations to investigate creep properties of steel were carried out. In order to implement intra-atomic interactions, embedded atom method potentials for iron have been employed. Figure 9 provides microstructural simulacrums for the creep deformation of steel. These help in visualizing the slippage and merging of grains during creep deformation process. Common neighbor analysis indicates that formation of crystalline structure of steel occurs during early and mid-stage of creep deformation process. Creep curves are well matched with the published simulation data as well as experimentally reported data at nano-meter length scales. At meso-scale, the multi-phase field model of phase field simulation for grain growth has been carried out. Figure 10 shows regression based machine learning approach for creep properties of steel. Regression calculations have been used to develop a correlation between simulated creep data and predicated data.

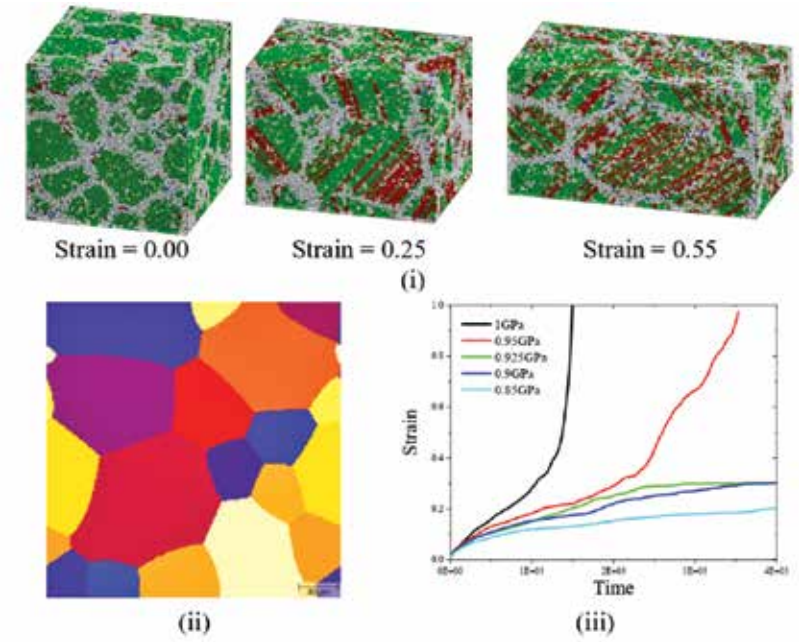


Figure 9: Multi-scale creep simulation of steel (i) at nano-scale, (ii) at meso-scale, and, (iii) creep curve.

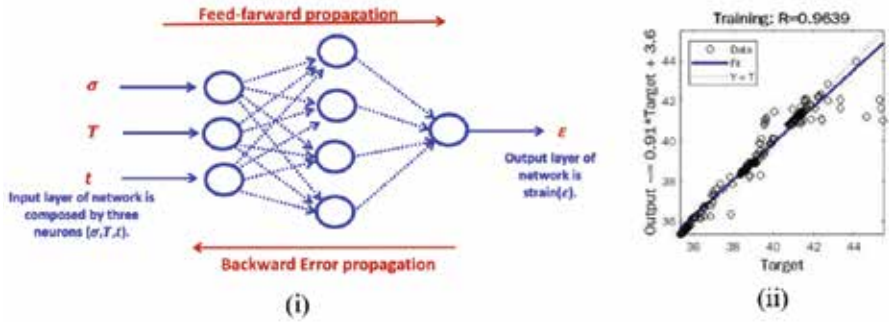


Figure 10: Regression based artificial neural network model for the data-analysis of creep properties of steel: (i) neural network schematic, (ii) plot for the target and out-put prediction.

Corrosion Behavior of Different Rail Steels in Various Environments

The rail steels are susceptible to three types of corrosion, namely, atmospheric, microbial and stray current corrosion, which result in 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 a steel major. 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.

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)* were assessed (a) through salt spray exposures in 5 % NaCl solution (ASTM B117); (b) cyclic humidity exposures (ASTM G60-01); and, (c) spray exposures in synthetic urine solution with or without bacterial species. The corrosion rates measured through salt spray tests were found to be as follows (Figure 11): 1080Cr < Cu-Mo < NCC < 705 < 699 < 90UTS.

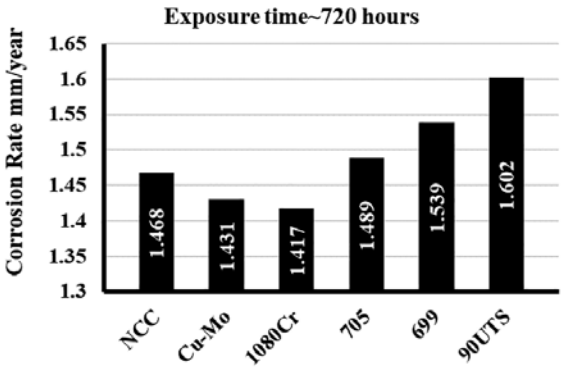


Figure 11: Corrosion rate of different grades of rail steels in salt spray tests

The localized corrosion (pitting, pit depth) rate (3D view provided in Figure 12) was found to be in the order 1080Cr < NCC < 90UTS < 699 <Cu-Mo < 705, whereas uniform thickness loss trends was 1080Cr < NCC < Cu-Mo < 90UTS < 699 < 705. The corrosion rates in humidity chamber followed Cu-Mo < 90UTS < 705 < 699 < 1080Cr < NCC

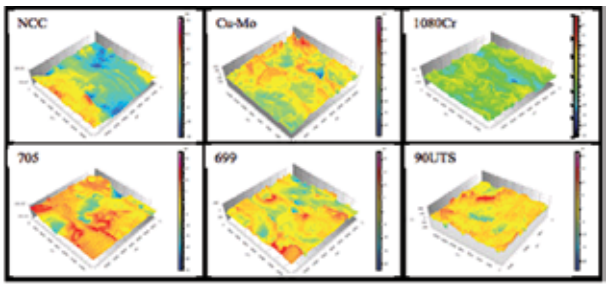


Figure 12: 3D topographical view of corroded surface (after cleaning) after 720 hour's exposure (as per ASTM B117) (Blue color indicates deep pit).

High Temperature Oxidation and Hot Corrosion behavior of selected materials for Clean Coal Technologies for Power Plant Applications

Candidate materials for advanced power plants were evaluated for their high temperature behavior. Hot corrosion studies were carried out on unwelded and laser-hybrid (LH) welded IN 617 and P 91 alloy samples. The samples were coated with (i) coal ash and (ii) salt coating. The coated as well as uncoated samples were exposed at 600 ˚C in flue gas environment for 600 h. The change in weight due to oxidation in different environments for the different alloys tested is shown in Figure 13. The characterizations of hot corroded specimens were carried out using XRD and EPMA. The XRD analysis of IN 617 alloys confirms the presence of oxides of Na2SO4, Cr2O3, FeCr2O4, NiCr2O4, Fe2O3 at 700 ˚C after 1000 h of exposure. FeCr2O4 is more protective to oxidation as compared to Fe2O3. In case of P91 alloy, the presence of (Na,K)2SO4, NiTiO3, Fe2O3, (Mn, Fe)2O4, (V, Cr)2O4 phases were detected. The presence of Fe2O3 in the outer scale is non-protective, which allow for ingress of oxygen through it to form more oxide, which leads to increase in weight for P91 alloys compared to IN

617 alloys. Creep rupture tests were carried out on as-received P 91 alloys, laser hybrid welded IN 617 (W), and P 91(W) alloys (Figure 14). It was observed that the creep strength of IN 617 was relatively higher than P91 alloys.

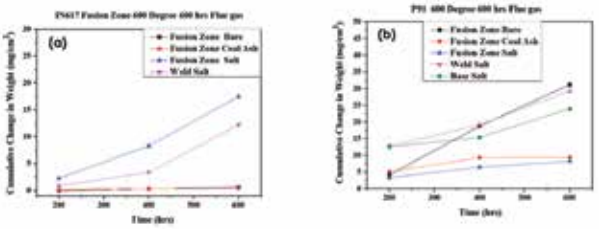


Figure 13: Oxidation kinetics curve of alloys exposed at 600°C for 600 h in flue gas environment for: (a) IN 617 & (b) P91.

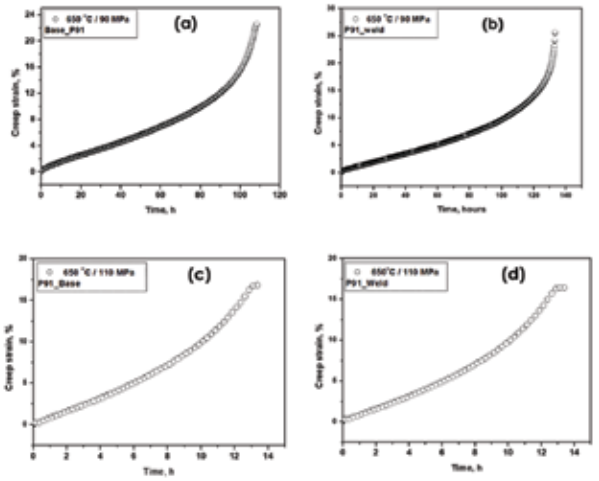


Figure 14: Creep tested: at 650 oC/ 90 MPa for (a) P91 (base) & (b) P91 (weld) specimens and at 650 oC/ 110 MPa for (c) P91 (base) & (d) P91 (weld) specimens.

Mechanical and Microstructural Health Assessment of Centre Buffer Coupler Parts

Through a long term collaboration with RDSO, Lucknow, CSIR-NML has been assessing the microstructural and mechanical health of center buffer coupler (CBC) parts. The supplied assemblies comprise of various components, like, CBC body, knuckle and yoke (Figure 15). Sampling followed by microstructural, compositional and mechanical property assessment is done using various techniques like light optical microscopy, scanning electron microscopy, optical emission spectrometry (OES), macro-hardness measurements, uniaxial tensile tests and Charpy impact toughness. The microstructural and mechanical health evaluation of supplied CBC components is done as per RDSO – WD-70-BD specifications.

Figure 15: CBC Assembly consisting of body, yoke and knuckle.

Failure Investigations and Residual Life Assessment

Failure Analysis of Front Axle Beam

Failure analysis of a front axle beam was carried out through visual observation, chemical analysis, inclusion rating, NDT (normal UT), microstructural evaluation and mechanical properties (tensile, hardness, impact) evaluation and fractograhy of the crack surface. Visual observation revealed a significant transverse crack. (Figure 16). SEM Fractography revealed concentric beach marks indicating that the crack nucleation and progression was under fatigue loading conditions. The crack had originated from central axis (straight rib) where a significant dent was observed. The dent could have been caused by grinding marks, and further accentuated by surface corrosion at this location, as shown in Figure 16a. The observed features under SEM were not very clear due to extensive surface oxidation/rusting, despite cleaning of the surface. The crack had grown towards the edge

of bottom section of the axle beam due to fatigue loading during operation. It was concluded that the grinding or dent marks on the straight rib at the bottom of front axle beam was the origin of fatigue crack nucleation and further propagated due to fatigue loading conditions in service aided by atmospheric corrosion and debonding of MnS inclusions.

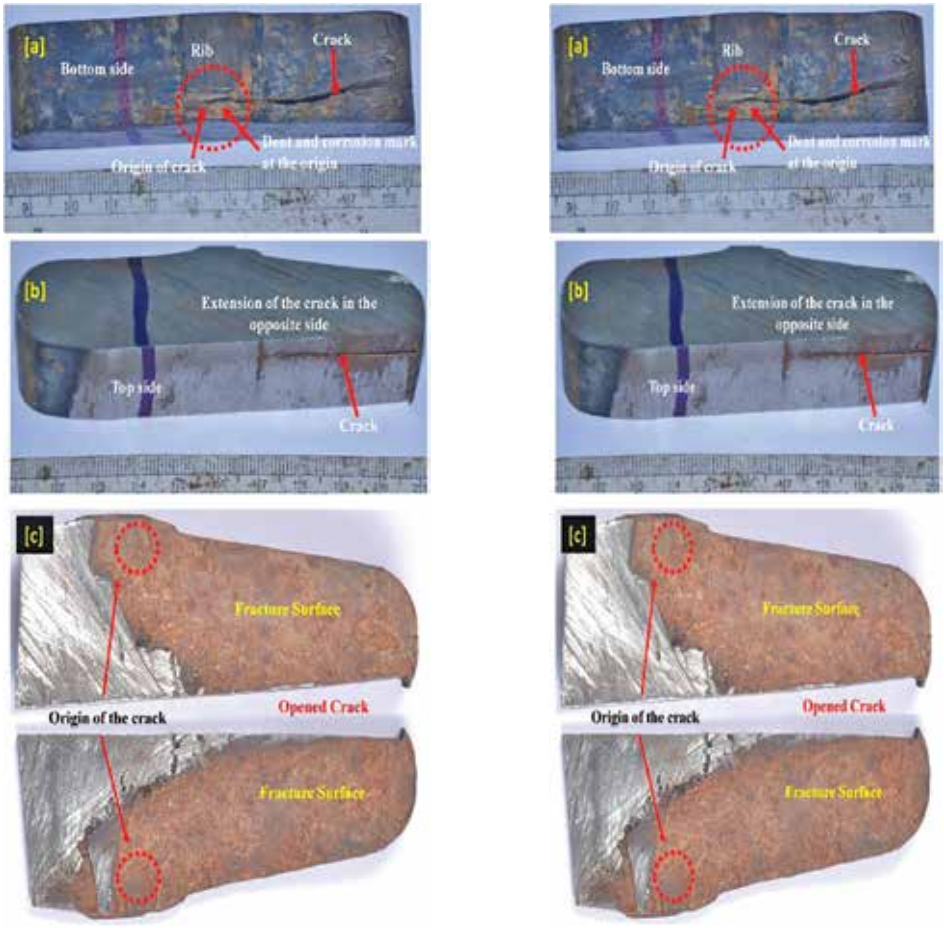


Figure 16: Macrographs of crack in different views: (a) Bottom side view of axle with the crack from the mid rib-showing dent and corrosion, (b) Top side view of axle also showing the crack, (c) Opening up (fracture surfaces) of the crack show corrosion/ oxidation on the fractured surfaces.

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, fluoresant bulb, etc.; and, holistic utilization of red mud (a national mission under the guidance of Niti Ayog where three R&D institute namely CSIR-NML, CSIR-IMMT, JNARDDC and three industries namely NALCO, VEDANTA and HINDALCO are participating).

Currently, 28 scientists are working in this division; four of them are listed in World's top 2% scientist list in their respective domains. 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.

Replacement of Bentonite with Alternative Binder for Iron Ore Pelletization

Bentonite is conventionally used as a binder for iron ore pelletization in steel industries. However, because of its high silica and alumina, it increases slag volume in the downstream process. Replacement of bentonite can be done with some organic binder (OB) that has good strength property. The OB loses its strength at high temperatures, consequently pellets may crumble during induration. Therefore, another additive with the organic binder in minor quantities can be used which provides strength to the pellet at relatively higher temperatures (above 350°C). In this study, some waste material of steel plants have been used to prevent the strength loss at high temperatures. This will give in-situ heat on oxidation and provide diffusion bonding at a lower temperature. The use of steel plant wastes of around 4-5 % in organic bonded pellets showed a considerable improvement in preventing the strength loss at 300 – 400°C, and showed pellet properties comparable with bentonite-bonded pellets. Complete replacement of bentonite without any adverse effect in pellet properties was found.

Upscaling (to 10 tons per day) of Red Mud Containing Geo Polymer Paving Blocks Process

Red mud generated during Bayer's process of alumina production has been a problem for the alumina industry since its inception. Its alkaline

nature and very fine size severely restricts its usage in many applications despite having oxides and hydroxides of Fe, Al and Si with minor quantities of CaO and TiO_2. Continued generation of red mud in large amounts (with no industrial demand) is aggravating the situation. In search of an appropriate solution, CSIR-NML has come up with incorporating red mud in the geopolymer based paving tiles production. Red mud constituents such as Al_2O_3, SiO_2 and caustic soda are desirable for geopolymerisation. This study focused on upscaling the process to 10 ton/day scale. The salient features of the study are as follows: The studies were performed using three different types of red mud from different geographical locations (Belgavi, Karnataka; Muri, Jharkhand; and Raigada, Orissa) differing in chemical composition. Despite the differences in origin and chemical compositions, similar properties of the paving blocks (with each of the red mud) indicated that the process is not sensitive to red mud composition available in India. The studies have revealed that up to 20% fly ash could be replaced by red mud without affecting the target strength of 20 MPa. The TCLP studies (using USEPA 1311 protocol) has shown that the release of all toxic elements are within the limits stipulated by USEPA. Ten tons of pavers of M30 grade made with red mud were laid in the Hindalco premises (Muri), Ranchi. Performance of these pavers under its designed duty and exposed to natural weathering conditions has shown some surface erosion because of efflorescence; however, there has been no strength deterioration. Using certain additives, efflorescence and consequent abrasion arising from unreacted alkali has been minimized. The red mud based geopolymer pavers complies with IS 15658 (2006) pavers. Life cycle analysis of the process based on the data obtained in this study shows that the red mud paving blocks have important environmental advantages; including minimization of natural resource depletion and environmental damages, besides sustainable management of wastes.

To develop an Effective Extraction and Separation Technology to Selectively Extract Rare Earth Elements (Er, Tb, Eu, Pr, Nd, Dy) from Waste Electrical and Electronic Equipment (WEEE)

The demand of rare earth elements is high due to its extensive use in high-end technological applications. However, the primary resources of rare earths are limited and their extraction is associated with many challenges. In view of this, it was proposed to develop an effective extraction and separation process to recover rare earths from waste electrical and electronic equipment (WEEE), mainly, spent NdFeB permanent magnets. This investigation focused on the recovery of rare earths from spent NdFeB magnet with minimum energy and chemical consumption. Three different processes, (a) Oxidation roasting - acid leaching (b) Chlorination roasting - water leaching, and (c) Electrochemical dissolution, have been developed for the recovery of rare earths from spent NdFeB magnets. The process parameters in all the three processes were optimized. High pure mixed rare earth oxides of Neodymium, Praseodymium and Dysprosium have been prepared, and iron oxide (Fe_2O_3) obtained as a by-product. Carbothermic reduction of iron oxide was also carried out to produce metallic iron powder. The products have been characterized by XRD, SEM-EDS and chemical analysis. Figure 1 shows SEM image of mixed rare earth oxide, iron oxide and metallic iron powder produced from spent NdFeB magnet. The solvent extraction studies have also been carried out for the separation of Nd, Pr and Dy from the process liquor of spent NdFeB magnets using Mextral®336At as extractant in the presence of EDTA as a chelating agent.

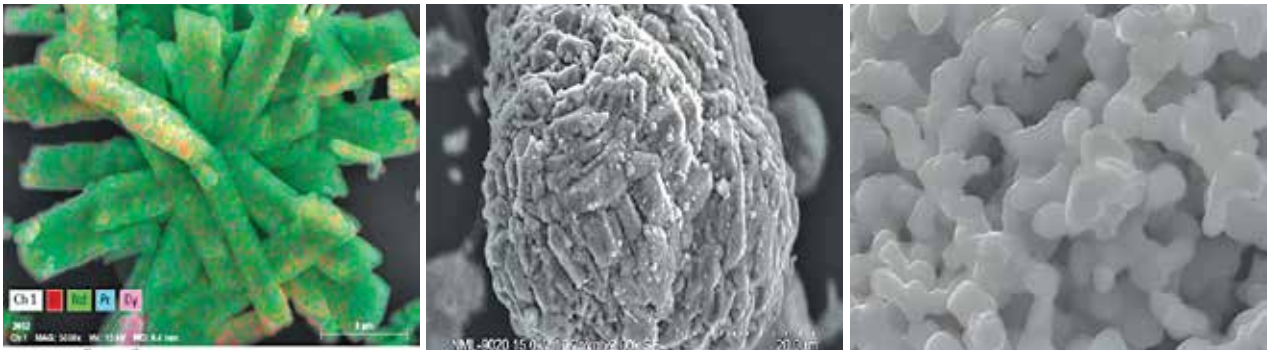


Figure 1: SEM of mixed rare earth oxide, iron oxide and metallic iron powder produced from spent NdFeB magnet

Development of Process for Refining of Commercial Magnesium Metal Through Vacuum Distillation

The objective was to develop a process for refining of commercial magnesium/magnesium scrap to high purity magnesium of more than 99.95% purity, by vacuum distillation in a vacuum distillation apparatus (VDA), designed by NML. High purity magnesium is in great demand in the extraction of titanium. Such high purity magnesium is imported, mostly from China. High purity Mg required in Ti extraction should have more than 99.95% purity, with stringent restrictions on iron (less than 100ppm iron) and aluminum. Furthermore, less than 40ppm aluminum containing high purity magnesium is required in zirconium extraction. High purity magnesium also finds applications in atomic energy, solid-state physics, organic compounds, etc. The refining process parameters such as the vacuum pressure and temperature, time, and, argon flow rate, were studied at a scale of 1.0 – 1.5kg, starting with commercial magnesium containing 99.80% to 99.91% magnesium. The high purity magnesium is directly obtained in ingot form, as shown in Figure 2. The refined high purity magnesium contained ≥99.96% magnesium with the iron content in the range of 20–70 ppm, suitable for titanium extraction. In the refined high purity magnesium, the aluminum content was also low (50–60 ppm) which is very close to the 40 ppm aluminum value required for the zirconium extraction.

Figure 2: Refined ingot of high purity magnesium containing 99.96-99.97%

Development of Innovative Hydrometallurgical process for Extraction of Rare Earth Elements from Metallurgical and Chemical Process Wastes (INNOVA-RARE)

INNOVARARE, an SERB funded project aims to extract Fe, Ti, and REEs from Red Mud and Phosphogypsum, to attain 100% bulk utilization as shown schematically in Figure 3**.** Red Mud (from NALCO) will be processed by multiple routes, like, direct acid leaching, reductive roasting, bioleaching, to sequentially extract REEs (Sc, La, Ce) from Fe and Ti, which end up in the residue, the

latter can be processed by conventional extraction routes. Similarly, Phosphogypsum (from FACT, RCFL) is being processed by acid and biological mediated leaching, to separate MREEs and HREEs from gypsum. The gypsum and silica residue from respective processing of phosphogypsum and red mud will be mixed and converted to hybrid building materials by geopolymerisation.

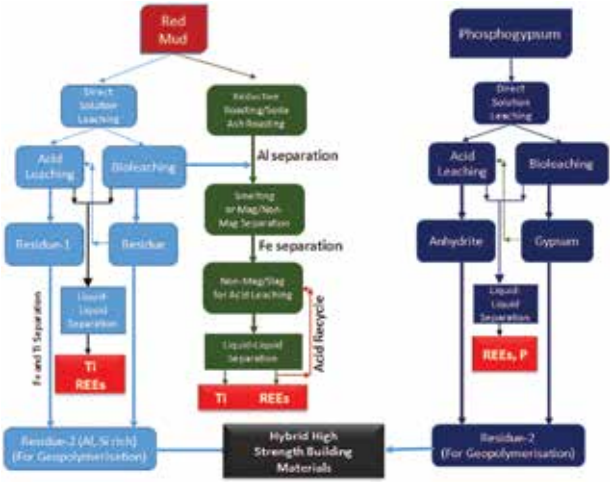


Figure 3: Scheme for extraction of metal values from Red Mud and Phosphogypsum, and comprehensive utilization of the waste

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

Copper slag is a by-product obtained from copper manufacturing through pyrometallurgical process. Globally, for each ton of copper metal produced, about 2.2-3.0 tons of slag is generated, which amounts to approximately 40 million tons of slag generation, annually. India is generating about 1.7 million tons of copper slag annually. A small amount of copper slag is utilized for low-end applications and the rest is dumped. Till date, this slag has been mostly utilized as aggregates for road construction and concrete, and mine backfilling. A few studies highlight its use as supplementary cementitious material after granulating by water quenching. However, its high iron content (~35-60%) and lack of suitable oxide components, limit its utilization in blended cement. Therefore, a process that can address both the recovery of high iron value in the molten stage and modification of the resulting slag by adjusting chemical composition for subsequent use in blended cement, was targeted. Carbothermic smelting of copper slag was carried out using metallurgical coke to remove Fe from FeO-SiO_2-Al_2O_3 slag, and modification of liquid slag composition was carried out using lime (CaO) to create CaO-SiO_2-Al_2O_3, which can be a suitable component for blended cement. Raw or pre-calcined limestone was used as a flux. The smelting of charge mixture was carried out in a 50kVA electric arc furnace at 1500-1600°C temperature, which resulted in the reduction of FeO into pig iron, which accumulated at the bottom due to its inherent high density; and it was tapped from the bottom. The chemical composition of extracted metal was 94-96% Fe, 3.5-5% C, and 0.5-2% Si, which can find application in general usage similar to cast iron. The resulting slag is tapped and subjected to water quenching to get a high reactive glassy material. This modified slag after grinding was mixed with clinker and tested for Portland slag cement composition. The physical properties of the mortar samples meet the Indian standard IS4031:1988.

Production of Fe-Ni/Co-Mo Metallic Alloy & Alumina Rich Slag from Ni-Mo/Co-Mo Spent Catalysts

Globally, about 200,000 metric ton of spent catalysts are being discarded by oil refineries every year (in India about 3000 ton/year), which pose severe environmental challenges; it also provides an opportunity for value harvesting. Spent refinery catalysts contain several critical and strategic metals, such as Mo, Ni, Co, W, etc., in appreciable quantities (total metal content could be as high as 25–30%), and therefore its efficient recycling has many advantages. Imports of ferro-alloys in India

is predominant because of negligible primary ore deposits of the alloying metals (Co, Ni, Mo etc.). Spent oil-refinery catalysts could be treated as rich grade secondary ore for development of indigenous technologies for such metals/materials. The target of this project is to develop a technology, which would be highly competitive and superior to several existing technologies in terms of product(s) grade, cost of production and environmental load. This will promote indigenous ferro-alloy production, and reduce import burden (~few million USD). Recycling technologies based on hydrometallurgy lack in complete recycling of spent refinery catalysts, while the smelting based technologies generate slag, which finds little utility, and are dumped. This technology addresses these issues through appropriate raw materials blending with careful choice of fluxes, by carbothermic smelting of spent catalysts followed by post processing steps to produce saleable ferro-alloys (Fe-Ni-Co-Mo) for special grades of stainless steel, and calcium aluminate slag suitable for construction/refractory industries. This project has developed a technology at 100 kg scale and tested its suitability with variety of spent refinery catalysts (Figure 4**)**. A few industries have shown their interests on the bench scale know-how, and scale-up studies, and licensing is being explored.

Figure 4: Spent catalysts used for production of ferro-alloy

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, and reduce 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, namely, 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 5 shows the EDS spectra acquired across a line for a hybridized geopolymer along with corresponding elemental distribution profiles. Similar distribution profiles of C, Si and Al in the geopolymer gel illustrates the simultaneous presence of the inorganic and organic phases, which substantiates the occurrence of 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. Fire resistance studies of the products developed are being carried out.

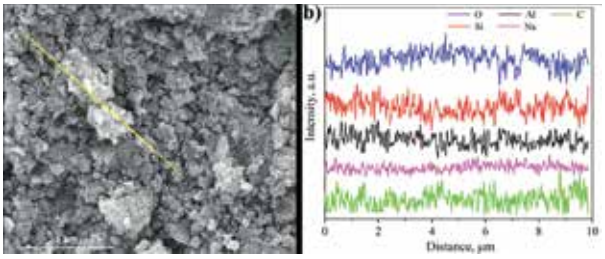


Figure 5: SEM-EDS of the hybrid geopolymer depicting individual elemental distribution profiles across the line.

Extraction of Rare Earth Elements from Granulated Blast Furnace Slag and Evaluation of Treated Material for Possible Applications

This project funded by a steel major aimed to extract REEs from ground granulated blast furnace slag (GGBFS), efficient purification to yield selective REE oxides, followed by complete utilization of metal depleted residue. The GGBFS sample contained REEs, especially Ce (157 ppm) and La (90 ppm). Leaching with HCl was followed by selective separation of REEs from gangue. Using a new solvent extraction reagent, it was possible to successfully recover La, Ce, and Nd in the range of 98-99% with lower (<4%) extraction of Al. The stripped REEs was further processed by precipitation and a second stage solvent extraction to yield 98% Ce product, and 96.8% pure La oxide. The chemically leached and REE depleted slag was processed to form a concrete sample using 40 wt% residue and possessed 30 MPa strength. The process (Figure 6) has been filed for patent jointly with the steel major.

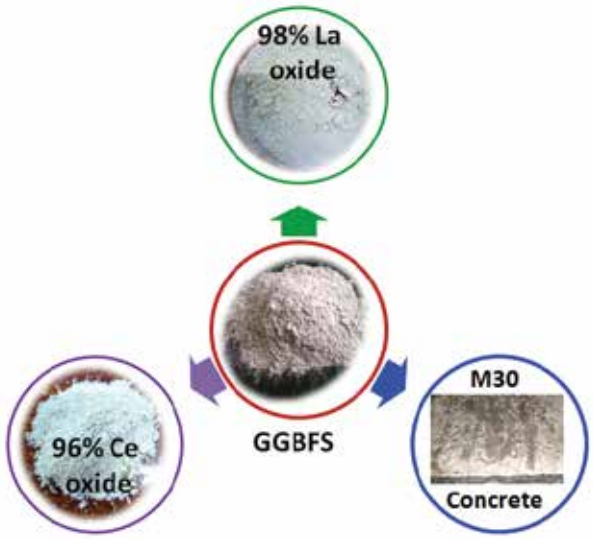


Figure 6: Process for extraction of REEs (La, Ce, Nd) from ground granulated blast furnace slag

Product Development from Waste Alumino-Silicate Fiber Material

Integrated steel plants are using different types of refractory materials for lining of different high temperature furnaces, ladles, vessels, etc. Alumino-silicate based fiber is one such refractory material, which has high temperature insulation properties. It is used in different forms such as board, furnace module, ceramic blanket, mineral wool, etc. Its

disposal, after end of life, is a concern, as it is a health hazard, besides being very light weight (thus occupying large space). Presently, the discard has no value nor application. At the behest of the sponsor, the disposal management is being addressed by CSIR-NML. This waste has been characterized and explored for different applications, and its chemical composition was found to be suitable for refractory applications. It has been explored for development of lightweight porous board/block for insulating applications using a novel geopolymer process at room temperature. Certain percentage of clay (alumino-silicate) in combination with Al powder is used for generation of pores during geopolymerization (Figure 7). Characteristics of the developed brick, such as thermal conductivity (one of the critical characteristic for insulation application) are promising. However, shrinkage after firing is excessive and physical damages (cracks) are developed on the surface, which are the drawbacks of this process for utilization of such waste fiber.

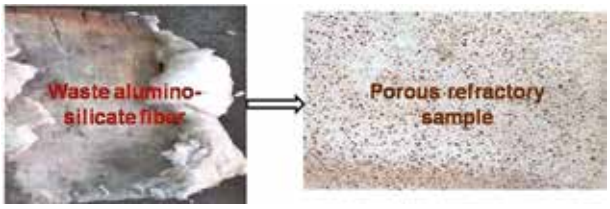


Figure 7: Photograph of clay (alumino-silicate) in combination with Al powder generated porous refractories

Development of Briquetting Technique for Utilization of Steel Plant Solid Waste

Several fines such as Basic Oxygen Furnace (BOF) sludge, Blast Furnace (BF) sludge, Electro Static Precipitator (ESP) dust, sinter returns, BF flue dust, etc., are generated in different units of steel plants, which have a substantial quantity of iron oxide. A major portion of these fines remains unused. These fines can be used as a coolant in BOF converter if agglomerated properly. The present study aims to utilize these fines in BOF after making briquettes. The process parameters for good quality briquettes have been optimized at a laboratory scale. The mix ratio, suitable binder, binder quantity, etc., have been optimized, and finally, cylindrical briquettes have been developed, 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 will be used for plant trial in a BOF of 100-ton capacity to assess its performance.

Feasibility study for Optimisation of Reductant Blend to Partially Replace Metallurgical Coke for Production of Ferro-Chrome

Smelting reduction of chromite ore in Submerged Arc Furnace (SAF) is a well-established process for production of ferrochrome utilizing nut coke as a reductant. Due to gradual escalation of nut coke price, several industries find it techno-economically unviable. In the recent past, attempts by CSIR-NML for production of ferro-chrome in different Cr/ Fe ratios using chromite ores, yielded very good results. A few attempts were made to partially replace the nut coke by conventional coking coal or its briquettes, but did not succeed due to lack of scientific understanding. In view of this, CSIR-NML is exploring the process feasibility for optimum replacement of nut coke/ metallurgical coal by lean grade/ anthracite coal briquettes. CSIR-NML has received 50 tons of chromite ore briquettes and 12 tons of coal briquettes containing different percentages of anthracite coal from Bhadrak, Odisha, to carry out the investigation for optimum replacement of metallurgical coke. Characterization of chromite ore briquettes, coal briquettes and flux are completed.

Smelting of Vanadium pentoxide for preparation of Ferro-Vanadium (FeV)

Pyro- & Hydro-Metallurgical Processing of Coke Cinder for Production of High Pure Fe-V

Ferro-vanadium is an important ingredient for specialty steel production. Indigenous production is not sufficient to meet Indian demands; the balance is imported from China, Japan, and Korea. Indigenous vanadium resources are extremely limited and it is mainly produced as a by-product from bauxite and titania refining. Significant amount of vanadium (up to 10 weight percentage) is often present in coal/coke and/or their burnt products such as fly ash, cinders, etc. Till date, these resources are mostly un-tapped.

An Indian multinational is setting up a large coal gasification unit. This plant would generate about 200 – 250 kilo ton of gasification cinders annually, which contain 2 – 6 % V, 0.5 – 1.2% Ni, and 10- 15% Al. The company has developed an in-house bench scale process flow sheet for extraction of V and Ni as ammonium meta-vanadate (AMV) and nickel carbonates from the pet coke cinders through a roasting – leaching–purification – precipitation process. The company in collaboration with NML, is upscaling the bench scale process flow-sheet up to 100 Kg/h roasting and 250 Kg/batch scale leaching – purification. Till date, three large-scale pilot plant campaigns have been completed successfully with the production of more than 100 Kg of iron-vanadate ($FeO.V_2O_5$) and about 140 Kg of AMV. Under another activity, the process of producing low carbon Fe-V has been developed using commercial grade V_2O_5 through an aluminothermic process. Process parameters have been optimized. 88% recovery of vanadium has been achieved as a precursor to prepare a Fe-V alloy containing more than 85% V. The process flow, input and the product obtained is given in Figure 8. At the next step, Fe-V will be produced from V_2O_5 or $FeO-V_2O_5$ produced at NML.

Coke-cinder

$FeO.V_2O_5$ Produced in Pilot Plant

Aluminothermic reaction

Figure 8: Process Flow-Sheet for Production of AMV and $FeO.V_2O_5$, the inputs and products

Mineral Processing

Mineral Processing (MNP) Division of CSIR-NML has been engaged in R & D in characterization, beneficiation and agglomeration of ores and mineral fines. The Mineral Processing Division comprising of Characterization, Beneficiation and Agglomeration facilities has been around since the inception of CSIR- National Metallurgical Laboratory (NML) in 1950. An integrated mineral beneficiation pilot plant was installed in 1962 to study the feasibility of commercial exploitation of the technologies, process flowsheets and products, developed in the laboratory. The division is well equipped to carry out planned research and development work on all types of ores and minerals for their utilization and conservation.

Working closely with industry partners, MNP Division has been continually working with innovative mineral processing methodologies and has augmented advanced facilities leading to the state-of-art technologies in the management of mineral resource base, enhancing productivity with sustainable environmental compliance. Expertise has been developed for new efficient processing options for beneficiation of strategic and non-strategic minerals such as ferrous, non-ferrous, industrial minerals and coals (coking and non-coking) through the design and optimization of processes. It has created confidence in the industry towards developing technology for converting wastes to resources.

Based on the technical know-how provided by CSIR-NML a number of commercial beneficiation and agglomeration plants have been commissioned in the public and private sectors, and it has contributed significantly to the development of mineral based industries. In addition to catering to the needs of mineral processing industry in India, CSIR-NML has maintained a strong international presence in mineral processing and has successfully executed a number of projects on samples of foreign origin from Asia, South-Asia, Middle East, Africa and Europe. Presently, the Mineral Processing Division is focusing on Fine particle processing, Dry beneficiation, Mathematical modeling and simulation, Plant performance auditing and improvement, and Equipment development. The research and developments carried out during the reporting year is presented below

Studies on Beneficiation of Bauxite Sample for Reduction of Reactive Silica

The principal ore of aluminum, which is the third most abundant element available in the earth's crust, is bauxite ($Al_2O_3.2H_2O$). It is also an essential ore for refractory and chemical industries. India has superior quality bauxite ore deposits (3.896 billion tons) as against world reserve (30 billion tons). The world production of bauxite was estimated at 326 million tons in 2018. Australia continued to be the major producer and accounted for about 29% share in total production, followed by China (19%), Guinea (18%), Brazil (10%) and India (7%). Good grade bauxites are depleting fast and the available bauxite contains significant amounts of reactive silica, although they contain fair amount of aluminum in them. Under the present investigation, studies were undertaken on processing of bauxite samples sourced from Chhattisgarh region for possible reduction of reactive silica to ~4% from a feed containing high reactive silica ranging from ~6-11.5%. Characterization of the bauxite ore revealed that the sample exhibits various types of textures, like, oolitic, colloform and replacement. The samples contained abundant gibbsite and boehmite, followed by clay, altered/translucent silicate and opaque minerals (Fe-oxides /hydroxides) and anatase. The beneficiation study

included scrubbing and washing, gravity separation, magnetic separation and froth flotation. Scrubbing and washing studies demonstrated that there is significant reduction in reactive silica content (to ~2%) with increase in total available alumina content in the washed product. The reduction in reactive silica in the washed product is possible because of the removal of the fine particles, which contains significant proportion of reactive silica in them. Process technologies/ flowsheets have been developed for low-grade bauxite samples obtained from different mines of Chhattisgarh region.

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. As a result, the white cement industry is facing an acute shortage of cement making raw material. To prepare clinker for white cement, it is necessary to minimize the extent of iron and other transition elements (titanium, chromium, manganese, nickel and zinc) in the raw mix composition. High-grade limestone containing less than 0.068% Fe_2O_3 and less than 0.015% MnO is generally required for white cement. Limestone deposits in the sponsor's mines is highly associated with lateritic coating. The iron in laterite adversely affects the white cement quality. Hence, detailed exploration of limestone deposits to convert the resources to reserves, and development of a cost effective dry beneficiation technique for up gradation of the low and sub-marginal grade limestone, is required. The current studies will explore the possibility of reduction of iron from 1.5% to 0.08% Fe_2O_3 for rejected limestone sample and 0.2% to 0.08% for regular limestone. Attempt was made to reduce the transition elements content from limestone to improve the clinker quality. Based on characterization and liberation study, the beneficiation of limestone through dry magnetic separation and Air table for the separation of contaminants from limestone, was explored. In addition, a beneficiation process for reduction of impurities present in rejected limestone sample at the mining site was developed.

Development of Dry Beneficiation Process Technology for Low-Grade Iron Ore for Iron and Steel Making

Wet Processing is a general practice for beneficiation of iron ore. Although wet processing is efficient in beneficiation of iron ore, it consumes large amounts of water. About one cubic meter of water is required to process one ton of iron ore at various stages of wet processing. Water is becoming a scarce commodity and in many regions, there is no availability of water for industrial applications. Rejects from wet processing are in the form of slurry containing fines, which cause environmental pollution. Dewatering of fines is a costly proposition. Dry beneficiation could be one of the feasible techniques, which can resolve the above problems. The current project aims to develop a dry beneficiation process technology for iron ore to produce sinter and pellet feed concentrates. Due to the unavailability of dry density separator technology for iron ore, the project aims at developing laboratory-scale dry density separators. As a part of the project, two indigenous dry separators at laboratory scales were fabricated: 1) Air pulsated stratifier 2) Terminal velocity separator. Iron ore with size range -20mm to +6mm was processed in the air pulsated stratifier, and ores with size range -3mm to +1mm was processed in the terminal velocity separator. 2-3% enhancement of Fe content with iron ore feed having Fe content of 59.5-60% was obtained in a single stage operation of the air pulsated stratifier (Figure 1). Similarly, in the terminal velocity separator, iron ore Fe content was enhanced by 2% in a single stage operation.

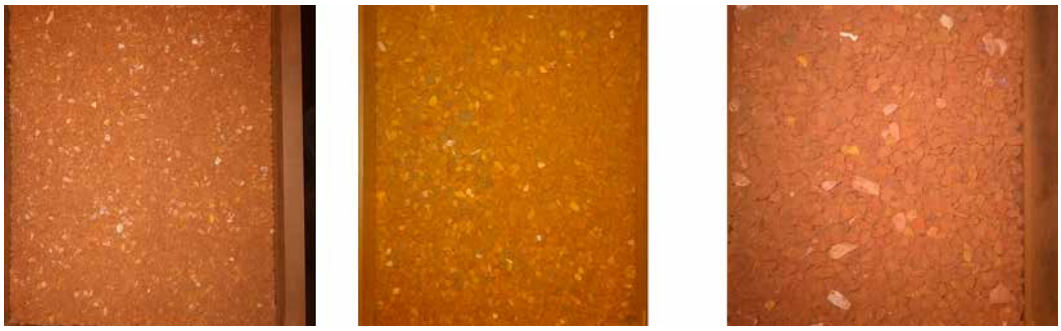


Figure 1: Top-layer after dry processing of iron ore in air pulsated stratifier

Continuous Pilot Scale Reverse Flotation of Iron Ore

The increase in production of iron metal in recent times consumes large amounts 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 low-grade ores comprise hematite, goethite (iron minerals) along with kaolinite and 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 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) obtained in an earlier project carried out at CSIR-NML, continuous pilot scale flotation of 15 tons of de-slimed product of iron ore slime was conducted, and it validated the bench scale results (Figure 2).

Figure 2: Pilot Scale Processing of Iron Ore Slime

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

Coking coal is a scarce commodity in India. Its reserve is about 10.8% of the total world reserves of around 320 Billion tons. The demand of coking coal in steel sector is increasing gradually due to the expansion of existing steel plants and addition of Greenfield projects in the country. Meeting the demand of quality coking coal to steel plants is a great challenge. Indian coking coals are characterized by high ash owing to their drift origin. The coking properties of indigenous coals are considerably inferior. Only 15% of India's coking coal requirements are met through indigenous supply; imported coking coals are blended with the indigenous coal. India imported 51.29 million tons of coking coal in 2020-21. Presently, the quality of coking coal treated for processing is deteriorating progressively due to the depletion of the good grade reserves. From the Indian coal washeries of coking coal, usually three types of products are obtained –clean coal, middling and reject. It is found that because of gradual depletion of the high grade raw coal, the generation of middling is increasing progressively, while the yield of clean coal is decreasing in the washeries. The middlings generated from the coking coal washeries are used presently for power generation. It contains a good amount of carbon values, which can be recovered. This substantial

amount of middlings can be an excellent potential source of coking coal. The coking coal resources can be conserved by recovering extra low ash coking coal from the washery middlings by suitable beneficiation processes. Keeping in view the above, a project has been undertaken to develop a suitable process for gainful utilization of the middlings of the coking coal washeries towards the enhancement of the carbon recovery for coke making.

Processing of Hydrocyclone Underflow for Recovery of Silver

A Lead-Zinc ore Concentrater plant of capacity 3.0MTPA is being operated by the sponsor of this investigation. The process route basically involves size reduction, differential flotation for separation of lead and zinc concentrate followed by dewatering of products. Preliminary studies conducted at the sponsor's end indicates the possibility of recovering the silver metal values from the hydrocyclone underflow streams of grinding circuit by using potential enhanced gravity separators.

NML undertook the investigation to find the possibility of recovering silver from the *hydrocyclone underflow of the* Lead-Zinc beneficiation plant using enhanced gravity separator. The *plant tailing consists of 179 ppm of silver. Bench scale experiments were carried out using a Falcon concentrator. Initial experimental results indicate the prospect of upgradation of Ag-metal recovery from the tailing (Figure 3). Detailed study is in progress.*

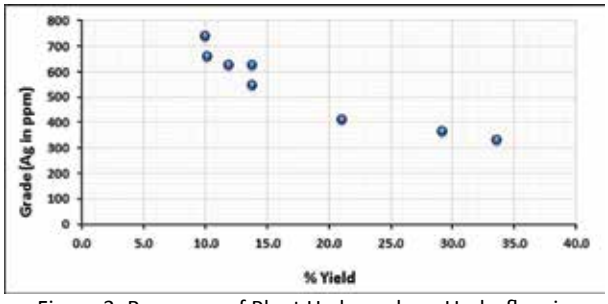


Figure 3: Response of Plant Hydrocyclone Underflow in Enhanced Gravity Separator.

Studies on Processing of Iron ore Sample for Beneficiation Plant

The sponsor of this project was interested to understand the amenability to beneficiation of iron ore sample for their beneficiation plant. The ROM iron ore sample was characterized and upgraded to pellet grade concentrate by desliming followed by magnetic separation. Processing of iron ore sample was done using hydrocyclone and high intensity magnetic separation (WHIMS). The as-received sample was assayed at 61.60% Fe, 2.72% Al_2O_3, 5.70% SiO_2, and 2.87% LOI. The mineralogical study of the sample revealed that the iron ore consists of a substantial amount of goethite and hematite. In coarser fractions, most of the hematite is interlocked with goethite and clay minerals. Liberation studies were carried out by modal analysis on different size classes using zoom stereomicroscope, which indicated that the interlocking of gangue and ore minerals persists and is significant in coarser fractions. Around 88% liberation of different mineral phases is expected below 0.15 mm. Detailed comminution studies were carried out to achieve the desired particle granulometry. The ground product was processed through hydrocyclone followed by WHIMS to assess the metallurgical performance of the unit operation for the processing of iron ore from the sponsor's stock. Significant variation in concentrate yield (53-63 wt.%) was observed with 64-66 % iron content. Considering the desirable particle granulometry, around 66-67% by weight (magnetic and middling product) pellet grade material was produced with an iron content of around 63.5%.

A Study on Hydrodynamics Characteristics in Separation of Minerals in a Monolithic Flotation Column

Flotation is one of the most used beneficiation process for separation of valuable minerals from

waste gangue minerals based on the difference in the surface properties of the minerals. Slurry columns are mostly used in the separation of three-phase processes due to their simple construction, high efficiency, low maintenance and operating costs. As time passed, new reagents were developed, and many mechanical arrangements of equipment were also changed and beneficiation problems of finer size particles were minimized. It brought great advantages to the mineral beneficiation industries. The hydrodynamic study in a flotation column is one of the important parameters that not only helps in understanding the performance, control, modelling, design, and optimization of the equipment, but also provides techniques for improving the separation process. Many studies on hydrodynamics characteristics have been carried out in cylindrical and rectangular flotation columns but their complexity pose great difficulty in understanding the complete behavior. Back-mixing is a prime factor in a conventional flotation column. Many industrial flotation columns could not achieve the targeted products and there has been low separation performance due to the low interfacial area, short residence time of gas bubbles, channeling, uneven flow pattern, entrainment and non-homogeneous bubble size and its distribution. To investigate these problems, a monolithic flotation column will be developed. The column will be made of transparent cylindrical Perspex, and inside the cylindrical column, the channels will be made using transparent Perspex. This column may eliminate or reduce the back-mixing in the gas and liquid phase, reduce channeling, reduce entrainment, provide homogeneous bubble size distribution, low coalescence rate, and high residence time. Knowledge of flow regime and gas holdup characteristics of the system will be helpful in the improvement of a flotation column performance by reducing pressure fluctuation, by directing transport processes, and by volume production.

Characterization of Microbubbles and its Subsequent Application in fine Particle Separation

Depletion of high-grade resources has necessitated the use of low-grade fines. These materials are fairly liberated and contain good amount of mineral values. Froth flotation is a physico-chemical surface-based process and is an established technique. Froth flotation involves several phases (particles, oil droplets, and air bubbles). The particle size plays a significant role in froth flotation. The fine-to-ultrafine particles are difficult to float by a conventional flotation cell, which generates larger size bubbles and is not effective for recovery of fines. As a result, the separation efficiency decreases. Flotation study with the microbubbles could show promising results of overcoming this difficulty. In this research, a flotation column fitted with microbubble generator was used to characterize the microbubbles and its subsequent effect on separation, i.e., adsorption of microbubbles by coal particles. Microbubbles of average size 67 microns could be produced (Figure 4). It shows promising results by overcoming the above-mentioned difficulties. The results of microbubble flotation are compared with those of conventional flotation cell. Two types of coal were used; first one was coking coal (Sample-A) and the other was non-coking coal (Sample-B). The representative samples were characterized, which included proximate analysis (Volatile Matter VM%, Fixed Carbon FC%, Ash% and Moisture %), ultimate analysis (Carbon%, Hydrogen%, Oxygen%, Nitrogen%, and Sulphur%), and gross calorific value estimations. The petrographic and geochemical analyses was done for both the samples. Microscopic studies for sample A showed that the coal sample was mainly dominated by argillaceous mineral matter dispersed

mostly in the coaly matrix. This type of distribution of mineral matter creates problem during the flotation of coal fines. To obtain best productivity of clean coal, it is essential to optimize reagent dosages. Open cycle batch flotation test work was carried with -0.5mm coal sample in a Denver flotation cell. Pine oil (2% strength) with dosages varying from 500-1500 gpt was used as a frother cum collector in all the test works for sample A. Pulp density was varied between 6 to 15% solid (w/w). Minimum ash of 13.07% was obtained at collector dosage of 500 gpt, but yield at this level was found to be low. For 19% ash the best yield obtained was at collector dosage of 1000 gpt. Therefore, further experiments in the flotation column was done at 1000 gpt of pine oil with variation of airflow rate and changing other parameters. It was found that with increase in airflow rate the yield increased to 57% with 20% ash at the same operating condition.

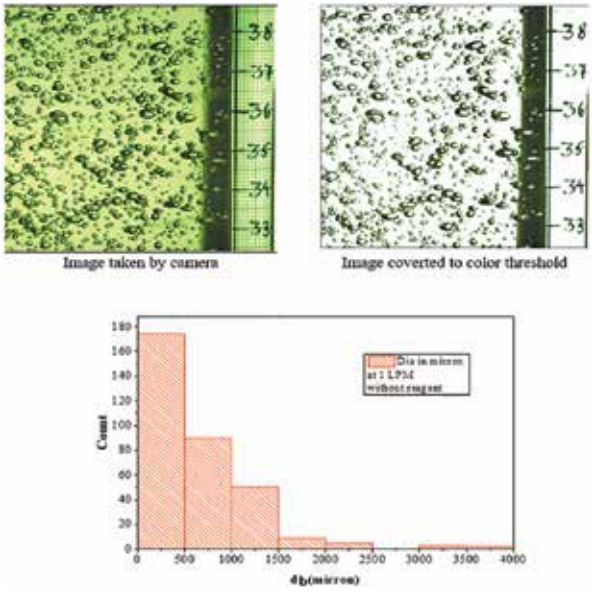


Figure 4: Bubble Size Distribution for Transparent Column Cross-Sections, Corresponding to Top Length.

Evaluation of Binder Properties for Pelletization

CSIR-National Metallurgical Laboratory Jamshedpur has been engaged in development of bench scale as well as pilot plant scale pelletisation technology for Indian hematite/goethitic/magnetite ore with varying degree of fineness. It has also engaged in evaluation of binder properties for pellet making. In connection with this CSIR-NML have evaluated the properties of newly developed organic binder for iron ore pellets. Efficacy of binder was evaluated based on characterization of the green and fired pellets (Figure 11), such as GCS, CCS, Drop number and Porosity. It was observed that impact of organic binder on pellet strength is very high and around 600 CCS was achieved by using the organic binder, but it has negatively affected the porosity and drop number.

Figure 5: Indurated Iron Ore Pellet Using Organic Binder

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.

Feasibility Studies on Flotation of High-Magnesia Limestone from Maharashtra And High-Silica Limestone from Rajasthan

The Cement Division of a multinational awarded two projects for beneficiation of limestone for reduction of SiO2 and MgO from two different locations. The feasibility study on beneficiation of high-magnesia limestone of sponsor, sourced from Maharashtra was studied by flotation. The objective of this project work was to obtain a concentrate with less than 3% MgO with optimum recovery from a high-magnesia low-grade limestone analysing 43.46% CaO, 7.50% SiO2 6.54% MgO (Figure 1). The process optimization for MgO reduction is being carried out. The work involves initial sample preparation and characterization of the low-grade limestone followed by process methodology planning, execution by experimental studies, and process optimization for silica reduction.

The second project was on limestone sourced from Chanderia, Rajasthan analysing 42.64% CaO, 16.15% SiO2 & 1.20% MgO (Figure 2), for the reduction of SiO2 and improving the CaO content in two different grades namely, sweetener grade (CaO ≥ 50% & SiO2 < 5%) and cement grade (CaO ≥ 43% & SiO2: 10 to 12%). A concentrate of 44.96% CaO, 10.26% SiO2 with 76.83% recovery for the cement grade, and 48.84% CaO, 5.64% SiO2 with recovery of 43.76% for the sweetener grade, could be achieved by flotation using eco-friendly collector.

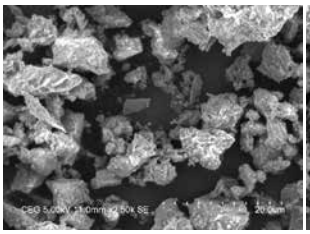


Figure 1: SEM image of high-magnesia limestone

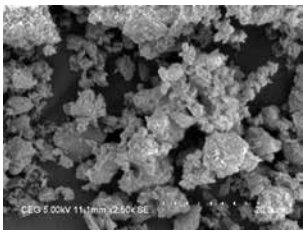


Figure 2: SEM image of high-silica limestone

Commercialization of Column Flotation Technology

Towards further commercialization of the NML Column flotation technology along with sustainable development, natural based eco-friendly flotation reagents were used for low-grade limestone beneficiation. The process was successfully demonstrated on a 25 tonnes per day capacity pilot plant scale flotation column (Figure 3) at the site of the sponsor in Telangana, leading to substantial reduction of silica in the low-grade limestone.

Figure 3: 0.5m diameter Pilot plant scale flotation column

Plans for Commercialization of Column Flotation Technology

On successful completion of laboratory R&D studies, on-site Pilot plant scale column flotation studies on the recovery of carbon from cinder and other materials from a large oil refinery is likely to be taken up. Similarly, installation of commercial scale flotation columns for the recovery of carbon from steel plant sludge of a steel major is being contemplated.

Recognition of CSIR-NML Column Flotation Technology

The CSIR-NML successes in column flotation were recognized by CSIR as one of the success stories of CSIR. A webinar to celebrate the success was organized on December 16, 2021 (Figure 4). The webinar was quite popular and was attended by researchers, students and stakeholders.

Figure 4: Webinar on Column Flotation held under the banner of "CSIR at 80: Success Stories"

Development and Commercialization of Eco-Friendly Flotation Reagents

For the last two decades, CSIR-NML Madras Centre has been in the arena of developing and commercialization of flotation reagents in collaboration with various reagents manufacturers. Laboratory scale studies using the developed reagents showed promising and better results in comparison to those being presently used in the mineral processing industry. To validate the laboratory scale results at commercial scale, field trials at pilot plant scales and at commercial scales were planned with an objective of commercializing the developed flotation reagents. In this context, a pilot plant and commercial plant scale flotation studies, using newly developed eco-friendly reagents, for low-grade limestone beneficiation and recovery of sillimanite from heavy mineral beach sand were initiated. Commercial scale demonstration and the technology for utilizing the newly developed reagent for sillimanite recovery was showcased in the successfully commissioned CSIR-NML flotation Column (2019) of 120 tonnes per day throughput capacity at a commercial plant. CSIR-NML Madras Centre is also focussing on evaluation of the performance efficacy of the newly developed natural product-based reagents on limestone sourced from various locations. On similar lines, low-grade Goan iron ore beneficiation by flotation using newly developed reagents is being studied.

Detailed Project Report Preparation

A state PSU awarded CSIR-NML with the task of Preparation of two Detailed Project Reports, on Wet Concentration Plant up-gradation and separating sillimanite-rich fraction from Wet Concentration Plant; and, for modernization and improving mineral recovery in Mineral Separation Plant. Both the DPRs are under preparation.

Metallurgical Failure Investigation of Boiler Tubes of Captive Thermal Power Plants

Metallurgical failure analysis of boiler tubes of a captive thermal power plant of the sponsor was carried out (Figure 5). Various metallurgical characterisation techniques like Optical

microscopy, Scanning Electron Microscopy and Energy Dispersive Spectroscopy were used for detailed analysis. Based on the results obtained, it was concluded that the waterside of the tubes underwent uniform corrosion to depths of 0.1-0.15 mm from the surface. The firesides of the tubes suffered localised corrosion and the damage progressed up to 0.15 - 0.2 mm depth. 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 is observed on the waterside of the tube surface.

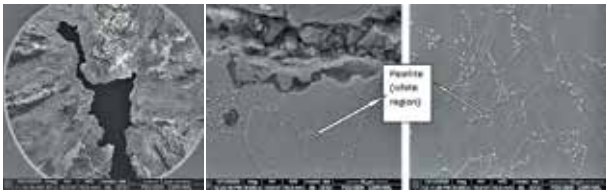


Figure 5: Fracture surface; pearlite depletion near crack tip due to overheating.

Management/Utilization of Metallurgical Wastes

Processing plant tailings and sludge from steel plants contain solids in water, which can contaminate soil and water supplies resulting in environmental damage. However, these solids suspended in water (sludge) still contain valuable minerals, which can be recovered for primary and secondary usage, as a step towards Waste-to-Wealth management. To address this issue, a neural network-based sensitivity analysis and performance optimization of carbon recovery from Blast furnace and Corex plant sludge of a steel major, using froth flotation, was taken up. Carbon in the sludge from Blast furnaces and Corex plants of the steel major was present in the range of 18%-25%. The objective of the investigation was to recover maximum carbon by flotation, process optimization, and, ANN-based sensitivity analysis for determination of the order of significance of input variables. A laboratory-developed reagent was used for the recovery of carbon. The recovered carbon can be utilized to supplement the carbon requirement for iron making. Feed sample was characterized using XRD, FTIR spectroscopy and SEM analyses to elucidate information on the mineralogical aspects of the sample quantitatively and qualitatively. The different collectors used in these experiments were Diesel oil, Kerosene oil and laboratory synthesized environmental friendly reagents FBD, PBD and SBD. MIBC was used as a frother. Assay analysis of concentrates and tailings obtained in preliminary experiments showed the best result in case of PBD as collector. Statistical experimental designs have been used to determine the relationship between the response functions (carbon grade and carbon recovery) and variables (collector dosage, frother dosage and cell rpm). Carbon recovery of 54.79% was obtained at cell rpm of 1200, frother dosage of 48 gpt and collector dosage of 430 gpt. Encouraged by the successful demonstration, the management of the steel major is interested in adopting this technology at commercial scale to recover carbon from the steel plant sludge.

Team-CSIR-NML Madras Centre

Medicine

LATA DESAI

DOCTOR & SOCIAL WORKER (Gujarat)

Doctor and Social Worker-providing health services to rural and tribal communities in Gujarat for over 5 decades

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Planning and Business Development

The division is engaged in a variety of activities like Business Development & Client Interfacing, Research Management, Information Systems & Database Management, Negotiations & Contracts, IP Services and Technology Marketing. The Division interacts dynamically with internal as well as external stakeholders to perform its various functions.

Research Management

RPBD has a role to play in all stages of R&D project execution as shown in Figure 1. In the reporting year, the Division was able to bring 14 new customers for the Lab., drafted 48 agreements (including one international agreement), and executed two bonds. In the same period, more than 58 new projects were evaluated for their compliance to the CSIR guidelines. The division also generated and sent 1041 invoices to customers for payments. The division has systemized the collection and distribution of project reports to the customers. Ten Customer Satisfaction Evaluation Feedbacks (with an average CSE Index of 4.9 (out of 5.0)) were also received by the Division.

Figure 1: Role of RPBD in Project Life Cycle

Business Development & Client Interfacing

The Division is the first point of contact for the new clients and sponsors seeking solutions for their R&D problems. The Division establishes the connection of the clients with the relevant technical experts. Any formalities to firm up the association is also taken up. The Division shoulders the responsibility of negotiating with the prospective customer on the terms of collaborations including financial and intellectual property terms. In the reporting year, 48 MoUs were drafted and 21 MoUs were finally executed. Figure 2 provides a representation of agreements negotiated.

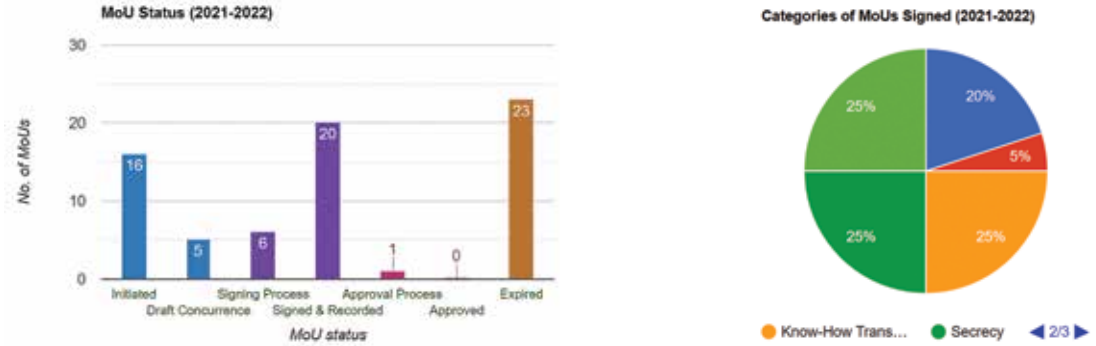


Figure 2: Agreements in 2021-22

The division also brings new projects by participating in the Tendering processes of various sponsors. In the reporting year **39** tenders were proffered by the Division, through which **20** projects were awarded to the Lab. A few of the successful bids tendered were to Tata Steel, Tata Power, ISRO (Vikram Sarabhai), Indian Air Force, Krishank Bharti Corporation, JSW Steel Ltd, Tata Sponge and Kerala Minerals Metals Ltd.

Procurement of Intangible Assets

As per the new CSIR Purchase procedure 2019, the procurement of intangible products has become the responsibility of the RPBD. An SOP for the same has been developed and is in use with effect from 15th January, 2020. A number of work orders for intangible products have been placed including those requiring IP inputs from the laboratory.

Information Systems & Databases

A number of web based information systems and related databases are continually developed and maintained in-house at CSIR-NML for the digital inclusion and efficient overall functioning of the laboratory. These e-information systems and databases provide input for managerial decision making by enabling a number of e-processes which are shown in Figure 3.

Figure 3: E-Information Management in key functional areas of laboratory

A few of the e-information management systems developed during the reporting year are indicated below:

i. **Development of e-Information Management System for MoUs to enable online MoU Creation and Real Time Access to all Information and Communications**

MoUs are the legal documents that are of confidential nature and contains terms and conditions for undertaking/executing any contract work. The new information system enabled an online repository

of all such contract documents and related data. The new system also enabled online MoU document creation, editing and recording, as well as tracking the status of MoUs. With around 50-70 MoUs being drafted every year, some of them involving multiple parties, the new information management system will efficiently capture all details at all stages (status updates) and real time access to the current information will be available.

ii. Development of a Tender Management System

The R&D Tender Management is an intranet based system and was launched in January 2022. This website provides details of the RFQs and research and testing tenders floated by various government as well as private organizations. During Jan-Mar, 2022, 17 bids were uploaded by the division and we have been awarded 6 work orders from different organizations.

Some of the websites developed are shown in Figure 4.

MoU Management System Website	Website for Managing the Symposium on Fatigue, Fracture and Integrity Assessment (FFIA)	Tender Management Website

Figure 4: Websites developed by RPBD

Interactions with and enablement of Internal Stakeholders

The division has developed, and maintains a number of databases that enables the division to have quick access on a variety of data pertinent to research activities, such as, *Projects, Manpower, External Cash flow, Intellectual Property, Agreements, etc*. Throughout the year, RPBD prepares and sends a variety of reports, some of which are periodic in nature, to the internal and external entities. The important ones include *Key Performance Indicator (KPI) Document, PMO Portal Data, Research Utilization Data, Monthly Reports, Quarterly Reports, Annual Plan Document, Replies to PMO & Parliament Queries, etc.*

Institutional Publications

RPBD publishes monthly newsletters about the significant activities of the laboratory. The publication of the Annual Report is also coordinated by the division jointly with the Knowledge Resource & Information Technology Division of the laboratory. Additionally, the RC Agenda, Technology Handbook, Director's Desk and Equipment Brochure, are also published by the division.

IP Services

Business Development group provides IP search and analysis services to external clients as well as to internal users especially to those involved in new technology or process development. The scope and capability of the division in these areas is indicated in Figure 5. During 2021-22 the division provided (i) IP search and Analysis, (ii) Evaluation of FTO Space, (iii) Patent Landscaping, (iv) Patent portfolio Analysis, (v) Patent Mapping, (vi) Patent Citation Analysis, (vii) White Space Mapping and (viii) Competitive Intelligence services in various technological domains in the area of Minerals, Materials and Metals.

Figure 5: RPBD Division Patinformatics Services

The group has relevant expertise in providing competitive intelligence services by way of (i) Competitor Tracking/Profiling, (ii) Comparative Technology Evaluation, (iii) Market Assessment Studies, (iv) Strategic Grouping/Collaboration, (v) Patent SWOT Analysis, (vi) Patent Claim Analysis and Market Segmentation Analysis.

Technology Marketing

CSIR-NML has a bundle of Technologies and Products ready for commercialization, and a number of them are already in the market. The second edition of the "Technology Handbook" was published containing more than 60 technologies that CSIR-NML can presently offer. Industrial /business meets and presentations are organized time-to-time by the Division to create awareness amongst the industries of various sectors about the available technologies.

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.

Intellectual Property Facilitation Center (IPFC)

The IPFC was conceptualized by the RPBD Division of CSIR-NML and was established in 2020 through funding from the Ministry of MSME, GoI, with an objective of "Building Awareness on Intellectual Property Rights (IPR)" for the MSMEs. The center has the objectives of bringing awareness about IP and exploitation of IP by the MSMEs. Through this initiative it is expected that an IP based start-up eco-system can be created. Since its inception, the IPFC center has organized several webinars to bring awareness about IP and the importance of IP protection for a competitive business sustainability. The IPFC has organized 15 webinars so far, through which around 1200 people got trained in the matters of IP. The center has 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 has registered 18 trademarks, 3 industrial designs and one copyright; and has filed 5 patents on behalf of the MSMEs.

Team-RPBD

Indian Women
Achievers

Social Work

SHAKUNTALA CHOUDHARY

SOCIAL WORKER (Assam)

102 Years old Gandhian Social Worker from Kamrup – popularly known as 'Shakuntala Baideo'

PADMA SHREE 2022

KV RABIYA

SOCIAL WORKER (Kerala)

Divyang Social Worker from Malappuram working with divyangjan and women- overcoming numerous personal tragedies and illness

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

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:

- Knowledge Resource Group (KRG)
- 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 Jigyasa - 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

Currently the CSIR-NML library has 55,553 documents including text books, reference books, technical reports, manuals, conference proceedings, standards, theses, maps, etc. That includes approximately 21,340 bound volumes of journals collected since 1950s. It also maintains various standards and codes (ASTM, BIS, and Indian Standards). The following Indices Databases are also available: Derwent Innovations Index; KCI – Korean Journal Database; and, Russian Science Citation Index. KRG also developed and maintains following e-resources:

Knowledge resource centre: http://krc.nmlindia.org/;

e-print: http://eprints.nmlindia.org/;

Transparency portal: http://library.nmlindia.org/tp/index.htm; and,

CSIR-NML website: www.nmlindia.org

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 2021-22, the volume 63 consisting of two issues 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 2021-2022, CSIR-NML received 85 RTI applications and 5 appeals, which were successfully

disposed of as per RTI guidelines. These applications were from sixteen different states and union territories. The CSIR-NML Transparency portal (http://library.nmlindia.org/tp/index.htm) 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 are 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

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 10.02.2022 and 15.03.2022 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 the 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 2020-2021:

(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 CSIR NML.

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

(k) IT support for organization of seminars, workshops & conferences at CSIR-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).

Indian Women
Achievers

Social Work

ACHARYA CHANDANAJI

SOCIAL WORKER (Bihar)

Jain Spiritual Leader and Social Worker from Rajgir-dedicated her life to the upliftment of the poor for over 5 decades

PADMA SHREE 2022

BASANTI DEVI

SOCIAL WORKER (Uttrakhand)

Inspirational woman environmentalist from Pithoragarh- known for her contribution towards revitalizing the Kosi river

PADMA SHREE 2022

GAMIT RAMILABEN RAYSINGBHAI

SOCIAL WORKER (Gujarat)

Tribal Social Worker from Tapi-leading SHGs in working across education, healthcare and sanitation

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

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 routine and repetitive. The division has two groups; Works Services and Maintenance (WSM) group and Project Planning and Engineering (PPE) Group. WSM group includes Civil Engineering Unit, Electrical Engineering Unit and Air-Conditioning Unit, while PPE group consists of the 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 design Engineering Group:

The activities of the group are 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. The major prototypes designed and developed are as follows :

1. Design and development of Foot operated sanitiser dispensers in the workshop. These are installed in CSIR-NML dispensaries.
2. Design and development of Column Flotation Cell.
3. Design and development of Microbial corrosion chamber with control panel.
4. Design and development of Water column simulation.
5. Design and development of prototype Air Jig for PIV experiment.

Research and Consultancy : In the reported period, the division has completed two consultancy projects and has been working on two major research projects. CSIR-NML is developing a state of the art welding research laboratory : The major achievements are the following:

1. Demonstration of the effects of microstructure evolution in weld heat affected zone on fracture toughness and fatigue of API steel (X70 / X80) weld joints.
2. Report on the effects of electrodes composition on the mechanical and corrosion behaviour of duplex stainless steel in corrosive environment.
3. Numerical modelling of heat transfer and fluid flow in Selective Laser Melting (SLM) of SS316L.
4. Wire arc additive manufacturing of Inconel 718 material.
5. Optimization of welding parameter using robotic MIG for automobile industry.

Setting up and Operation of Critical Infrastructure: In the reporting 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 upcoming pilot plants.
3. Operations of 493KW solar power plant for catering to the electrical load requirement of the Laboratory, due to which saving of over Rs. 2.5 Lakhs per month in the running expenditure has been observed.

Finite Element and CFD Modeling : The division is actively contributing in process modeling activities. The group has been 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. Study of fluidized angles and boundary wall effects on density stratification in pulsated air stratifier using Particle Image Velocimetry (PIV)
2. Optimization of FBG sensors requirement for locating the critical zone of blow pipe by numerical simulation and ANN.
3. Process Modelling and Design Optimization for development of water-cooled caster.

Basic Engineering Packages : The group has been involved in Preparation of **Detailed Project Report** (BEP/DPR) for Jafarnagar Silver Cluster, Nadia, West Bengal.

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 campaigns in annealing simulator facility.
3. Support in revival of critical R&D equipment.

Maintenance and Up-keep of Equipment : The division is actively involved in providing in-house maintenance support to high value equipment of the laboratory. During the reporting period the following high value equipment were serviced:

1. Amorphous melt spinning wheel setup.
2. Rolling mill
3. AKA flow system
4. Water circulation system of Servo Hydraulic Unit of MTE Division and its upgradation.

Central Workshop

Central Workshop receives jobs from various divisions, for specimen preparation of different materials, fitting, machining & fabrication of prototypes and repairing of miscellaneous items. 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.

Works Services and Maintenance Group:

This group has diverse responsibilities to upkeep infrastructure; create new infrastructure and renovation of facilities in various campuses of the laboratory. These services include civil engineering, electrical engineering and refrigeration & air conditioning, maintenance of lifts, water supply, etc. The infrastructure management team has successfully completed new facilities creation

jobs as per the requirements of the laboratory. In addition, annual maintenance & overhauling of infrastructure were carried out.

Some of the important work undertaken were as follows:

- Renovation and Modification of an old shed in LSTF to use as coal sample stock room and sample logging room
- Renovation of Auditorium in CSIR-NML, Jamshedpur
- Electrical renovation of work centers at Main Laboratory and pilot plants
- Operation and comprehensive annual maintenance of new energy efficient central AC Plant
- Comprehensive civil and electrical maintenance of the laboratory and pilot plants and residential areas including air conditioning and lifts.

Team - Engineering

Indian Women
Achievers

Art - Singer

SHYAMAMANI DEVI

SINGER (Odisha)

Renowned Odia Singer-with thousands of her songs influencing generations

PADMA SHREE 2022

PRABHA ATRE

CLASSICAL VOCALIST (Maharashtra)

Globally renowned Veteran Hindustani Classical Vocalist from Kirana gharana with an illustrious career spanning 6 decades

PADMA VIBHUSAN 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

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.
- Provide healthy working conditions and atmosphere to Institute by correct interpretation as well as implementation of governing rules and regulations.
- Assist authorities of the laboratory, like the Director, Advisor - Management, Head -Human Resource Group, for decisions on administrative matters.
- Implement instructions of the Director 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, JSA 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 ERP. 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

Art - Acting

SOWCAR JANAKI

ACTRESS (Tamilnadu)

Veteran Actress for over 7 decades- acted over 400 films across 5 languages

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Stores & Purchase

The Stores & Purchase Division is mainly responsible for procurement of capital gods, spares & consumable items and annual maintenance services, and distribution of material. Different committees like Technical & Purchase Committee, Purchase Committee, Equipment Prioritization Committee, Vendor Registration Committee and Standing Disposal Committee help the division in arriving at suitable decisions as per CSIR Manual on Procurement of Goods 2019. The major procurements for which orders have been placed during 2021-2022 are:

1. Laboratory Scale Inert Gas Atomizer for Producing High Purity Spherical Metal / Alloy Powder
2. FACTSAGE Software
3. Automatic Twin Jet Electro Polisher for TEM Sample Preparation.
4. Phased Array Ultrasonic System
5. Tubular High Temperature Vacuum Furnace with Gas Purging Facility

Apart from these, many other minor equipment, accessories and spares were also ordered. The S&P Division also processes Annual Maintenance Contract for all the major equipment of the Institute.

The division is undertaking procurement through Government E Market (GeM) platform as well as Central Public Procurement Portal. It is coordinating with CSIR Team and others in ensuring a speedy implementation of ERP, E-Procurement and GeM. S&P Division has also undertaken disposal of various unserviceable items. The Stores & Purchase Division is headed by Controller of Stores and Purchase (CoSP). The CoSP is supported by Section Officer, Sr. Secretariat Assistant, Stenographers and other supporting staffs. The Stores and Purchase Division is a team of hardworking professionals under the leadership of Controller of Stores and Purchase, who strive to keep the system of R&D and other supporting services running smoothly, by taking care of procurement activities related to materials / services in time and within the ambit of public procurement rules/guidelines.

Team -Store & Purchase

Indian Women
Achievers

Art- Folk Singers

GURMEET BAWA
PUNJAB

Celebrated Punjabi Folk Singer credited with Popularizing folk instruments-famous as the 'Lambi hek ki Malika' (Posthumous)

PADMA BHUSAN 2022

SULOCHANA CHAVAN
MAHARASHTRA

Legendary Lavani singer from Kolhapur,famous as Lavanisamradhni-having made immeasurable contribution in the past 75 years

PADMA SHREE 2022

AJITA SRIVASTAVA
UTTAR PRADESH

Popular Kajari folk singer from Mirzapur

PADMA SHREE 2022

MADHURI BARTHWAL
UTTARAKHAND

Garhwali folk singer, composer and teacher-especially known for promoting folk music among women

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

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.
- Ensuring funds availability to acquire the resources needed by the organization.
- Ensuring cost control while facilitating adequate spending within laid down guidelines and procedures in the matter.
- Ensuring adequate cash flow and proper management of funds.
- Providing 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.
- Preparation of 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 project sponsors 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 2021-22

1. Utilized Budget Grant allocated by CSIR- Rs.6691.558 lakhs + Rs.4993.515 lakhs (pension)
2. Utilization from Laboratory Reserve - Rs. 227.187 lakhs
3. Generation of interest by investment of surplus funds- Rs. 681.745 lakhs
4. Generation of Lab Reserve - Rs. 3168.437 lakhs.
5. Bank reconciliation of the Cash Book completed up to 31st March, 2022.

6. GPF Account as on 31st March 2021 has been reconciled, finalized and closed.
7. During the year 35 new cases of pension and 24 family pension cases have been completed with the issuing of PPO and pension papers on time.
8. CSIR-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 Paras have been settled.
10. Accounts Division has been renovated for better ambiance.
11. Provision of QR Code for online money receipt in the NML official Account.

Team - Finance & Accounts

Activities of 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, Hindi Magazine Samanvay, CSIR-NML Newsletter and Brochures have been published in Hindi and English, 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 in the scheme.

Hindi Workshop

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

Hindi Competition

Due to COVID-19 pandemic, Hindi Competitions were organized online from 7th to 14th September, 2021, for CSIR-NML Employees. The competitions included discussions on implementation of Hindi, self-written poetry recitations and singing, etc. The online program had wide participation by NML employees.

World Hindi Day

On the "World Hindi Day", an online technical lecture was organized on 10th January, 2022, 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.

International Mother-Language Day

On the "International Mother Language Day", 21st February, online scientific lectures were organized on different scientific topics. In this event many senior scientists and research scholars of CSIR-NML participated and presented their research work or lectures on science and research, in their mother tongue. Dr. Arvind Sinha, Chief Scientist and Advisor, Management, delivered a lecture on "Local Language and Science: Mann Ki Baat" in Hindi. Dr. Atanu Das, Senior Scientist, presented "A Brief Discussion on Welding Research" in Bangla. Dr. Shailendra Kumar Jha, Principal Scientist, delivered a lecture on "Utility and possibilities of electroplating technology", in Maithili. Dr. Ganesh Chalvadi, Senior Scientist, talked about

"Dry Coal Beneficiation" in Telugu. Dr. Sumant Kumar Pradhan, Scientist, discussed "Corrosion: Curse or Boon" in Odia, while, Mr. Premkumar M., Senior Scientist, explained "Science in Ancient Tamil Literature", in Tamil. In the above program, apart from the senior scientists and researchers of the laboratory, students of IIT Kharagpur, several member offices of Narakas, Jamshedpur, like NIT Jamshedpur, Indo Danish Tool Room, CRPF, AMD, etc., participated enthusiastically.

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 Jamshedpur and adjacent areas. Several TOLIC programs were organized online.

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 thirty-eight i-PSG supported projects were in progress during 2021-22. Some of the significant outcomes/achievements of these projects are as follows:

Processes and Products:

- Process developed for corrosion resistant rebars using an aqueous solution on hot rebar, primer synthesized for direct application on rusted steel, ceramic coatings developed for mild steels against acid fume as well as high temperature environments.
- A statistical empirical model developed for process optimization of carbon recovery from blast furnace and corex steel plant sludge using froth flotation. The recovery of this carbon can further supplement the carbon requirement for iron making under waste to wealth management.

Publications:

- High strength metakaolin/epoxy hybrid geopolymers: Synthesis, characterization and mechanical properties, Applied Clay Science 221 (2022) 106459.
- Phosphonomethyl iminodiacetic acid-functionalized metal-organic framework supported PAN composite beads for selective removal of La (III) from wastewater: Adsorptive performance and column separation studies, Journal of Hazardous Materials 425 (2022) 127802.
- Enhancing the properties of Al–Ni added medium Mn steel by tailoring B2–NiAl precipitates through aging treatment, Materials Science & Engineering A 837 (2022) 142757.
- Enhancement of dry beneficiation of coal by air distributor design modification in an air-pulsated stratifier, Natural Resources Research 30 (2021) 3643-3658.
- Studies on Tensile Behaviour of Selective Laser Melted 316L Stainless Steel Using SEM straining Stage, Trans Indian National Academy Engg 6 (2021) 1005-1015.

Indian Women
Achievers

Art - Dance

R MUTHUKANNAMMAL

BHARATNATYAM DANCER (Tamilnadu)

Veteran 7th generation Sadir Dancer from Viralimalai-a custodian of the early tradition of Bharatnatyam

PADMA SHREE 2022

KAMALINI AND NALINI ASTHANA

KATHAK DANCER (Uttar Pradesh)

Acclaimed Kathak Dancer duo from Agra-known for teaching and propagating it globally

PADMA SHREE 2022

PADMAJA REDDY

KUCHIPIDI DANCER (Telangana)

Acclaimed Kuchipudi Dancer and Guru-credited with reviving the Kakatiyam dance form

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

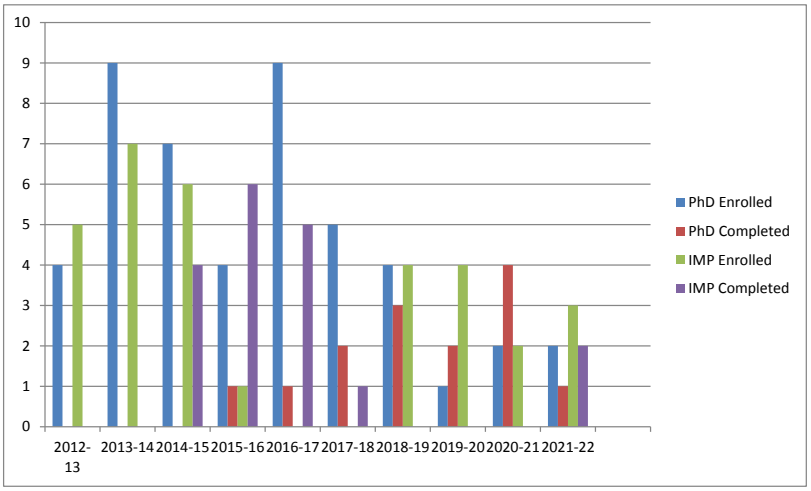
AcSIR – NML Activities

New Admission Details

August 2021		
Student Name	**Program**	**Sponsorship**
Shemshetty Saicharan	IDDP	CSIR-GATE-JRF
DSV Abhishek	PhD	Project Assistant
January 2022		
Student Name	**Program**	**Sponsorship**
Sayan Ghosh	IDDP	Industry Sponsored (Tinplate)
Mayank Srivastava	IDDP	Industry Sponsored (Tinplate)
Vijay Kumar Tiwary	PhD	Industry Sponsored (Tata Steel)

Achievements:

- Dr. SK Jabed Miadad completed his doctoral degree in the academic session August 2021 under the supervision of Dr. B. Ravikumar.
- Mr. PS Manoranjan Jena and Ms. Shubhada Kar were awarded their M.Tech degrees in the Academic Session August 2021 under the supervision of Dr. Jitendra Kumar Sahu and Dr. Gopi Kishor Mandal, respectively.
- The total strength of AcSIR students at NML is 39.



Student Enrollment and Completion of Degree

Indian Women
Achievers

Art - Regional Handicrafts

LOUREMBAM BINO DEVI

APPLIQUE ARTIST (Manipur)

Veteran Applique artist- preserving the Leeba textile art of Manipur over 5 decides

PADMA SHREE 2022

DURGA BAI VYAM

PAINTER (Madhya Pradesh)

Renowned Gond painter from Mandala

PADMA SHREE 2022

LALITA VAKIL

EMBROIDERY ARTIST (Himachal Pradesh)

Veteran Embroidery Artist-reviving and modernizing Chamba Rumali artwork

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

CSIR-NML-NASI Activities

In association with CSIR-NML Jamshedpur, The Jharkhand state chapter of The National Academy of Sciences, India (NASI) organized the following online programs during FY 2021-22:

National Science Day Celebrations at CSIR-NML & Best Science Teacher Award 2021-2022

The National Science Day was celebrated on 28th February 2022. **Prof. Indranil Manna**, Vice-Chancellor, BIT Mesra, Ranchi was the Chief Guest of the function. In addition to CSIR-NML Scientific and technical staff, more than 100 researchers participated in the program, online. The Chief Guest, delivered a lecture on "Challenges for Development of Materials and Components for Structural Applications at Elevated Temperature".

National Science Day celebrated under joint aegis of SIR-NML & NASI, Best Science Teacher Award 2021-202

News Service

ushedpur, Feb 28: I R - National llurgical Laboratory, hedpur and the hand Chapter of the onal Academy of nces, India (NASI) ly celebrated the nal Science Day on day, 28th February g which the award of Science Teacher for '22 was presented to isha Dhawan (TGT, ic High School, arhi) and Anju Kumari , BPM+2 High ol, Jamshedpur). They each presented a on, plaque and cash of 1000. ce-Chancellor, BIT a, Ranchi, Prof nil Manna was the f Guest at the ion. More than 100 bers of CSIR-NML ntific and technical p along with rchers, participated in rogramme that was ucted online.

In his welcome address, Dr Indranil Chattoraj, Director, CSIR-NML briefed the audience on the importance of National Science Day for the scientific community of India. Dr. Arvind Sinha, Chairman of the Jharkhand Chapter of NASI, apprised the audience about NASI and its role in promoting science and technology in India. He deliberated on the plethora of work carried out by NASI Jharkhand chapter for students and teachers in uplifting science scientific processes.

The Chief Guest, Prof. Indranil Manna delivered a lecture on "Challenges for Development of Materials and Components for Structural Applications at Elevated Temperature." Prof Manna underlined the inevitable role of tougher, lighter, formable, and formidable metals for wide application at high temperatures in space, aircraft, thermal power plants and other sectors. His lecture unfolded the latest progress achieved globally and in India.

Dr. Abhilash, Member, NASI Jharkhand Chapter announced the awards for best science teacher for 2021-22. The awards w conferred upon Manisha Dhawan (T Public High Sch Ramgarh) and Ms. A Kumari (PGT, BPM High School, Jamshedp The awardees receiv citation, plaque, and 10000 each.

Dr. RK Sahu, Principal Scientist, CS NML, and Secretary NASI Jharkhand Cha presented the vote thanks. The program supported by Dr San Ghosh Chowdhury, Dr Sahu, K Sudhakar R Chanchal among ser others.

Figure1: Media coverage of The National Science Day, celebrated jointly by CSIR NML and Jharkhand Chapter of NASI.

Jagrukta Abhiyan for Covid-19 Pandemic/ Azadi ka Amrit Mahotsav

On 26th August 2021, CSIR-NML in association with The National Academy of Sciences, India and its Jharkhand state chapter organized an online webinar, entitled "Jagrukta Abhiyan for Covid-19 Pandemic/Azadi ka Amrit Mahotsav". The event was organized under the Jagrukta Abhiyan Mission on Covid-19, launched by NASI, under the leadership of Prof. Manju Sharma, Former Secretary, Department of Biotechnology. Eminent scholars including Prof Chandrima Shah, Hon'ble President, INSA, Prof Ajoy Ghatak, Hon'ble President, NASI, Dr Kiran Katoch, Former Director NJIL and MD (ICMR), Prof P. K. Seth, Former Director CSIR-IITR, Dr Shantanu Sengupta, Senior Principal Scientist, CSIR-IIGB, Prof P. K. Bhattacharya, Head ICU, RIMS (Ranchi), Dr. Neeraj Kumar, Executive Secretary, NASI, and Dr Archana Pant, Woman Scientist, NASI, participated in the webinar and deliberated in details spreading the necessary awareness on Covid-19 among the natives of Jharkhand.

Figure 2: NML-NASI online webinar on Awareness on Covid-19 pandemic

Others-Animal Husbandry

SOSAMMA IYPE

KERALA

Animal Husbandry practioner and academician from Thrissur-led conservation efforts to save and promote indigenous Vechur Cattle

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Awards & Recognitions

National/International Awards/Recognitions

Young Metallurgist (Metal Science) Award, 2021

Dr. Ashok K

Ms. Minal Shah

Commemorative medal for enhancing international recognition of the University of Miskolc

Dr. Sanjay Kumar

NACE Corrosion Awareness Award, 2021

Dr. Raghuvir Singh

MEAI 2020, NMDC Award, 2020

Dr. Shobhana Dey

CV Raman Prize, 2021

Dr. GVS Murthy

Scientific Excellence Award

Dr. Abhilash

CSIR- Technology Award 2021


CSIR-NML Team: Dr. SK Pal, Dr. A. Mitra, Dr. KL Hansda, Dr. Mita Tarafder, Dr. GVS Murthy, Dr. Beena Kumari, Ashish Kr. Upadhyay, and K. Sudhakar Rao

CSIR-NML Foundation Day Awards (26th November 2021)

V.A. Altekar Award for the Best Technology Developed/ Transferred during 2020, for the commercialization of Column Floatation Technology for the Recovery of Sillimanite from Heavy Mineral Beach Sand.


Dr. T.V. Vijaykumar and Ms. N. Vasumathi

B.R. Nijhawan Award for the Best Paper published from laboratory during 2020 was awarded to the paper "Effect of cooling rate on the evolution of microstructure and mechanical properties of nonisothermally partitioned steels" published in Materials Science and Engineering.






Mr. G.K. Bansal, Dr. V. Rajinikanth, Dr. Chiradeep Ghosh, Dr. V.C. Srivastava, Dr. Monojit Dutta, Dr. S Ghosh Chowdhury

Prof. Shilowbhadra Banerjee Award for the Best in-house Project completed during 2020 was given to for the project "Development of indigenous Air Stratifier for dry beneficiation"








Dr. Ganesh Chalavadi, Mr. Abhishek Kumar, Mr. Kalicharan Hembrom, Dr. R.K. Rath, Dr. Rajneesh Kumar, Mr. M. Udaya Bhaskar Rao, Ms. Monica Sahoo, and Mr. Pankaj Kumar

Prof. S.P. Mehrotra Award for the Best Colloquium Speaker in 2021 was jointly shared by


Dr. Gopi Kishore Mandal, and Dr. Tarun Kumar Das

Prof. P. Ramachandra Rao Award for the Best Employees


Technical Category : Mr. Dilip Kumar Sumbrui, and Mr. Saroj Kumar


Non-Technical Category: Mr. Anil Kumar and Mr. C.R. Chakraborty

Editorial Board Memberships/National/International Committee Memberships

 Dr. Sanjay Kumar	• Transactions of Indian Ceramic Society (A Tailor & Francis Journal) • Review Editor for Frontiers of Chemistry Journal • Chairman, Jamshedpur Chapter of Indian Ceramic Society from Oct 2021. • International Scientific Committee of 4th International Bauxite Residue Valorization and Best Practices Conference, to be held on Oct 11-14, organized by Katholic University, Leuven, Belgium
 Dr. Trilochan Mishra	• Editorial board member of International Journal of Material and Chemistry and American Journal of Physical Chemistry (Science publisher, USA), • Open Chemical Engineering Journal and Current Graphene Science (Bentham Publisher) • Member of board of studies for Department of Chemistry, CV Raman Global University, Bhubaneswar, Odisha
 Dr. Abhilash	• Mineral Processing and Extractive Metallurgy Review (Taylor Francis) • Russian Journal of Nonferrous Metals (Springer) • Section Editor, Microbiology Insights (SAGE) • Youth Editorial Committee Member, Journal of Central South University (Springer) • Review Editor, Frontiers in Chemical Engineering • Member, National Academy of Sciences, India
 Dr. Pratima Meshram	• Austin Journal of Environmental Sciences • International Journal of Mineral Processing and Extractive Metallurgy

 Dr. Sandip Ghosh Chowdhury	Transaction of Indian Institute of Metals	 Dr. Sarmishtha Sagar	Organizing committee member, National Conference on NDE, 2021

 Dr. Sobhana Dey	International Journal of Coal Preparation and Utilization	 Dr. Manis Kumar Jha	Chief Editor, International E-Magazine Manthan

High Impact Factor Publications

 Dr. Pallab Bhattacharya	JS Yeon, N Gupta, P Bhattacharya, HS Park; A New Era of Integrative Ice Frozen Assembly into Multiscale Architecturing of Energy Materials; Advanced Functional Materials, 2022. Impact factor: 18.808.
 Pankaj Kumar Choubey	Pankaj Kumar Choubey, Om Shankar Dinkar, Rekha Panda, Archana Kumari, Manis Kumar Jha, Devendra Deo Pathak; Selective extraction and separation of Li, Co and Mn from leach liquor of discarded lithium ion batteries (LIBs). Waste Management. Impact Factor: 7.145
 Dr. Trilochan Mishra	U Kumar, S. Das Chakraborty, R. K. Sahu, P. Bhattacharya, T. Mishra; Improved interfacial charge transfer on noble metal-free biomimetic CdS based tertiary heterostructure @ 2D MoS2-CdS-Cu2O with enhanced photocatalytic water splitting, Adv. Mater. Interfaces. Impact Factor: 6.2
 Rekha Panda	Rekha Panda, Om Shankar Dinkar, Archana Kumari, Rajesh Gupta, Manis Kumar Jha, Devendra Deo Pathak, 2021. Hydrometallurgical processing of waste integrated circuits (ICs) to recover Ag and generate mix concentrate of Au, Pd and Pt. Journal of Industrial and Engineering Chemistry 93, 315-321 Impact Factor:6.064
 Dr. Abhilash	Abhilash, Y. Usha, K. Seetharaman, Pratima Meshram, K.D.Mehta, B.D.Pandey; Application of hydrodynamics using CFD in evaluating efficacy of external loop airlift reactor biochemical leaching of sea nodules, Mineral Processing And Extractive Metallurgy Review. Impact Factor: 5.248

Book Chapters

 Dr. Trilochan Mishra	Oxide based self-cleaning and corrosion protective coatings; T. Mishra, M. Mahato & S. K. Tiwari in Chapter-5 in "Handbook of Modern Coating Technologies: Applications and development, Vol 3", 135-173, Editor: M. Aliofkhazraei, A. Nasar, M. Chipara, N. B. Laidani, J. T.M. De Hosson, Elsevier (2021)
 S Das Chakravarty	S Das Chakravarty, P. Bhattacharya and T. Mishra, "Recent advances in 2D MXene based heterostructured photocatalytic materials" in "Sustainable Material Solutions for Solar Energy Technologies" (Eds.) Mariana A. Fraga, Delaina A. Amos, Savas Sönmezoglu and Velumani Subramaniam, Elsevier, pages 329-362, 2021
 Dr. Pallab Bhattacharya	Bhattacharya, P. (2021). Conducting-Polymer-Based Supercapacitors. In: Kar, K.K. (eds) Handbook of Nanocomposite Supercapacitor Materials III, Springer Series in Materials Science, vol 313. Springer,
 Dr. Manis K Jha	Manis Kumar Jha, Archana Kumari, Rekha Panda, Rukshana Parween, Sanchita Chakravarty, Rajesh Kumar Jyothi, 2021. Coal Burn Ash: A Sustainable Future Resource for Critical Metals Production. In: Clean Coal Technologies. Springer, 473-485
 Pankaj Kumar Choubey	Pankaj Kumar Choubey, Rukshana Parween, Rekha Panda, Om Shankar Dinkar, Manis Kumar Jha, 2022. Recovery of Lithium from Black Cathode Active Materials of Discarded Lithium-Ion Batteries. In: REWAS 2022: Developing Tomorrow's Technical Cycles (Volume I), 739-745, Springer
 Rekha Panda	Rekha Panda, Om Shankar Dinkar, Pankaj Kumar Choubey, Rukshana Parween, Manis Kumar Jha, Devendra Deo Pathak, 2022. Recovery of Precious Metal Silver from Scrap Computer Keyboards. In: REWAS 2022: Developing Tomorrow's Technical Cycles (Volume I), 71-81, Springer

 Rekha Panda  Dr. Archana Kumari	 Pankaj Kumar Choubey	Rekha Panda, Manis Kumar Jha, Jae-chun Lee, Devendra Deo Pathak, 2021.Developed Commercial Processes to Recover Au, Ag, Pt, and Pd from E-waste. In: Rare Metal Technology 202, The Minerals, Metals and Materials Society 2021, 115-126, Springer. Pankaj Kumar Choubey, Archana Kumari, Manis Kumar Jha, Devendra Deo Pathak, 2021. Recovery of Cobalt as Cobalt Sulfate from Discarded Lithium-Ion Batteries (LIBs) of Mobile Phones. In: Rare Metal Technology 2021, The Minerals, Metals and Materials Society 2021, 47-53, Springer. Archana Kumari, Pankaj Kumar Choubey, Rajesh Gupta, Manis Kumar Jha, 2021.Recovery of Lithium (Li) Salts from Industrial Effluent of Recycling Plant. In: Rare Metal Technology 2021, The Minerals, Metals and Materials Society 2021, 91-100, Springer. Jae-chun Lee, Manis Kumar Jha, Rekha Panda, Pankaj Kumar Choubey, Archana Kumari, Tai Gyun Kim, 2021. Developing Feasible Processes for the Total Recycling of WEEE to Recover Rare Metals. In: Rare Metal Technology 2021, The Minerals, Metals and Materials Society 2021, 197-209, Springer.

Highly Downloaded Articles

Articles which were listed as amongst the most downloaded by the respective journals

1.	***Hydrometallurgical recovery/recycling of platinum by the leaching of spent catalysts: A review*** Manis Kumar Jha, Jae-chun Lee, Min-seuk Kim, Jinki Jeong, Byung-Su Kim, VinayKumar Journal: Hydrometallurgy
2.	***Environmental impact of spent lithium ion batteries and green recycling perspectives by organic acids – A review*** Pratima Meshram, Abhilash Mishra, Abhilash, Rina Sahu Journal: Chemosphere
3.	***Extraction of lithium from primary and secondary sources by pre-treatment, leaching and separation: A comprehensive review*** Pratima Meshram, B.D. Pandey, T.R. Mankhand Journal: Hydrometallurgy

Best Paper/Poster Awards: Participation in Conferences/ Seminars

Mr. Santanu Pahari

Dr. Pallab Bhattacharya

Certificate of Merit as Winner in Metallography session of "Scanning Electron Microscopy" in the Indian Institute of Metals- 75th Annual Technical Meeting (IIM-ATM 2021), held Online during 13th to 15th November 2021.

Dr. Pallab Bhattacharya

First Prize in Poster Competition in International Online Conference on energy Sciences (ICES 2021) organized by Mahatma Gandhi University, Kottayam, Kerala, India during 10th - 12th December 2021

Dr. Sudeshna Das Chakraborty

Best Paper Award at the International Conference (Online) on "Covid Challenges of Energy and Environment Management for Sustainable Growth of Process Industries (CCEEMSGPI- 2021)" organized by AICTE on 10th -11th September 2021.

Mr. Bappaditya Das

Dr. Rajen Kundu

Best Oral Presentation award in Nano Science and Technology during 74th Annual Session of Indian Institute of Chemical Engineers (CHEMCON -2021) held at CSIR-IMMT, Bhubaneswar

Invited Talks Delivered by Staff

Speaker	Topic/ Event
 Dr. I. Chattoraj	"Corrosive Failures and Prevention Strategies"; Platinum Jubilee Lecture series IIM@75; 10th May 2021.
	"REE from Secondaries @ CSIR-NML"; 70th Anniversary of IREL, 18th August 2021.
	"Corrosion in Pipelines"; IEOT Foundation day celebration, 10th November, 2021.
	"Mineral Processing @CSIR-NML: Thrusts and Achievements"; KS Mohapatra Memorial Lecture of SGAT, 18th December, 2021.
	"Traditional Indian Metals Craftmanship"; Science Day Celebration by BIT Meshra; 28th February, 2022.

 Dr. Mita Tarafder	"My Journey as a women scientist and micro-entrepreneur"; Vigyan Jyoti of DST and JNV; 21st May, 2021).
	"Innovations, R&D and Entrepreneurship in Materials & Metallurgy"; IIM, Jamshedpur Chapter; 7th July, 2021).
	"E-Waste Management: Upcyclic and Recycling"; Al-Kabir Polytechnic; 7th September, 2021).
	"Engineering Innovations by Women in Materials and Metallurgy", National Council for Cement & Building Materials (NCCBM); 8th March, 2022).
 Dr. Sandip Ghosh Chowdhury	"Advancement in Clean Steel Processing Technology and its effect on final products"; Webinar organized by TATA Steel Long Products; 23rd November, 2021.
 Dr Sanjay Kumar	"Waste management for ceramic and metallurgical industries"; National Workshop on Advanced Ceramics (WOAC 2022) at NIT Jamshedpur; 19th February 2022.
 Dr. Sarmishtha Sagar	"Sensors Technology"; FDP at University Institute of Engineering & Technology, Kurukshetra University, 6th – 10th September, 2021.
	"Non-Destructive Evaluation"; National Conference on Non-Destructive Evaluation, 9th -11th December, 2021.
 Dr. GVS Murthy	"Importance of non-destructive testing in Archaeometallurgy"; National Research Laboratory, Lucknow; 9th August 2021.
 Dr. VC Srivastava	"An Introduction to Materials and Processes"; FDP at Department of Mechanical Engineering IIT-BHU, Varanasi, 20th -24th September, 2021.
	"Materials, Processes and Environmental Sustainability: A Perspective"; FDP at Mechanical Engineering, NIT-Patna, 20th -24th September, 2021.

 Dr. Sital Kumar Pal	"Patent as strategic tools for MSME development"; Webinar on Idea to Innovation: Role of Patents organized jointly with MSME-DI, Ranchi on 16th July 2021.
	"Role of Trademark in brand building of MSMEs"; Webinar on Importance of IP in Brand Building organized jointly with MSME-DI, Ranchi on 31st Sept., 2021.
	"Technology Upgradation of Engineering Goods with a focus on enhancing exports"; Technology Meet organized by EEPC, Kanpur on 9th March 2022.
 Dr. Shobhana Dey	"Coal Beneficiation in India: Problems and Prospects"; International Women's Day by Indian Institute of Mineral Engineers, Hyderabad Chapter; 8th March, 2022.
 Dr. Jay Chakraborty	"High energy synchrotron X-ray diffraction for solving materials research problems in industry"; National conference on "Applications of high energy X-rays in materials science: role of high energy 4th generation light sources" RRCAT Indore; 21st March, 2022.
 Dr. Trilochan Mishra	"Designing of 2D material based heterojunction for green hydrogen by solar photocatalysis"; International Online Conference on Energy Sciences (ICES 2021) held at Mahatma Gandhi University, Kottayam, Kerala, 10th-12th December, 2021.
 Dr. Mainak Ghosh	"Aerospace Materials : A Glimpse on Present & Future"; Webinar on Aeronautical Applications in Defense Systems, organized by ARP (AR & DB) Kanpur, NML & NIT Jamshedpur, 25th January, 2022.
 Dr. Manis Kumar Jha	"Role of science and technology for sustainable future"; National Science Day, Graduate School & College for Women, Jamshedpur, 9th March, 2022.

 Dr. Asit Baran Panda	"Greener synthetic approaches for the synthesis of size, shape, and morphology selective nano-structured materials"; Conference on "Current Trends in Chemical Sciences and their Industrial Applications (CTCSIA-2021)", organized by Haldia Institute of Technology (HIT) and Indian Chemical Society (ICS) 29th October – 2nd November, 2021.
	"Simple, Cost Effective and Scalable Synthesis of Porous Hollow-spheres: The Efficient Materials for Energy Storage and Conversion Application"; 2nd International Conference on "Nanomaterials for Energy Conversion and Storage Applications (NECSA-2022)"; Pandit Deendayal Energy University, Gandhinagar, Gujarat, January 19th -21st, 2022.
 Dr. Abhilash	"Critical Metals for Mobility and Energy"; FDP, CV Raman Global University, 14th - 18th December, 2021.
	"Sustainable extraction of metals and materials from chemical and metallurgical wastes"; National Conference on Modern Emerging Trends: Future of Chemical Sciences (MET-FCS-2021) 23rd -24th April, 2021.
	"Achieving Sustainability in Lithium supply chain via spent battery recycling- Indigenous Developments and New Opportunities" IEI Technical Webinar on Exploration, Upgradation and Extraction of Lithium from Rocks, Tailings and Used Batteries, The Institution of Engineers (India), Odisha State Centre, 5th August, 2021.
	"Microbiology in Metals, Materials and Environment"; PES University, Bangalore, 8th December, 2021.
 Dr. DC Sau	"Treatment of iron ore fines /slimes"; FDP, Department of Chemical Engineering, L D College of Engineering, Ahmedabad, 16th - 22nd December, 2021.
 Dr. Pratima Meshram	Technological advancements in Lithium-ion battery recycling - an Indian perspective; The International Virtual Conference on Recent Advances in Lithium-ion Batteries (LIBs) and their Recycling Methods for Sustainable Development, jointly organized by The Open University, UK, and the Indian Institute of Technology Hyderabad, 1st -3rd December, 2021.
	Recycling of Anthropogenic and Industrial Wastes for Material Replenishment; Waste 2 wealth, BIT Meshra, 12th March, 2022.
 Dr. Pallab Bhattacharya	Plenary Lecture, International Online Conference on Energy Sciences (ICES 2021), Mahatma Gandhi University, Kottayam, Kerala, 10th – 12th December, 2021.

 Dr. Naveena	"Characterization of creep properties of materials using small punch test method"; Theme meeting on "Small Specimen Testing Techniques", 29th September, 2021.
 Sudhakara Rao K	"Make IP India"; National e-Workshop on Innovation and Intellectual Property Rights (New IPR-2021) from June 14th-19th, 2021.

Meritorious Student Awards-2021

Awards for scoring 85% or above marks in best four subjects in ICSE/CBSE in class 10th and/or 12th examination held during 2021.

#	Student's name		Guardian		(%)
1.	Mr. Abhishek Sahu		Dr. Jitendra Kumar Sahu,		97.00
2.	Miss Samikshya Sahoo		Mr. D.P. Sahoo		96.50
3.	Miss Chayanika Chakraborty		Mr. C.R. Chakraborty		96.25
4.	Mr. Soumyajit Ghosh		Dr. Rachit Ghosh		95.50

#	Student's name		Guardian		(%)
5.	Mr. Debjit Ghosh		Dr. Rachit Ghosh		94.75
6.	Miss Sneha Shaw		Mr. Ashok Kumar Shaw		93.50
7.	Miss Saptadeepa Pal		Mr. Partha Partim Pal		92.25
8.	Mr. Bundhu Sumbrui		Mr. Dilip Kumar Sumbrui		88.00
9.	Miss Dishanwita Ghosh Chowdhury		Dr. Sandip Ghosh Chowdhury		93.50
10.	Mr. S P Ruchir		Dr. S. Sivaprasad		91.50
11.	Mr. Abhishek Kumar		Mr. Manoj Kumar		91.00

Awards for securing 100% marks in any subject in the ICSE/CBSE in class 9th/10th/11th and 12th examination

held during 2021.

#	Student's name		Guardian		Class	Percentage (%)
1.	Mr. Abhishek Sahu Subject: Computer Applications		Dr. Jitendra Kumar Sahu		12th	91.50
2.	Mr. Soumyajit Ghosh Subject: Computer Applications		Dr. Rachit Ghosh		12th	sss

Awards for securing Admission in the premier/national level educational institution for higher studies during the year, 2021.

#	Student's name		Guardian		(%)
1.	Mr. Saurabh Hansda Secured Admission in The Indian Institute of Management (IIM), Kolkata		Dr. Kanhai Lal Hansda		91.50

Indian Women
Achievers

"Every new experience brings its own maturity and a great clarity of vision".

Mrs. Indira Gandhi (1917-1984),
First Lady Prime Minister of India (1966-1977 and 1980-84)
Also known as "Iron Lady of India"

Source: https://www.woodenstreet.com/blog/15-firsts-by-indian-women-who-have-made-the-nation-proud

New Facilities Created

Gaustec Miniflow Slurry Pump

This is a specifically designed unit of wet high intensity magnetic separation (WHIMS) equipment. It is used for pumping of the feed and discharge of slurry material to WHIMS. Miniflow pump is an accessory spare unit of WHIMS. These slurry pump units can be hyphenated to any pilot scale wet beneficiation operation where pumping of slurry material is required.

Hydrogen Determinator (LECO RHEN 602)

The LECO RHEN 602 Hydrogen Determinator is used to measure hydrogen content in metals, refractories, and inorganic materials. It has an advanced electrode furnace, operating system for more detailed temperature profiles, programmable ramping, and complete control of set points. RHEN 602 is equipped with automatic cleaning system facility for easy operation. The equipment has facility for drift correction, blank calibration, multipoint calibration as well as gas dose calibration which makes its usable for hydrogen determination of wide range & variety of samples from PPM to % level. At CSIR-NML it is also going to be used for development of Fe based CRMs for Hydrogen along with other analysis work.

Specifications

Instrument Range at 1 g sample : Hydrogen : 0.05 ppm to 250 ppm

Precision : 0.02 ppm or 2% RSD, whichever is greater

Detection Method : Thermal Conductivity

Vertical Planetary Ball Mill

Model: Al-VPB-25; Make: Amaze Instrument;

Consists of four grinding tanks. Jars with vacuum and inert gas purging facility are used. Ball and samples inside the jars are impacted strongly in high-speed movement, and samples are eventually ground into powder. Different materials like powders, fibers, etc., can be ground by the mill, dry or wet. Minimum granularity of ground powder can be 0.1µm. The rotational speed is more than 500 RPM and it is capable of milling continuously for more than 24 hours.

Microwave Digestion Table Top System-ETHOS UP

Microwave digestion is a preparation technique for converting solid samples into solutions suitable for analysis by ICP-OES, ICP-MS, AAS, as well as to perform optimized extractive metallurgy evaluation studies. The solid sample is chemically digested using a liquid reagent (usually one or mix of mineral acids) by microwave heating in a closed vessel in the temperature range of 200-260°C, which accelerates the digestion process. This system gives perfect controls in temperature and pressure, and can process a whole range of samples (geochemical, metals, ceramics, industrial wastes, etc.) using more than 100 US EPA methods.

CSR-CRI Equipment

The **CRI CSR Test System** is an automatic **device for determination of the Coke Reactivity Index (CRI) and Coke Strength after Reaction (CSR)**. This test device is fully compliant with ISO 18894, ASTM D 5341 and IS 4023.

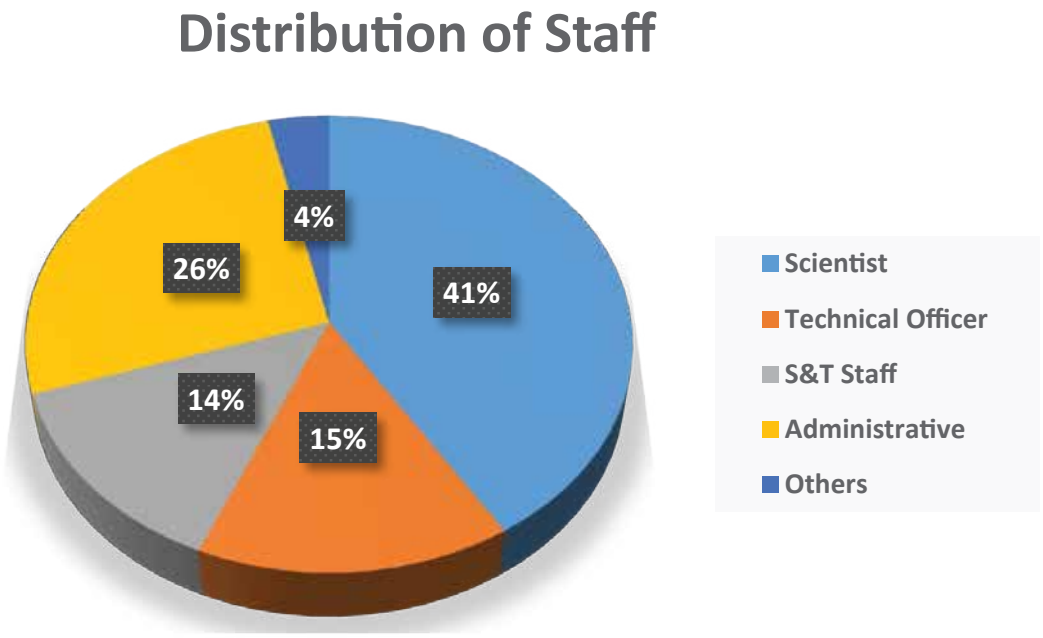
Bottom Pouring Melting Furnace under inert atmosphere

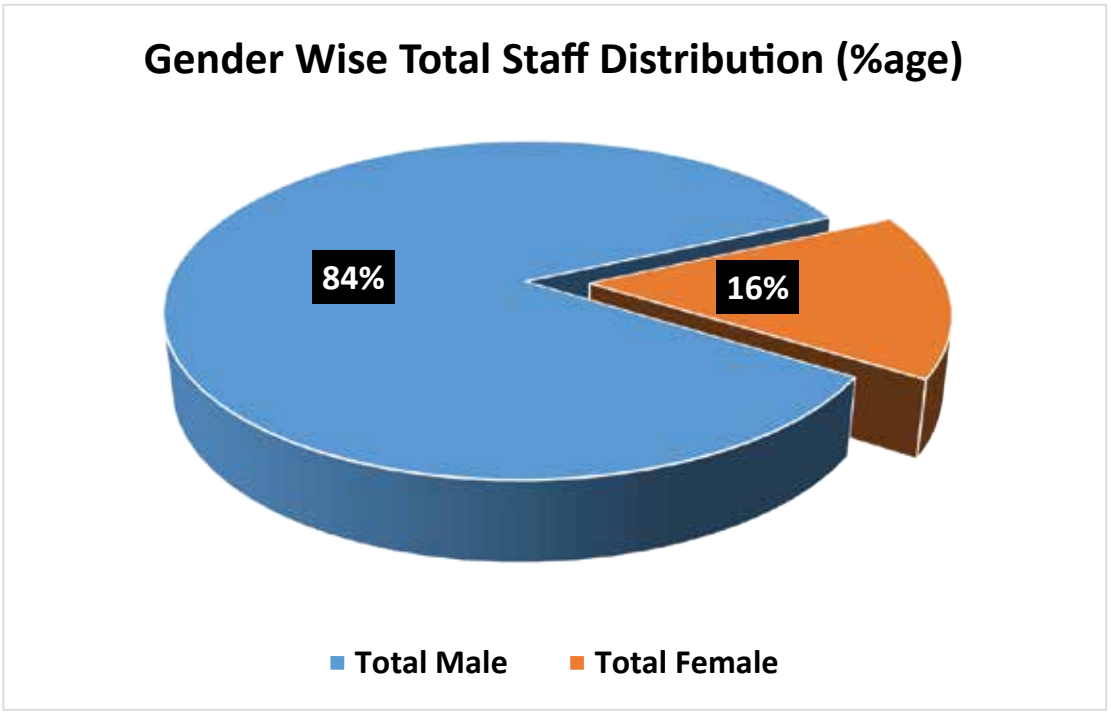
Make : Labtherm Scientific Products

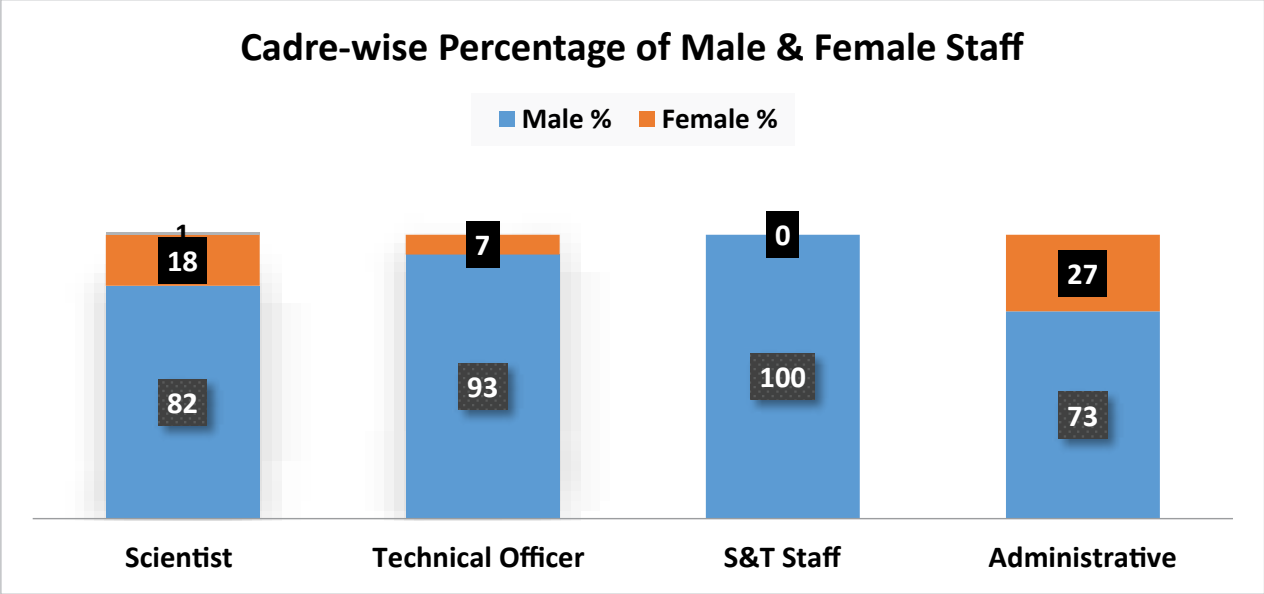
The furnace with a capacity of 5 Kg of Al and its alloys, has a working temperature of 1000°C. It is resistance heated with a heating rate of 10-15 °C/min. The system is capable of melting aluminum and its alloys under positive pressure of inert gases (Argon). It has provision for maintaining vacuum of 0.1 bar before purging of inert gases and then maintaining positive pressure up to 1.2 bar constantly after purging. The system has facility of degassing of hot metal (by purging the argon gas in the melt). Two separate and Independent arm facilites for alloy addition up to 1.0 kg per arm, is available.

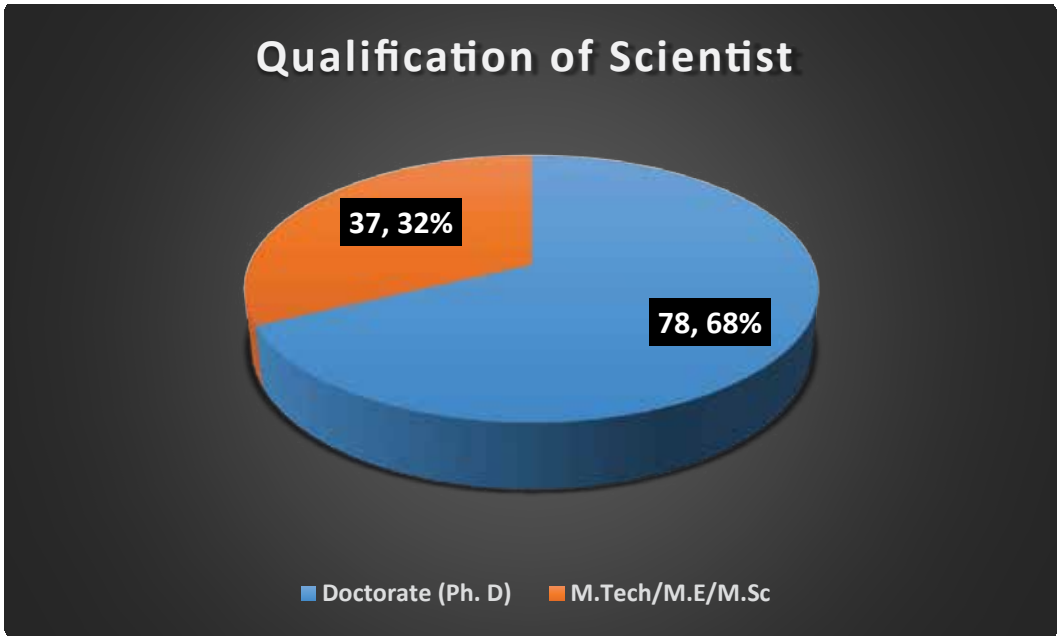
Human Resource Portfolio

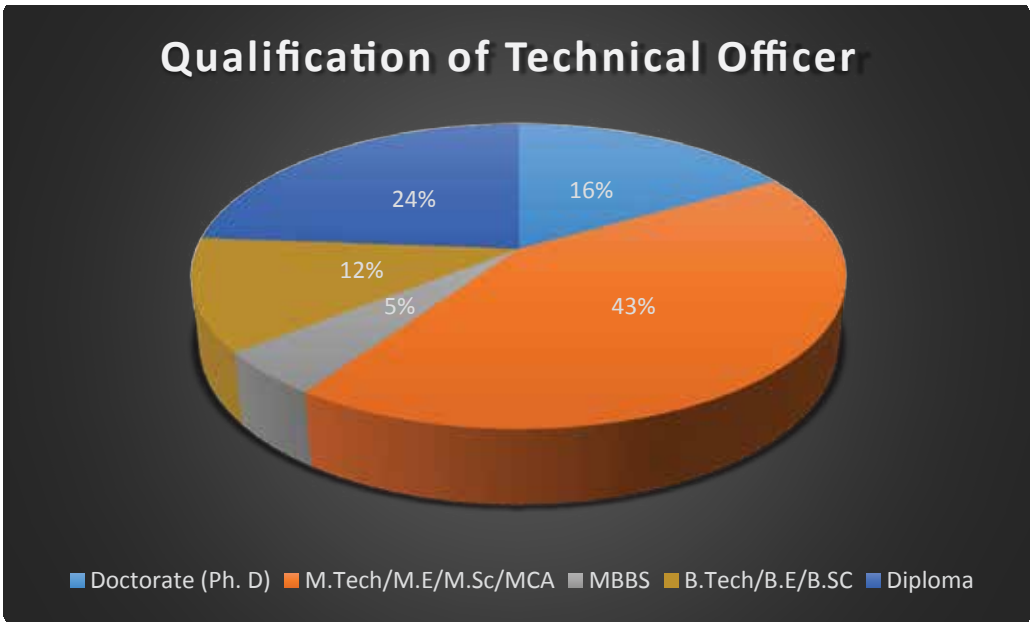
Current Manpower Position of CSIR – NML



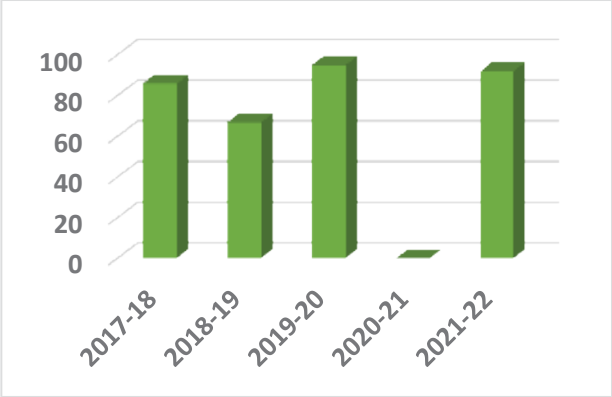



Cadre-wise Percentage of Male & Female Staff
Male %
Female %
1
18
82
7
93
0
100
27
73
Scientist
Technical Officer
S&T Staff
Administrative

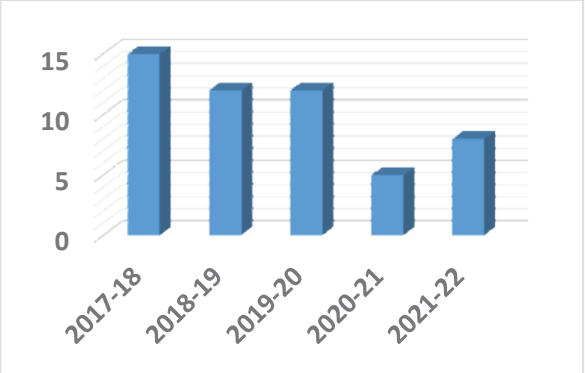

Qualification of Scientist
37, 32%
78, 68%
Doctorate (Ph. D)
M.Tech/M.E/M.Sc



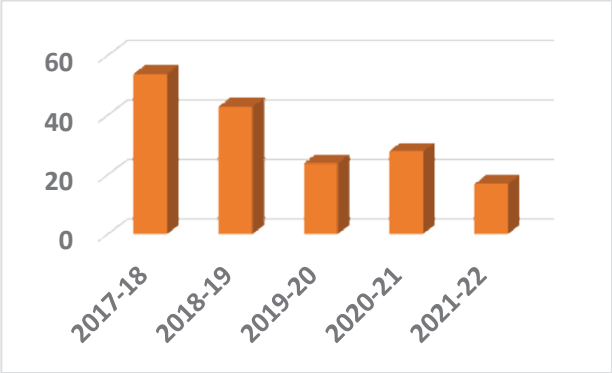
Number of Industrial Training Imparted



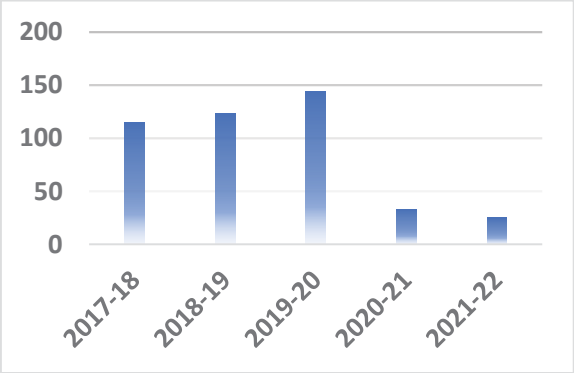
Number of Ph.D Awarded



Number of M.Tech Students Trained



Number of School Children Visited



"Women have talent and intelligence but, due to social constraints and prejudices, it is still a long distance away from the goal of gender equality.".

Mrs. Pratibha Patil,
First Lady President of India (2007-2012)

Source: https://www.woodenstreet.com/blog/15-firsts-by-indian-women-who-have-made-the-nation-proud

Staff News

Staff Joined on Promotion-Transfer from Sister Laboratory

We welcome them and wish them a fulfilling career at CSIR-NML

Transferred from CSIR-CMERI,

Dr. Rajen Kundu, Scientist
W.e.f 31st May 2021

Mr. Ratnakar Behera,
Controller of Finance & Accounts
W.e.f 08th April 2021

Mr. Subhajit Banerjee,
Administrative Officer
W.e.f 16th August 2021

Mr. Pankaj Kumar, Finance & Accounts Officer
W.e.f 10th August 2021

Mr. Chandresh Kumar,
Section Officer (Admin),
W.e.f 31st December 2021

Transferred from CSIR-IICB, Kolkata

Smt. Monalisa Bhattacharya,
Section Officer (G)
W.e.f 02nd November 2021

Transferred from CSIR-NEERI, Nagpur

Mr. Pravin Ananadrao Nagrare,
Assistant Section Officer(G)
W.e.f 31st December 2021

Transferred from CSIR-HRDG, Complex, New Delhi

Mr. Rajkumar Droch,
Senior Controller of Finance
W.e.f 31st December 2021

Transferred from CSIR-CGCRI, Kolkata

Ms. Rubai Ray,
Controler of Stores & Purchase,
W.e.f 1st September 2021

Transferred from CSIR-CDRI, Kolkata

Mr. Mahesh Babu,
Section Officer
W.e.f 23rd August 2021

Staff Transferred on Promotion to Join Sister Laboratory

We appreciate their dedicated services for the laboratory and wish them success in their future endeavors...

Transferred to CSIR-CIMFR, Dhanbad

Mr. Nalin Kumar Singh,
Controller of Store & Purchase
W.e.f 18th August 2021

Mr. Kumar Rahul,
Administrative Officer
W.e.f 18th August 2021

Mr. Lakshmi Narayan Singh,
Section Officer (S&P)
W.e.f 18th August 2021

Mr. Anand Bharti,
Store & Purchase Officer
W.e.f 18th August 2021

Mr. P D Lakra,
Section Officer (G)
W.e.f 18th August 2021

Transferred to CSIR-IICB, Kolkata

Mr. Amrendra Kumar,
Section Officer (G) W.e.f 16th August 2021

Mr. Naveen Kr. Sharma,
SPO W.e.f 16th August 2021

Transferred to CSIR-IIMT, Bhubaneshwar

Mr. Robert Barla,
FAO W.e.f 16th August 2021

Mr. OJ Kandulna,
Section Officer (G) W.e.f 16th August 2021

Transferred to CSIR-CMERI, Durgapur

Mr. Anuja Mohan Pradhan,
FAO CSIR, W.e.f 17th August 2021

Transferred to CSIR-IITR, Lucknow

Mr. Uttam Kumar Jha,
Administrative Officer, W.e.f 17th August 2021

Transferred to CSIR-CGCRI, Kolkata

Dr. (Mrs.) Ranu Verma,
Section Officer (G), W.e.f 17th August 2021

Staff Superannuated

We wish them a happy life ahead...

Mrs. Panmai,
Multi Tasking Staff
31st May 2021

Mr. Aboni Pradhan,
Laboratory Assistant
30th April 2021

Ms. Prabha Srinivasan,
Private Secretary
30th June 2021

Mr. Sarathi, Multi
Tasking Staff
30th June 2021

Mr. Duryodhan Das,
Laboratory Assistant
30th June 2021

Capt. Rajesh Lal,
Senior Security Officer
31st August 2021

Dr. Jayanto Konar,
Senior Technical Officer
31st August 2021

Mr. Anil Kumar Sharma,
Senior Administrative Assistant
31st August 2021

Mr. Parvesh Kumar
Dhawan, Chief Scientist
30th November 2021

Mr. H.D. Banerjee,
Multi Tasking Staff
30th November 2021

Dr. Soumitra Tarafder,
Chief Scientist
31st October 2021

Mr. Sahdeo,
Multi Tasking Staff
31st December 2021

Dr. (Ms.) Sheuli Hore,
Senior Principal Scientist
31st January 2022

Mr. Sheetal Kumar Singh,
Laboratory Assistant
31st January 2022

Dr. Anjan Pradhan,
Chief Scientist,
31st January 2022

Mr. Suresh Chandra Thakur,
Laboratory Assistant 31st March 2022

Mr. Daljit Singh,
Multi Tasking Staff 31st March 2022

Staff Resigned:

Wishing them very best in their new responsibilities

Dr. Arti Kumari, Senior Scientist
March 2022

Ms. Minal Shah, Senior Scientist
January 2022

Dr. Ashok K., Senior Scientist
Dec 2021

Sad Demise of Staff :

Our heartfelt condolences to their families

Dr. Ramesh Kumar Ram,
Chief Medical Officer,
30th April 2021

Mr. Dileshwar Behera,
Lab. Attendent
15th June 2021

Mr. Jay Narayan Patel, Senior
Technical Officer (1),
18th May 2021

Mr. Rahul Kumar Jha,
Senior Technical Officer (1)
5th December 2021.

OTHERS, NRIs

MADHUR JAFFREY

(USA)

Globally celebrated Chef & food journalist-credited with taking Indian cuisine in the world

PADMA BHUSAN 2022

TATIANA LVOVNA SHAUMYAN

(Russia)

Russian scholar and champion of Indo-Russian friendship-doyen of Indology in Russia

PADMA SHREE 2022

PRABHABEN SHAH

(Dadra and Nagar Haveli and Daman and Diu)

Veteran Social Worker from Daman- working for women empowerment and the environment for over 6 decades

PADMA SHREE 2022

Source: https://www.padmaawards.gov.in/
Wikipedia.org; Outlookbusiness.com; Google.com, Twitter.com

Deputations

#	Name	Participation As	Event	Organized By	Duration
1	Ms. Jayati Priya, Project-JRF	Speaker	25th International Conference on Non-ferrous Metals 2021 (ICNFM-2021)	Corporate Monitor, Kolkata, JNARDCC, MRAI and AAI	03rd -4th September 2021
2	Dr. Navneet Singh Randhawa, Senior Technical Officer (1)	Speaker			
3	Mr. Shivendra Sinha, Scientist	Delegate & Speaker			
4	Dr. Abhilash, Principal Scientist	Speaker			
5	Mr. Krishna Kumar, Senior Scientist	Speaker			
6	Mr. Saurabh Shekhar, Scientist	Speaker			
7	Mr. Rajanikant Choudhari, Technical Assistant	Speaker			
8	Ms. Rupa Das Biswas, Senior Technical Officer (2)	Delegate	Training program on " Key aspects for production of RM: ISO 27034 and ISO Guide 35"	NABL, Gurugram, Haryana	15th – 17th September 2021
9	Dr. Sanchita Chakravarty, Chief Scientist	Delegate			
10	Dr. Arvind Kumar Upadhyay, Principal Technical Officer	Delegate			
11	Mr. C. Soupramanian, Senior Technical Officer (2)	Speaker	International Mechanical Engineering Congress & Exposition	ASME	01st – 4th November 2021
12	Mrs. Y. USHA, Scientist	Delegate	Training Program on "Role of technology in community level disaster mitigation for scientist and technologies"	Center for Disaster Management, LBSNAA, Mussorie	08th – 12th November 2021
13	Ms. Subhada Kar, GATE-SRF	Delegate	Symposium on Fatigue, Fracture and Integrity Assessment-2021	Jointly organized by InSIS, IIM-Jamshedpur Chapter and CSIR-NML	09th -11th November 2021
14	Mr. Chandra Veer Singh, Scientist	Delegate			
15	Mr. Vikash Kumar Sahu, GATE-JRF	Delegate			
16	Dr. Himadri Nandan Bar, Principal Scientist	Delegate			
17	Dr. Naveena, Senior Scientist	Delegate			

#	Name	Participation As	Event	Organized By	Duration
18	Mr. Sumanta Bagui, Principal Scientist	Delegate			
19	Dr. Avijit Metya, Principal Scientist	Delegate			
20	Mr. Krishna Guguloth, Principal Scientist	Delegate			
21	Ms. Monalisha Mandal, SERB-NPDF	Delegate			
22	Mr. Rahul Chauhan Project Assistant-III	Delegate			
23	Mr. Ammasi A, Senior Scientist	Speaker	NMD ATM 2021-75th Annual Technical Meeting of IIM	IIM and Tata Steel Jamshedpur	13th – 15th November 2021
24	Mr. Bhupendra Kumhare, AcSIR(PhD)	Speaker			
25	Mr. K E Vijay Amruth, Project Associate-I	Speaker			
26	Dr. Sanjay Agarwal, Principal Scientist	Speaker			
27	Mr. Vaibhav Gaur, AcSIR(PhD)	Speaker			
28	Mr. Santanu Pahari , Project Assistant	Speaker			
29	Dr. Pankaj Kumar Choubey, Research Associate-I	Speaker			
30	Mrs. Rekha Panda, SRF	Speaker			
31	Mr. Nityanand Singh, Project Assistant	Speaker			
32	Mr. Saurabh Shekhar, Scientist	Speaker			
33	Mr. Rajanikant Chaudhari, Technical Assistant	Speaker			
34	Mr. Om Shankar Dinakar, Project - SRF	Speaker			
35	Mr. Ammasi A, Senior Scientist	Speaker	International Conference on Asia steel-2021	The Korean Institute of Metals and Materials, Korea	05th -9th December 2021

#	Name	Participation As	Event	Organized By	Duration
36	Dr. Sarmishtha Sagar, Chief Scientist	Speaker	National Seminar On Non Destructive Evaluation NDE-2021	Indian Society for Non-destructive Testing(ISNT)	09th -11th December 2021
37	Dr. Ashish Kumar Panda, Principal Scientist	Speaker			
38	Dr. Rajat Kumar Roy, Principal Scientist	Speaker			
39	Mr. Pallab Bhattacharya, Senior Scientist	Speaker	International Online Conference On Energy Sciences (Ices 2021)	School of Energy Materials (SEM), Mahatma Gandhi University, Kottayam, Kerala	10th -12th December 2021
40	Mr. Bappaditya Das, Project Assistant	Delegate	Indian Chemical Engineering Congress (CHEMCON-2021)	CSIR-IMMT, Bhubaneswar	27th -30th December 2021
41	Ms. Sneha Kumari, Project Assistant	Delegate	National Seminar on "75 years of mineral Exploration and Future Challenges in India" (MEFCI-2022)	Atomic Minerals Directorate for Exploration and Research, Hyderabad-500016	24th -25th March 2022
42	Mr. Bapaditya Das, Project Assistant	Delegate			
43	Mr. Seshasai Srihari Hanuma R, Field Worker	Speaker	ATL school visit under CSIR-Skill Development Program and visit women Technology Partk NIAMT for DST-WTP project	SS+2 High School Childag, Ranchi and NIAMT, Ranchi	15th March 2022
44	Ms. Pragati Jha, Project Associate-I	Speaker			
45	Mr. Aniket Kumar Dutt, Project Scientist	Speaker			
46	Mrs. Sanghita Mridha, Project Associate-I	Speaker			
47	Dr. Ganesh Chailavadi, Sr. Scientist	Speaker	MBD-2022, International Conference & Exhibition On "Mineral Business Development", Nagpur, India	Mineral Information and Development Nagpur, India	02nd -4th March 2022
48	Dr. Sanjay Agrawal, Principal Scientist	Delegate	PAN-India Program for Building Competencies for Personal Excellence" of the Art of living for all the Scientists & Technologies in the Government Sector.	Mineral Information and Development, Nagpur, India	07th – 11th March 2022

Indian Women
Achievers

“I want to tell the youth, don't just focus on your future but also lay the foundation of the country's future. As President, you have my full support."

Mrs. Droupadi Murmu,

Hon’ble President of India (sworn on 25th July 2022),
First tribal woman to take oath as the President of India

Source: https://www.woodenstreet.com/blog/15-firsts-by-indian-women-who-have-made-the-nation-proud

Distinguished Visitors

Sl. No.	Speaker		Date	Topic
1.	**Dr. Ajay Agarwal** (Cardiology), Brahmananda Narayana Multispecialty Hospital		25th June 2021	"Post Covid Period Heart Care"
2.	**Dr. Madhusudhan Reddy,** Director-DMRL		26th September 2021	"Materials for Defense Applications"
3.	**Dr. S. K. Pandey,** Sct, 'F' Addl. Director, Member Secy (ARP, M&M, SSE, GTMAP), Aero R&D Board (AR&DB)		18th November 2021	"Research Opportunities with AR&DB "
5.	**Dr. Sujata Mandal,** Principal Scientist & Associate Professor, CSIR-Central Leather Research Institute (CLRI), Chennai		17th March 2022	"Spectroscopic Techniques of Chemical Analysis"
6.	**Dr. Gopal Ravichandran** (Vice President), R&D refining, Reliance Industries limited		24th March 2022	"Energy Transition- Opportunities and Challenges in Emerging Technologies"

Indian Women
Achievers

"Empowered women who reach tough or unconventional positions make CHOICES not sacrifices."

Mrs. Kiran Bedi,

24th Lieutenant Governor of Puducherry (2016-2021),
First Women to join the Indian Police Service

Her team towed improperly parked vehicles using six tow trucks ("cranes") for traffic control. This earned her the nickname "Crane Bedi"

Source: https://www.woodenstreet.com/blog/15-firsts-by-indian-women-who-have-made-the-nation-proud

Special Days and Events

Tree Plantation Program (21st -26th June, 2021)

On the occasion of International Yoga Day, under the aegis of Town Official Language Implementation Committee (TOLIC), Jamshedpur, CSIR-NML organized the Tree Plantation Week during 21st to 26th June, 2021. A number of trees were planted in all the campuses of the laboratory. This was possible through the help and facilitation of the local CISF and its commander Mr. Hari Om Gandhi.

Covid-19 Vaccination Drive @CSIR NML (17th July, 2021)

The Staff Welfare Committees of CSIR-NML organized Covid Vaccination camps for the staff and their families. More than 50 beneficiaries were given first /second doses of the vaccine in two rounds of the drive.

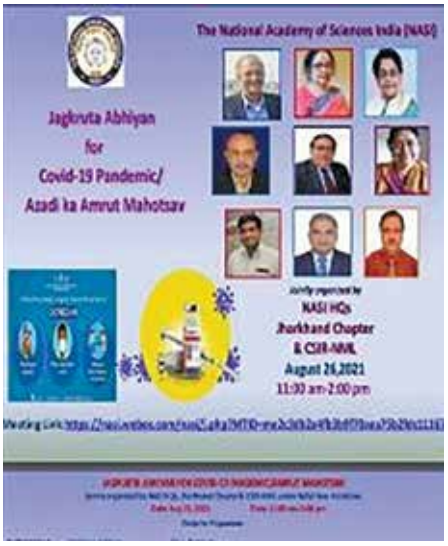
उदित वाणी

एनएमएल आवासीय परिसर में 80 का हुआ टीकाकरण

Independence Day Celebration 2021

Webinar on "Jagrukta Abhiyan for COVID-19 Appropriate Behavior" (26th August, 2021)

The webinar was jointly organized by NASI, Jharkhand Chapter and CSIR-NML. It was attended by some of the national stalwarts in the respective areas.



CSIR - Foundation Day Celebrations (26th September, 2021)

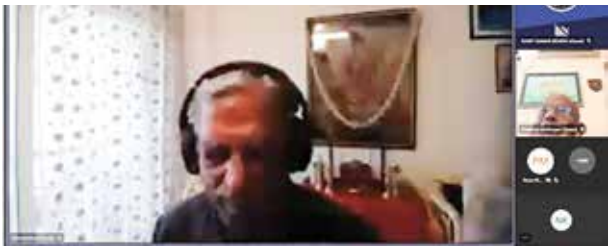
The foundation day lecture was delivered by Dr. Madhusudhan Reddy, Director-DMRL on "Materials for Defense Applications", online. The staff who had superannuated during the previous year and staff who had completed 25 years of service were felicitated during the event.

Vigilance Awareness Week (26th October to 1st November, 2021)

Winners of Essay Competition on the occasion of Vigilance Awareness Week

CSIR-NML Foundation Day-2021 (26th November, 2021)

CSIR-National Metallurgical Laboratory celebrated its 72nd Foundation Day, online. Prof E.S. Dwarkadasa, Former Professor, Indian Institute of Science, Bangalore, and CEO & MD, Karnataka Hybrid Micro Devices Ltd., graced the occasion as the chief guest. He delivered the foundation day lecture "The beginning of metals and the growth of civilization". The Laboratory annual awards of lab were also conferred by the chief guest to the laboratory staff and their wards. The day was also celebrated as the Constitution day and the Constitution day pledge was taken by the dignitaries and the staff during the function.



Some of the Foundation Day Awardees

77th Meeting of Research Council (21st December, 2021)

World Hindi Day Celebrations (10th January, 2022)

A Hindi Poetry recitation program by the staff members was organized to celebrate the occasion. Technical lectures by a number of staff members including scientists and research scholars were organized.

Celebration of Republic Day 2022

Town Official Language Implementation Committee (Nagar Rajbhasha Karyanvayan Samiti) Meeting (24th February, 2022)

National Science Day Celebrations and NASI (Jharkhand Chapter) Best Science Teacher Award 2021-2022 (28th February, 2022)

CSIR-National Metallurgical Laboratory, Jamshedpur jointly with The Jharkhand Chapter of the National Academy of Sciences, India (NASI), celebrated the National Science Day on 28th February 2021. Prof. Indranil Manna, Vice-Chancellor, BIT Mesra, Ranchi graced the occasion as the chief guest. In addition to CSIR-NML staff, more than 100 researchers participated in the program online. The chief guest delivered a lecture on "Challenges for Development of Materials and Components for Structural Applications at Elevated Temperature". In his lecture, Prof. Manna deliberated the inevitable role of tougher, lighter, formable and formidable metals for wide application at high temperature in space, aircraft, thermal power plants and other sectors. The best science teacher awards for 2021-22 were conferred upon Ms. Manisha Dhawan (TGT, Public High School, Ramgarh) and Ms. Anju Kumari (PGT, BPM+2 High School, Jamshedpur). The awardees recieved a citation, plaque and Rs. 10,000 each.

International Women's Day Celebrations (9th March, 2022)

Technology Transfer and Memoranda of Understanding Signing Events

Licensing of technology for e-waste recycling to Metaore Recycler Pvt. Ltd., Kolkata

15th July, 2021


हिन्दुस्तान
बेकार मोबाइल फोन की 98% तक हो सकेगी रिसाइकिलिंग

Transfer of Technology for the "Magnetostructure Sensing (MsS) Device for Pipe Inspection (MagStrics)" to Accelor Microsystems, Mohali

27th December, 2021

MoU between CSIR and Tata Steel

An umbrella MoU was signed between Tata-Steel and CSIR. Dr. I. Chattoraj, Director-NML signed on the behalf of all CSIR laboratories. Dr. Debashish Bhattacharjee, Vice President, TSL, signed on behalf of Tata Steel. Dr. SC Mande, DG-CSIR, Mr. TV Narendran, MD, TSL, various Directors of CSIR-Laboratories and other invitees witnessed the ceremony.

31st January, 2022

Technology transfer for Recycling Lithium Ion Batteries (LIBs) to recover saleable metal/salts of Li, Co, Mn, Ni. Cu, Al, graphite and plastics (Know-How Transfer)

28th February, 2022

MoU Signing with OMKARA UDYOG, Jamshedpur

For contract research on "Development of rust converter composition for treatment of rusted steel".

Symposia and Workshops

Symposium on Fatigue, Fracture and Integrity Assessment (FFIA 2021) (9th-11th November, 2021)

CSIR-NML, in association with Indian Structural Integrity Society (InSIS) and Indian Institute of Metals (IIM) organized a 3 day hybrid symposium on "Fatigue, Fracture and Integrity Assessment (FFIA 2021)". Mr. Debashish Bhattacharjee, VP: Technology & New Materials, Tata Steel, graced the inaugural ceremony as the chief guest. Dr. Soumitro Tarafder, Former-Chief Scientist, CSIR-NML was felicitated in the ceremony, for his outstanding contributions in the field.

Branch Level Welder Competition (16th -17th November, 2021)

Industry Meet on Lithium Battery Recycling (25th November, 2021)

One-day industry meet on Lithium battery recycling was organized at CSIR-NML under the aegis of CSIR Bulk Chemicals Mission project and CSIR 4M theme on strategic metals. The dignitaries present in the inaugural function included Dr. I. Chattoraj, Director, CSIR-NML; Dr. R.P. Singh, CSIR-HQ, New Delhi and Dr. Sanjay Kumar, Chief Scientist, CSIR-NML. The event was attended by 27 organizations outside CSIR domain. Some of them were Renault-Nissan, Star Exports, SD Auto, Auto Fibre Craft, Reamp technologies, Hira Ferro Alloys, E-Reclaim and Li-Circle. The event ended with signing of agreements with two startups, Reamp Technologies and Star Exports, who were also keen to become technology licensee on lithium battery recycling with CSIR-NML.



Online outreach program of IISF 2021 on Celebrating Creativity in Science, Technology and Innovation for Prosperous India (29th November, 2021)

Trainings and webinars

Training on Multidisciplinary Materials Technology

The training was organized to promote multidisciplinary R&D activities like software, sensors, tools, devices, IOT, Machine Learning, AR & VR and other systems development. Students/ Graduates were eligible to attend this Societal Training Program (STP).

Webinar on Idea to Innovation : Role of Patents

16th July, 2021

The webinar was organized by the NML-Intellectual Facilitation Center for the benefit of startups. A total of 91 participants attended the program.

Professional Training Program: "Metallurgy for Engineers (M4E)"

24-27th August, 2021

Science and Science Teacher Conclave

27th August, 2021

Webinar on "IP Strategy for Brand Building" by NML-IPFC

31st August, 2021

CSIR-National Metallurgical Laboratory- Intellectual Property Facilitation Center in association with MSME-Development Institute, Ranchi, organized this webinar for the benefits of Entrepreneurs, MSME's, Startups and Others. 30 participants joined the program.

Corporate Training Program for CIPET officials

13th-17th September, 2021 & 27th September-1st October, 2021

Training on "Applied Chemistry in Metallurgy"

20th- 22nd September, 2021

Training program on "Secrets of Intellectual Property : Why Should we Protect It!"

4th October, 2021

180 participants attended the program conducted by Intellectual Property Facilitation Center of CSIR-NML.

Webinar on "Design, Develop and Distinguish: Innovation on Industrial Designs and Protection"

29th October, 2021

70 participants attended the program conducted by Intellectual Property Facilitation Center of CSIR-NML.

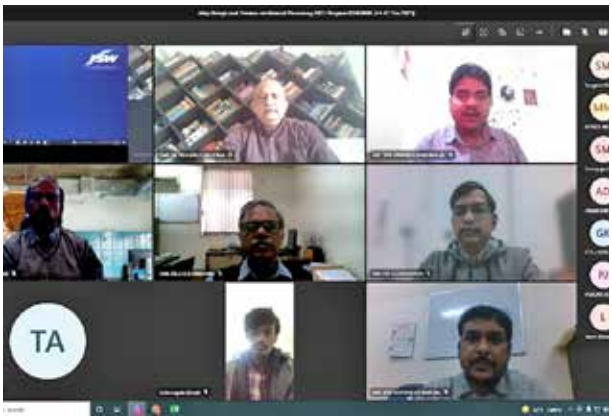
Webinar on "Copyright protection in India"

3rd December, 2021

37 participants attended the program conducted by Intellectual Property Facilitation Center of CSIR-NML.

Webinar on "Alloy Design and Thermomechanical Processing 2021"

14-17th December, 2021



Webinar on "Success Story on Commercialization of CSIR-NML Column Flotation technology"

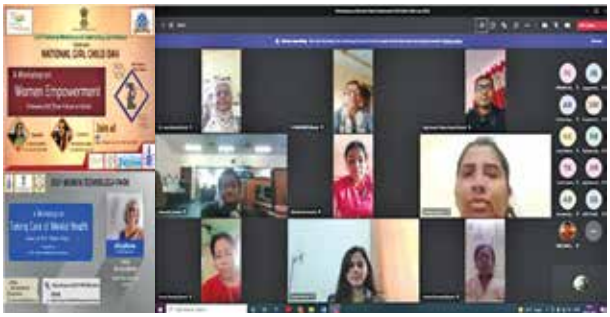
16th December, 2021

As a part of the "Azadi Ka Amrit Mahotsav" and CSIR@80 celebrations, the webinar was organized to disseminate information on CSIR-NML's many

successful commercializations of the named technology.

Jigayasa Virtual Laboratory Program "A workshop on women empowerment"

24th January, 2022



Webinar on "Patent Protection Strategy for Start-ups & MSMEs Economic Growth"

3rd February, 2021

41 participants attended the program conducted by Intellectual Property Facilitation Center of CSIR-NML.

Corporate Training on "Fatigue, Fracture and Creep Behavior of Materials"

The training was conducted by CSIR-NML for the Quality Assurance Officers of the Indian Navy (Regional Aeronautical Quality Assurance Service, INS Shikra, Colaba, Mumbai)

Job Oriented Training under DST sponsored "Women Technology Park" 11th February, 2022

Webinar on "Popular Lectures on Computational Materials Science" 11th March, 2022

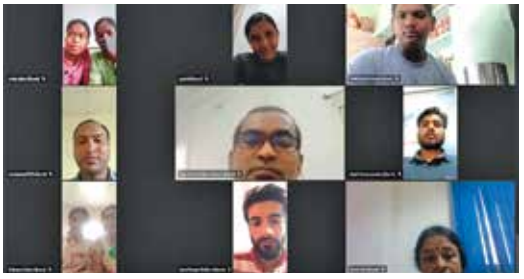
Webinar on "IP strategy for trademark protection and brand building"

30th March, 2022

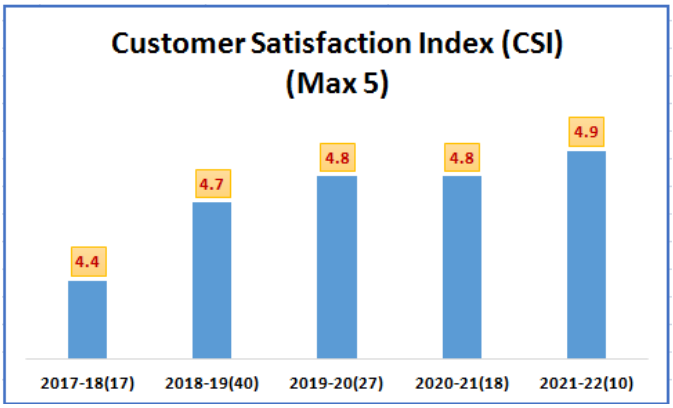
37 participants attended the program conducted by Intellectual Property Facilitation Center of CSIR-NML.

Workshop on Video Editing

31st March, 2022



Customer Satisfaction Index & Feedbacks



Very good; Timely execution of the project (CLP 205)

Overall approach towards the testing works were very good with great response towards the sample collection and data representation.; Although the testing of water samples has been completed, the report has provided insights towards potential corrosion allowance and subsequent pipe selection. Benefits in terms of cost are yet to be realized. (M/s. Tata Steel Ltd , SSP 1162)

Overall experience with NML is very nice. On time and transparency is fantastic.
(M/s Mageba Bridge Products Pvt Ltd Kolkata, SSP 1264)

Good response for any requirement, can be contacted easily. Feedback based on the limited service taken from lab. (M/s. SGS India Pvt Ltd, SSP 1219)

We feel privilege to associate ourselves with CSIR, its people and technology. The research being conducted is remarkable and is seen to have positive impact on common people, society, and economy at large. At MetaOre, we will try to leverage the technology transferred to meet our motto of e-waste free India. We would like to sincerely express our gratitude to Director NML, Dr. Indranil Chattoraj; Project Leader, Dr. Manis Kumar Jha and his team; RPBD Head, Dr. S.K. Pal; Head MER, Dr. Sanjay Kum, Dr. Sanjay Kumar; Sr. Scientist Dr. Beena Kumari, and many other fellow scientists and researchers, with whose constant and enduring support, we are able to associate ourselves with the CSIR family. We wish and hope to further strengthen and expand our collaboration with CSIR in near future.; (M/s. Metaore Recycler Private Limited, SSP 1274)

Professional approach and Technical competence. (M/s. The New India Assurance Company Limited, SSP 1091)

Good learning experience (BARC, SSP 1074)

Completed project as per their commitment; NML, Jamshedpur should submit more project proposals needed for Coal industry like Assessment of futuristic elements like Lithium, Cobalt and Alumunium being used in battery industries in India. (M/s. Central Mine Planning Design Institute (CMPDI),Ranchi, CLP 0191)

Indian Women
Achievers

“I have always had a fascination for mysteries of outer space, and knew that's what I wanted to get into.”

Dr. Ritu Karidhal,

Scientist, Indian Space Research Organisation. She was a Deputy Operations Director to India's Mars orbital mission, Mangalyaan. She has been referred to as one of the many "Rocket Women" of India

Source: https://www.woodenstreet.com/blog/15-firsts-by-indian-women-who-have-made-the-nation-proud

Fortune 1000 and ET 500 Clients (2021-2022)

Indian Women
Achievers

"Gender does not matter.
You work as a scientist, not as a woman."

Dr (Ms) Tessy Thomas,

Distinguished Scientist, Director General of Aeronautical Systems and the former Project Director for Agni-IV missile in Defence Research and Development Organisation. She is the first ever woman scientist to head a missile project in India.

Source: https://www.woodenstreet.com/blog/15-firsts-by-indian-women-who-have-made-the-nation-proud

List of SCI Publications

1. Abhilash; Agarwal, H; Meshram, P; Meshram, RB; Jha, S; Patel, JN; Soni, M; Rokkam, K; Mashruwala, S. (2021), SEPARATION SCIENCE AND TECHNOLOGY, **56**(18), pp. 3183_3200.
2. Abhilash; Hedrich, S; Schippers, A. (2021), HYDROMETALLURGY, **202**, pp. 105621
3. Abhilash; Swetha, V; Meshram, P. (2021), CARBON LETTERS, pp. 00313-7.
4. Abhilash; Tabassum, Shirin; Ghosh, Anirban; Meshram, Pratima; van Hullebusch, Eric . (2021) METALS, 11(2), pp. 317.
5. Abhilash; Usha, Y; Seetharaman, K; Meshram, P; Mehta, KD; Pandey, BD. (2021), MINERAL PROCESSING AND EXTRACTIVE METALLURGY REVIEW, 1959329.
6. Adeleke, A A and Odusote, J K and Ikubanni, P P and Lasode, O A and Malathi, M and Paswan, Dayanand (2021), INTERNATIONAL JOURNAL OF ENERGY RESEARCH, **45**(2), pp. 1375_1395.
7. Adeleke, AA; Odusote, JK; Ikubanni, PP; Orhadahwe, TA; Lasode, OA; Ammasi, A; Kumar, Krishna (2021), SCIENTIFIC REPORTS, **11**(1), pp. 547_556.
8. Akcil, A; Ibrahim, YA; Meshram, P; Panda, S; Abhilash (2021), JOURNAL OF CHEMICAL TECHNOLOGY AND BIOTECHNOLOGY, **96**(7), pp. 1785_1797.
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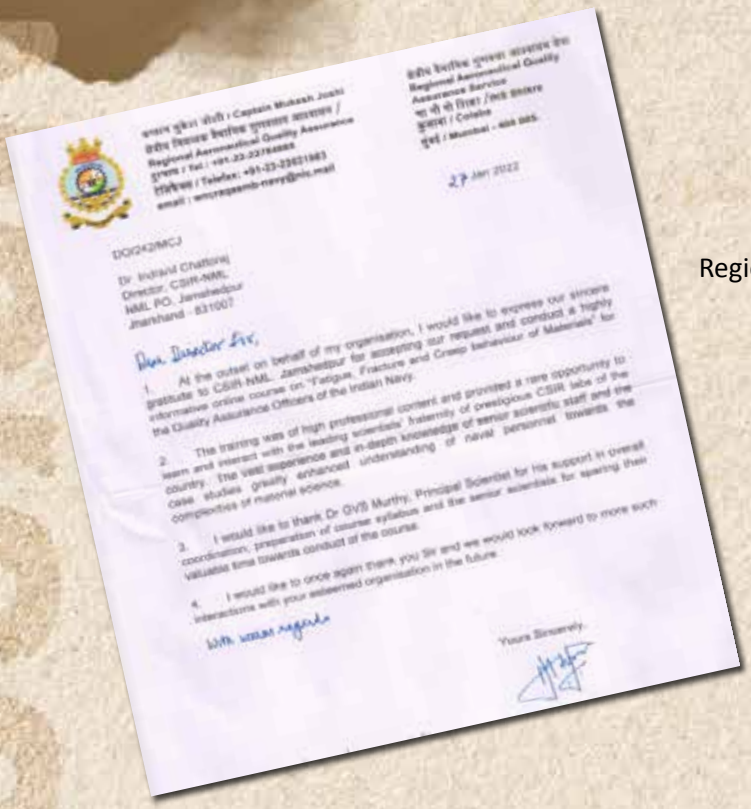

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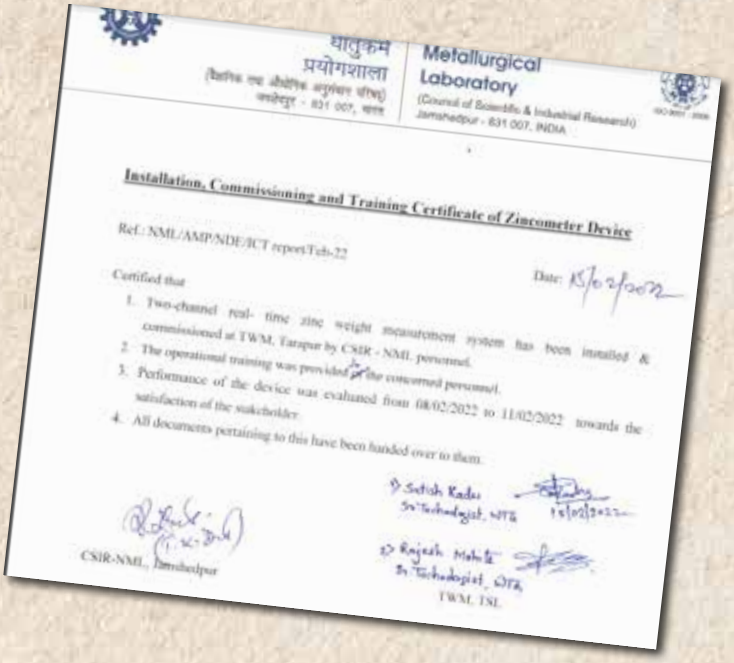

R. Jayagovindan
30th March 2022

Thank you for arranging a very good Informative & Educative program Webinar on IP ***Strategy for brand building for MSMEs and startups***. Kindly convey my thanks to both the speakers and the organizers.

Intellectual Property Rights

Patent No.	Title	Year	CSIR No.	Application No.	Inventors
616	Durable Anti-icing and Hydrophilic Copper-based Alloy Coating Grown by HVOF method	2022			Paritosh Dubey, Lokesh Chandra Pathak, Himangshu Bapari, and Hemant Das
615	A Simple And Cost-Effective Process For Developing High-Quality Titanium Based Max Phase	2022			Pallab Bhattacharya, Nisha Gupta, Trilochan Mishra, Himangshu Bapari
614	Process For Extraction Of Lithium As High Pure Lithium Carbonate From Spodumene Ore/ Concentrate	2022			D Mishra, KK Sahu, Saurabh Shekhar, MK Mohanta, Shobhana Dey, K Hembrom, Tanusree Dutta, Rahul Kumar
613	Process For Extraction Of Lithium As High Pure Lithium Carbonate From Lepidolite Ore	2022			D Mishra, KK Sahu, Saurabh Shekhar, Manoj Kumar Mohanta, Rahul Kumar, Suhani Kumar, Tanusree Dutta
612	Production of electrolytic grade metals (Cu, Ni, Co, and Mn) from the purified leach liquor of different solutions of e-waste	2022			MK Jha, Jhumki Hait, Ranjeet Kumar Singh, Sanchita Chakravarty, Pankaj, Rekha, Om shankar dinakar
611	A process to recover Lithium and Manganese metal from the effluent and black cathodic material of Li-bearing spent battery	2021	0173NF2021	202211013669	Manis Kumar Jha, Ranjeet Kumar Singh, Pankaj Kumar Choubey*, Archana Kumari*, and Rekha Panda*
610	Low alloyed thicker section abrasion resistant steel and method of manufacturing thereof	2021		202231004340	Gaurav Kumar Bansal, Snehashish Tripathy, Avanish Kumar Chandan, V. Rajinikanth, VC Srivastava
609	A Novel Closed-Loop Extraction-Separation-Utilisation Process For Recovery Of Rare Earth Elements From Ground Granulated Blast Furnace Slag And Synthesis Of Building Materials From Residue	2021	0225NF2021	202131057022	ABHILASH, PRATIMA MESHRAM, SUSHANT KR. NATH
608	A New Process For Selective Extraction-Separation-Recovery Of Lithium From Spent Lithium Based Batteries Of Any/Mixed Chemistry	2021	0142NF2021	202111040165	Abhilash, Pratima Meshram, Sanjay Kumar

Patent No.	Title	Year	CSIR No.	Application No.	Inventors
607	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	2021	0140NF2021	202111040164	Pratima Meshram, Abhilash, Sanjay Kumar, Vikash Bharti
606	Synthesis of biomass-derived heteroatom-doped porous graphitic carbon and metal phosphides / oxides / sulphides based composite for energy storage application	2021	0131NF2021	202111052186	Pallab Bhattacharya, Nisha Gupta
605	A process for arrangement of amorphous / nanostructured microwires in an array for enhancement of signal response in a magneto-impedance sensor	2021	0105NF2021	202111039713	Ashis Kumar Panda, Somnath Das, Tarun Kumar Das, Premkumar Murugaiyan, Rajat Kumar Roy, Abhishek KS
C100	CSIR-NML_IPFC - A website for management of activities of Intellectual Property Facilitation Centre at CSIR-NML	2021			Beena Kumari, SK Pal, Santosh Tiwary, Sudhakara Rao Kogapu, Ashish Upadhyay

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One day workshop on lithium battery recycling at NML

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जंग प्रतिरोधी टीएमटी बार उत्पादन के लिए टाटा स्टील में चल रहा प्रौद्योगिकी परीक्षण

- सीएसआईआर-एनएमएल में राष्ट्रीय प्रौद्योगिकी दिवस पर हुआ ऑनलाइन व्याख्यान

मनीषा व अंजू को सर्वश्रेष्ठ शिक्षक अवॉ

चमकता आईन

Popular Science lecture series on 'Sphere of Materials around us' organised at the CSIR-NML

सीएसआईआर–एनएमएल के स्वच्छता पखवाड़ा में हो रहे कई कार्यक्रम

एनएमएल ने किया स्वच्छता पखवाड़ा का आयोजन

CSIR - NML workshop on Women Empowerment on the occasion of National Girl Child Day

Mail News Service

THE AVENUE MAIL

THE AVENUE MAIL — 12
Jamshedpur, Wednesday, March 10, 2021

NML salutes 'Matru Shakti'

Mail News Service

Integrated Skill Initiative Industrial R&D Training at NML

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प्रभात खबर

अब देश में ही लिथियम आयन बैटरी का हो सकेगा उत्पादन

Women should be determined to excel in STEM: Dr. Arvind Sinha

International Women's Day celebrated at the CSIR-NML

Mail News Service

एनएमएल के कर्मियों व परिजनों को लगा टीका

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

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टाटा स्टील टीएमटी बार को जंग
बचायेगी एनएमएल की टेक्नोलॉज

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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.

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