CSIR-National Metallurgical Laboratory
(1950-2020)

70 years of unalloyed excellence

वार्षिक प्रतिवेदन 2019-20
Annual Report 2019-20



CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, India

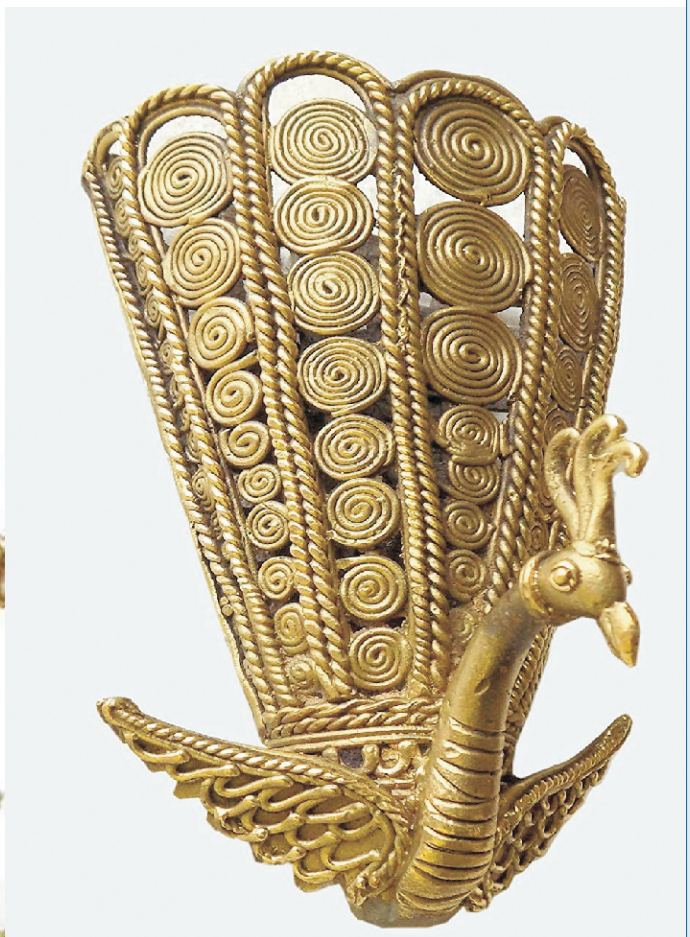
Dhokra - *The Tribal Metal Art*

Dhokra is non-ferrous metal casting process that is using the lost-wax casting technique in India for over 4,000 years. One of the earliest known lost wax artifacts is the dancing girl of Mohenjo-daro. The product of Dhokra artisans are in great demand in domestic and foreign markets because of primitive simplicity, enchanting folk motifs and powerful form. Dhokra horses, elephants, peacocks, owls, religious images, measuring bowls, and lamp caskets etc., are highly appreciated. There are two main processes of lost wax casting: solid casting and hollow casting. Dhokras of Central and Eastern India have traveled south as far as Kerala and north as far as Rajasthan and hence are now found all over India. Dhokra, craft from Dwariapur, West Bengal, is popular. ***Some Dhokra Sculptures-***











Source: Wikipedia and Google Images

Cover Page Image Source : http://www.un.org



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.

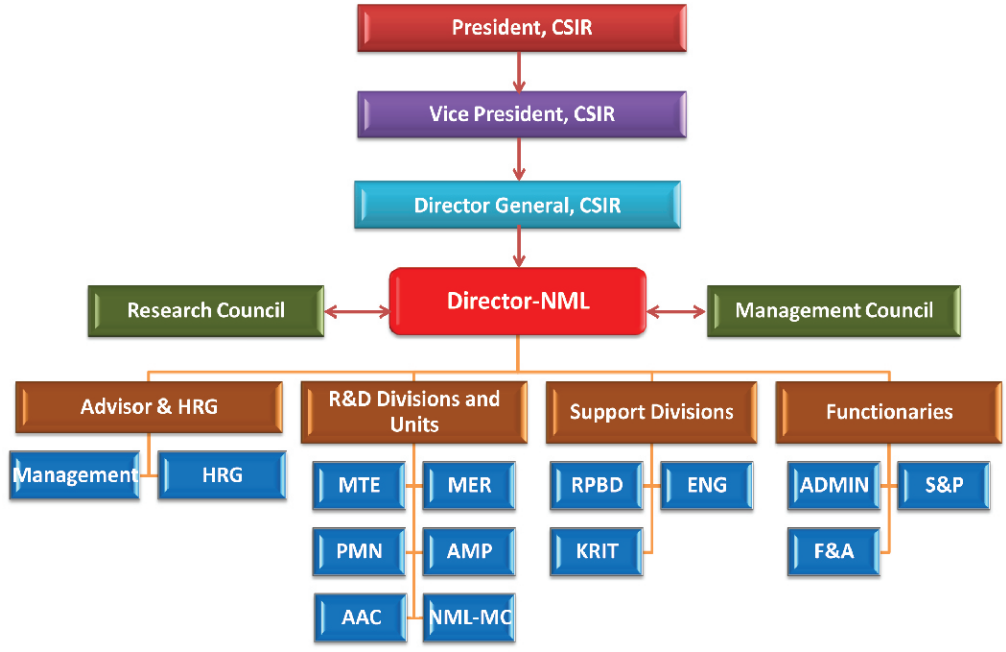
CSIR-NML envisions becoming a self-reliant, self-sufficient R&D laboratory by providing feasible and sustainable solutions to the industries in the areas of metals, minerals and materials. The laboratory strives to recreate its niche in the areas relevant for empowering the evolving India via catering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

Organizational Structure





Shri Narendra Modi
President, CSIR
Hon' Prime Minister of India



Dr. Harsh Vardhan
Vice-President, CSIR
Hon' S&T Minister of India



Dr. Shekhar C. Mande
Secretary, DSIR
Director General, CSIR



Dr. Indranil Chattoraj
Director, CSIR-NML



Dr. S. Tarafder
Adviser-Management



Dr. S. K. Mishra
Head, HRG



Dr. Sital Kumar Pal
Head, RPBD



Dr. Mita Tarafder
Head, KRIT



Shri Parvesh Kumar
Head, Engg.



Dr. S. G. Chowdhury
Head, MTE



Dr. Sanjay Kumar
Head, MER



Dr. S. Chakravarty
Head, AAC



Dr. Ratnakar Singh
Head, MNP



Dr. Arvind Sinha
Head, AMP



Dr. T.V. Vijayakumar
Head, NML-MC



Shri K. Bhattacharya
COA, ADMIN



Shri N. K. Singh
Officer, S&P



Shri A. M. Pradhan
Officer, F & A

NKN & ICT (National Knowledge Network & Internet Communication Technologies), MTE (Materials Engineering Division), MER (Metals Extraction & Recycling), MNP (Mineral Processing), AMP (Advanced Materials & Processes), AAC- Applied & Analytical Chemistry, NML-MC (NML-Madras Center), RPBD (Research Planning & Business) Development), ENG (Engineering), KRIT (Knowledge Resources & Information Technology), HRG (Human Resources Group), ADMIN (Administration), S&P (Stores & Purchase), F&A (Finance & Accounts)

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Research Council (RC)



Prof. Amol A Gokhale (Chairman)
Department of Mechanical Engineering, IIT Bombay, Former Director, DMRL, Hyderabad



Dr. Gautam K. Dey (Member)
Former Associate Director, Materials Group, Bhabha Atomic Research Centre (BARC), Mumbai



Prof. V. S. Raja (Member)
Institute Chair Professor, Dept. of Metallurgical Engineering and Materials Science, IIT Bombay



Mr. Vinay Mahashabde (Member)
Chief Technology Officer (Products),Tata Steel, Jamshedpur



Dr. Vilas D. Tathavadkar (Member)
Senior Vice President, Aditya Birla Science and Technology Company, Raigarh



Dr. R. N. Patra (Member)
Former chairman IRE, Mumbai



Prof. S. K. Bhatnagar (Member)
Former Dean, College of Biotechnology, Sardar Vallbhbhai Patel University of Agriculture & Technology, Meerut



Dr. R. R. Hirwani (Member)
Former Head, CSIR Unit for Research and Development of Information Products (URDIP), Pune



Dr. K. Muraleedharan (Member)
Director,
CSIR-Central Glass & Ceramic Research Institute, Kolkata



Dr. Arun K. Bhaduri (Member)
Director, Indira Gandhi Centre for Atomic Research (IGCAR) Kalpakkam



Prof. B.K.Mishra (Member)
Institute Chair Professor, Dept. of Metallurgical Engineering and Materials Science, IIT Bombay



Prof. Dipak Mazumdar (Member)
Ministry of Steel Chair Professor, Department of Materials Science & Engineering, IIT Kanpur



Prof. Suddhasatwa Basu (Member)
Director, CSIR-IIMT, Bhubaneswar



Dr. I. Chattoraj (Member)
Director, CSIR-NML, Jamshedpur

IMPRESSION

...This is my first visit and it has been very pleasant and revealing. CSIR-NML has carried a very rich legacy. It continues to do extremely well, which is pleasing to see. There are lots of hopes, which I am confident that CSIR-NML will fulfill in the coming years. All the best to CSIR-NML family.

Shekhar C. Mande, *Director General, CSIR, New Delhi*
21st April 2019

...It was my honor and pleasure to visit NML on its foundation Day and deliver the Nijhawan Memorial Lecture. Excellent work is being done at NML, which can be converted into technology, particularly for waste management and valorization. Kudos to all scientists and the Director, Dr. I Chattoraj for his inspiring leadership. I also remember one of its previous directors, Prof. Altekar who come from ICT (then UDCT), Mumbai, my almamater. Today being the constitution Day, it was a special day.

G.D. Yadav, *Institute of Chemical Technology, Mumbai*
26th of November 2019

...As per the agreement of project "Improvement of the mechanical property and microstructure of continuous annealed cold rolled dual phase 590 MPa grade steel" we have achieved Hole Expansion more than 50 % in our plant trail from the given process parameter of NML. The tensile strength and Lankford value in C direction is also achieved. We wish to thank you for your help and support during the project and also in evaluating plant annealed sample.

Ajit Kumar Thakur, *Manager Technology & QA*
JCAPCPL, Tata Steel Ltd.
12th February 2020



Foreword

I write this foreword in the shadows of events of the recent past, which will be a watershed of shorts in modern human history. I am of course referring to the pandemic, which has crippled the world and which will have far-reaching effects on our social, economic, biological and possibly political landscapes. However, humans are a resilient species and I am sure that, although it may take months or years, we will eventually be back to our old forms, albeit with modulations in our daily habits.

The fiscal year 2019-20 was a mixed year for the laboratory. It was a year, when three of our dear colleagues left us forever. The economic growth around the world, as well as in India, was low, R&D investments were consequently muted. Moreover, in the fag end of the fiscal, the Covid19 pandemic ravaged the world. However, there were several high points. Through our help and assistance the first pilot scale facility for commercial sodium production in the country is about to start. We have started the first of its kind, urban ore recycling centre in the country. The laboratory earned high satisfaction ratings from most of our important stakeholders; the average customer satisfaction index climbed to 4.8 (out of a maximum of 5). Our SCI publications were reasonable in terms of numbers (123) as well as average impact factor (~2.4).

With regards to other performance parameters, we could file 23 Patents and 3 Copyrights which were as per our annual target. We have imposed very stringent guidelines on what can be considered as a developed technology, to ensure the exclusion of trivial and non-critical technologies from our profile. Three technologies were developed in the reporting year. These were "Electrolytic Manganese Metal (EMM) from medium and low grade Mn Ores", "Recovery of vanadium as ammonium metavanadate and vanadium pentaoxide from spent sulfuric acid catalysts" and "Induction Active Sole Plate for Iron Press". Our technology transfers were three, well below our target of six for the year. The technology transfers were as follows: Extraction of Cobalt and Manganese from the Black cathodic material of Li-cobalt batteries (SBCON Recycling Private Limited, Ahmedabad), Extraction of cobalt and gold from the black cathode material of Li-Co batteries and gold coated surface of e-waste, respectively (EXIGO Recycling Pvt. Ltd., New Delhi) and Extraction of cobalt metal/salt from the black powder of Li-cobalt batteries (Evergreen Recyclekaro India Pvt.Ltd, Mumbai).

Our earnings (external cash flow) was pegged at Rs 30.25 Crores, well below a target of Rs. 42 Crores. The shortfall was due to a lack of Grant-in-aid projects and funds from such projects. On the other hand, our earnings from Industrial Projects was very good and we exceeded our target in this regard.

A number of flagship projects were undertaken by our laboratory, in this financial year, and those initiated earlier were pursued. These include the national mission programme on development of Ultra-Supercritical power plants in the country. Connected to that mission is another programme on creation of a National Centre for Development of Advanced Materials and Manufacturing Processes for Clean Coal Technologies for Power Applications. The laboratory is also pursuing a pilot scale project to develop Amorphous electrical steel for energy applications.

CSIR-NML through the establishment of an "Urban ore recycling centre" and through a proliferation of activities on e-wastes utilizations has emerged as possibly the most comprehensive laboratory in industrial wastes utilization. The focus is now on extraction of Rare Earths from all possible sources, to replenish the mushrooming needs for these elements for critical applications.

In addition to the abovementioned flagship projects, several impactful projects were successfully completed, and to the complete satisfaction of our sponsors. Some of these were: Development of a Smart Sensing System for Cold Drawn High End Wires, Self-healing Coating for Corrosion Protection of Steel and Aluminium Alloys, Annealing simulator integrated with online process control sensors for run out table process simulation, Scale up and commercialization of indigenously developed hydrogen standard in steel, and others.

I would like to express my gratitude for the continuous help and advice provide by our Director General, Dr. Shekhar C Mande. The recommendations and advice of our Research Council, the encouragement and sponsorship provided by our valued clients and sponsors, is gratefully acknowledged. The efforts put in by the laboratory employees of all categories, in difficult times, is quite praiseworthy. We, as a collective unit of kindred spirits, have resolved to overcome the hurdles which we anticipate in this financial year and to do our bit to restart the Indian economy through our research, innovations and intermediations.

Jai Hind.



(Dr. Indranil Chattoraj)
Director, CSIR-NML

CSIR-NML Responses to the Pandemic

CSIR-NML developed alcohol-based sanitizer as per WHO norms. The sanitizer is used for office sanitization and was distributed to essential services staff. It is replenished as and when required by the AAC division, and CSIR-NML will continue to make its own sanitizer for in-house consumption. CSIR-NML also developed IR Thermometers within a period of seven days for in-house use. These are deployed at the laboratory and Pilot Plant entry gates and are accurate and calibrated. This was done at a time when essential parts to make such a thermometer was difficult to obtain.



WILL MAKE MORE ONCE INFRARED SENSORS ARE BACK IN STOCK

NML develops no-contact thermometer

ANTARA BOSE

Jamshedpur: A team of CSIR-National Metallurgical Laboratory (NML) in Burmamines has developed two infrared thermometers that are necessary for temperature screening at workplaces, but are already missing from the market.

An infrared thermometer facilitates temperature checks from a distance, a feature crucial for fever screening in the wake of the coronavirus pandemic. Along with temperature checks, the use of masks and hand sanitisers have been made mandatory in all workplaces.

CISR-NML will use the two thermometers to screen its skeletal staff who are coming to office with specially issued passes.

A team led by senior principal scientist Sharmishtha Palit and comprising principal scientist Tarun Kumar Das; research fellow Chandan Dutta and project assistant Ravi Bhushan developed the thermometers that will be used at the institute's two entry gates.

The team members said making the gadget at a time when the materials weren't easily available was a challenge for them.

"The infrared thermometers are mandatory for any organisation, but we didn't get it anywhere. Also, we couldn't order those available online because their delivery wouldn't have been possible amid the lockdown. India, I believe, doesn't have too many manufacturers of infrared thermometers, and the ones that were available ran out of stock. Therefore, we decided to make them ourselves," Palit said.

Palit said that it was NML director Indranil Chattoraj who motivated the team to develop the mandatory gadget. For the team, the biggest challenge was to procure the infrared sensors, capacitors and micro-controllers. The thermometer developed by the NML team can detect temperature in the range of minus 20 to 125°C from a distance of approximately four inches.

The team is now trying to get contacts of suppliers for infrared sensors that aren't available in the market.

"Once we get the sensors, we can develop more thermometers for other organisations. We are in constant search for the product. As of now, we will use the available devices at our entry gates," Palit added.



The infrared thermometer developed by NML. Telegraph picture

IR Thermometer developed in-house which was reported in the media (The Telegraph)

The welfare committee with the help of staff club members distributed grocery packages including 5 kg rice, 5 kg wheat flour, 1. 5 kg cereals, 1 kg sugar, 1 kg salt, 1 litre of cooking oil, turmeric, tea-leaves, and bathing and washing soaps to the Janitorial services staff who were continuously working for cleaning and maintenance of the premises. Till 3rd May 2020, two rounds of support were provided.



Grocery packaging and distribution to the Janitorial services staff and others

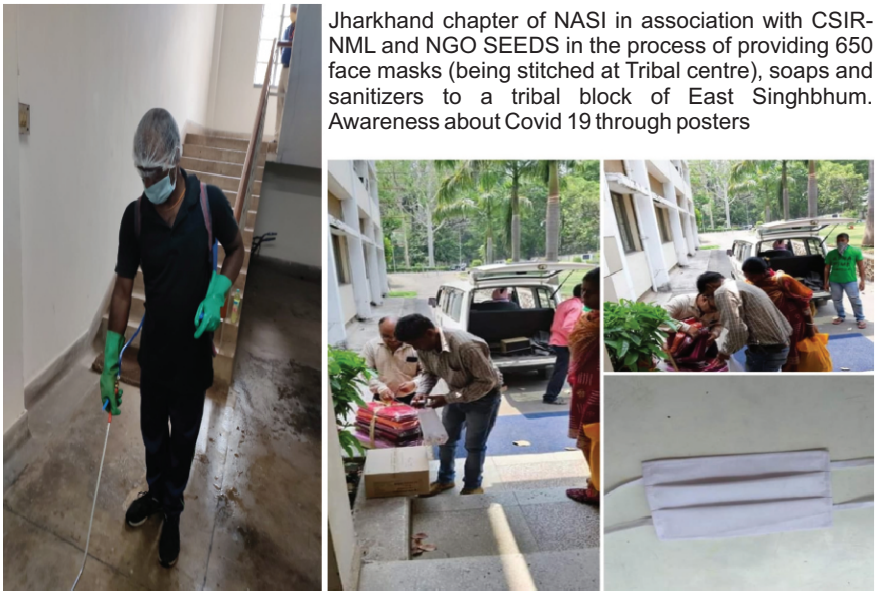
In association with the Roti Bank, Jamshedpur, home-made food packets were provided by our residents from 17th April till 3rd May 2020. More than 30 food packets were provided daily, as lunch, to Roti bank members, which were distributed in Gandhi Ashram-MGM area and Ram Mandir- Bistupur area in Jamshedpur.

Touch free hand washing system was developed and deployed at NML main campus and residential premises.



Touch-free hand washing system installed at various points including entry gates

CSIR-NML in collaboration with NASI and a local NGO distributed facemasks and sanitizers to a tribal village in the district.



Jharkhand chapter of NASI in association with CSIR-NML and NGO SEEDS in the process of providing 650 face masks (being stitched at Tribal centre), soaps and sanitizers to a tribal block of East Singhbhum. Awareness about Covid 19 through posters

CSIR-NML-NASI activities for tribal

IMPACT



Indian Coins & Coinage Metals

The history of Indian coins is comprehensive due to its artistic merit, its variety spanning across diverse regions, for its beautiful symbolism and for the legacy it has left on subsequent coinages across various parts of the world. Indian currency ranks as one of the great coinages of the world. A number of incredible facts about Indian coins highlighted in this report will uncover our unbelievable coin heritage.

The invention of metallic coins and their use as a money started around 700 BC in western world history and in ancient Indian history near about 6th century BC. The primitive coins were made of electrum, a naturally occurring pale yellow mixture of gold and silver that was further alloyed with silver and copper. Historically the precious metals were used to cast the coins but with changing time the trend has also changed towards use of most in-expensive and easily available metals for the purpose. This report highlights the journey and trends of Indian coins since the historical times to the medieval times and finally to the modern world.

The most coinage metals (or alloys) are from the three nonradioactive members of group 11 of the periodic table: copper, silver and gold, the copper usually being augmented with tin and often other metals to form bronze. Gold, silver and bronze or copper were the coinage metals of the ancient world, and most medieval coins.

Source: http://www.suvarnamohur.com/articles/7-incredible-facts-about-indian-coins.php

IMPRESSION

...Monitoring of thermal profile throughout the operation of Blow -pipe through which Hot air goes inside the furnace @1230^{0}C, can deliver early sign on erosion or local high temperature and this may help operator in preventing catastrophic failure of blow pipe. 2015 onwards, post high PCI injection rates H & I Blast furnaces had few blow pipe bursting case, due to sudden rise of blow -pipe temperature beyond design limit and led to hot metal production losses. A cross functional team comprising Blast Furnaces and R&D of Tata Steel and CSIR-NML (Dr. S. Palit Sagar & Team) and CSIR-CGCRI has worked to develop an embedded sensor based process to monitor the health of blow pipe in real-time and predict any abnormality. CSIR-NML and CSIR-CGCRI through their innovative concepts of using Fibre Bragg Grating (FBG) as sensors and its deployment at HBF of Tata Steel has made it possible to capture thermal profile of blow pipe. POC has been completed successfully. This is possibly first time in the world such development has happened in-house at H Blast furnace for one blow pipe. Now there is plan to implement solution first in all 34 blow pipes of HBF and other furnaces as well.Tata Steel congratulates the whole team for this work and look forward for further collaborations.

TATA STEEL

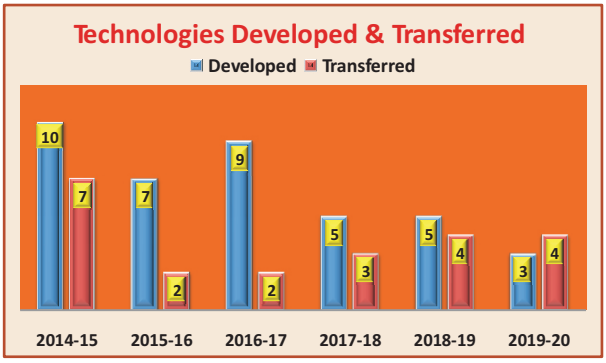
Padmapal, *Chief of Blast Furnace*
Tata Steel Limited
13th February 2020

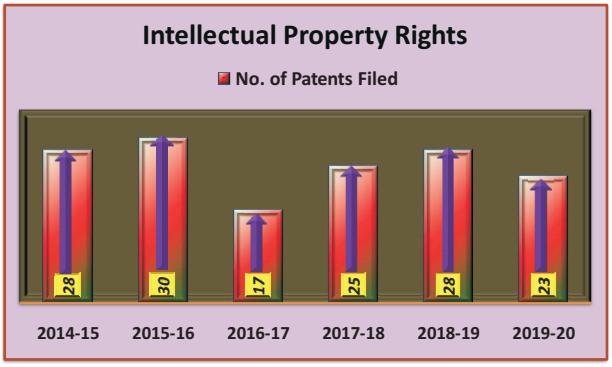
---I take this opportunity to express all my appreciation and honest thanks for the tremendous time and energy spent by CSIR NML on the collaborative study: "Effect of inclusion on pitting Corrosion on the line pipe steel", with IEOT, ONGC Panvel. The findings of the research work has established that the presence of non-metallic inclusions in steel have a definitive effect on enhancement of pitting corrosion. This becomes one of the factors responsible for accelerating failure of carbon steel components. In several failure case studies conducted by IEOT, it was found that inclusion content in the material was very high. For line pipe steels, API 5L recommends for clean steel but doesn't specify the level of cleanliness and this project has been highly beneficial for defining the level of inclusion in quantitative terms. The recommendations of the study have already been communicated to all the end users of ONGC for incorporation in the purchase order specifications for improved performance of the material.

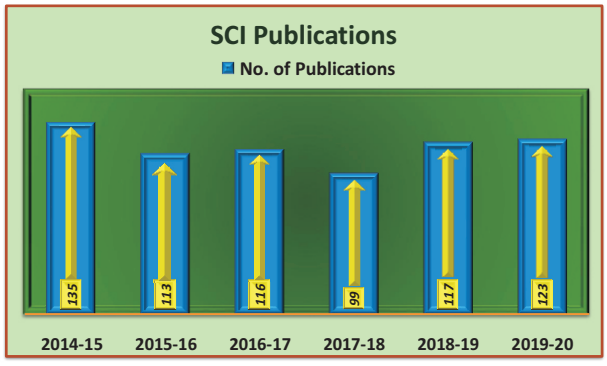
ओएनजीसी
ONGC

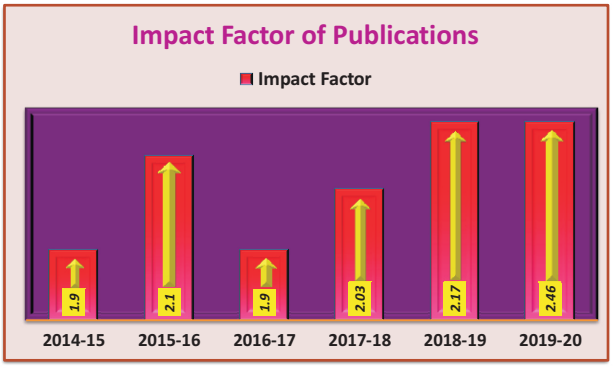
P. K. Borghate, *GM (Electrical),*
Head-Materials and Corrosion Section
Institute of Engineering & Ocean Technology
Oil and Natural Gas Corporation Ltd, Mumbai
25th October 2019

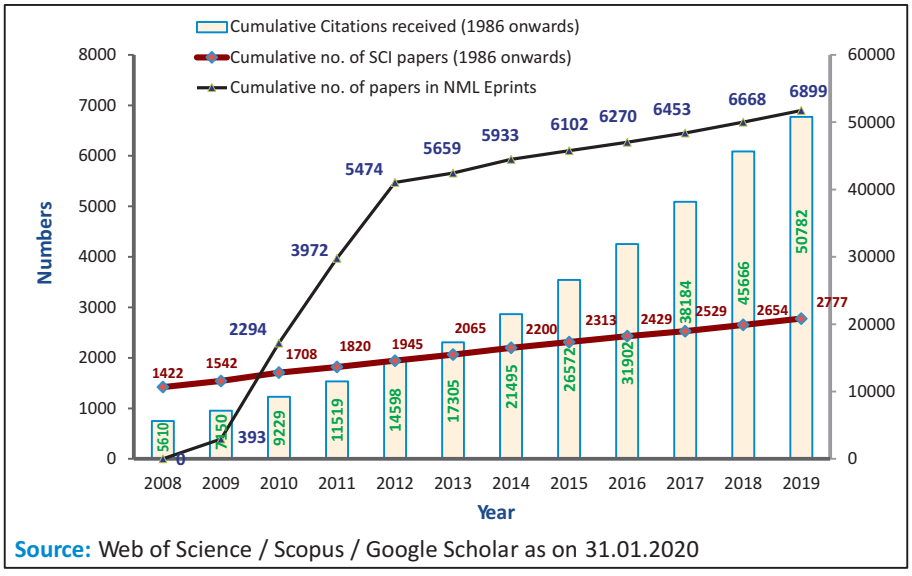
R&D OUTPUT





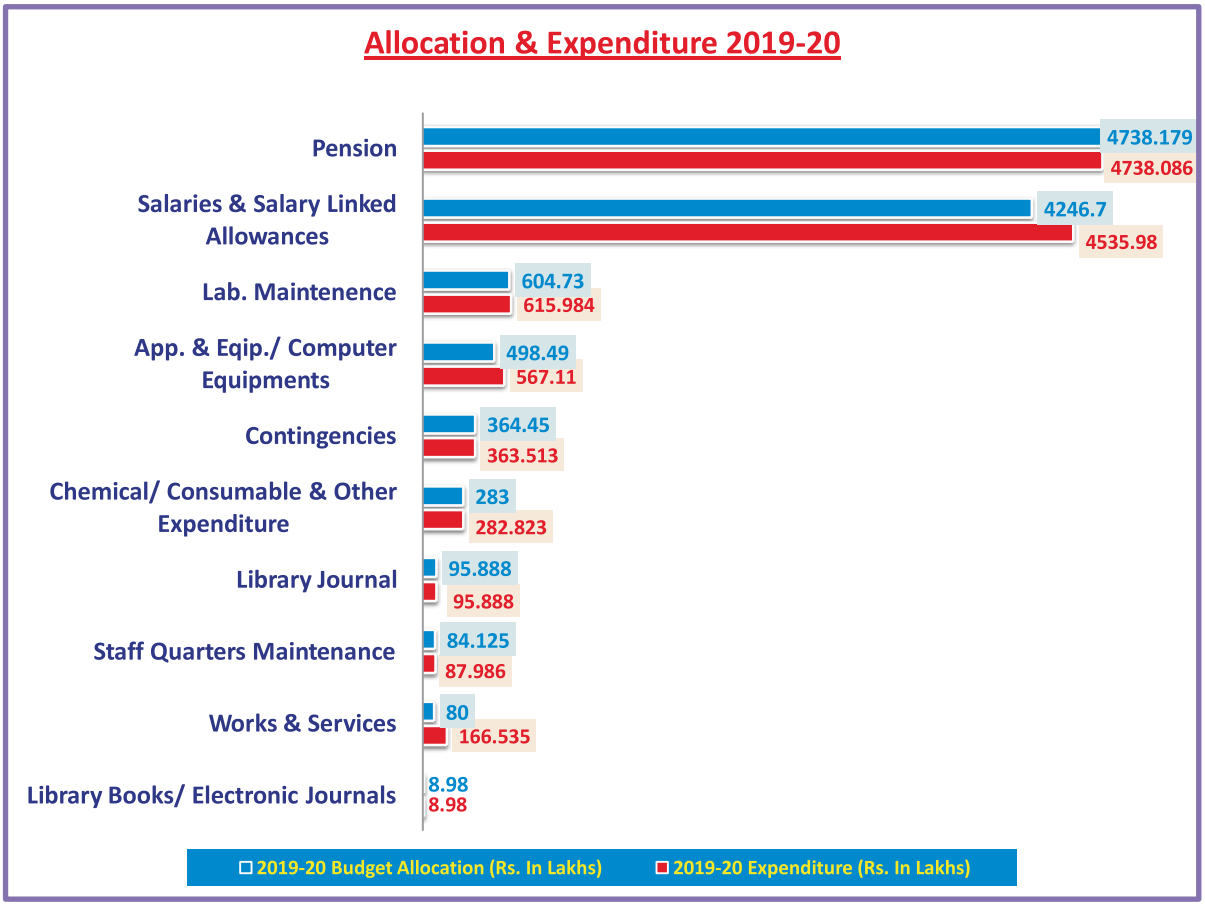


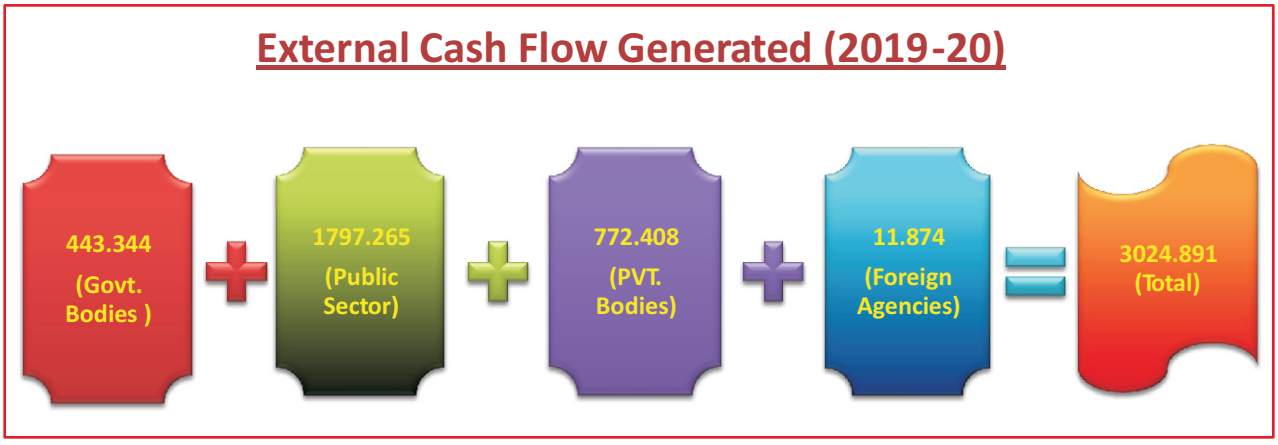




Source: Web of Science / Scopus / Google Scholar as on 31.01.2020

Budget & External Cash Flow (ECF)





New Technologies on Offer

Electrolytic Manganese Metal (EMM) from Low & Medium Grade Mn-Ore(s)

Manganese is the fourth largest consumed metal and is used in a variety of industries; from alloy and steel to batteries and catalysts. Besides applications in iron and steel industries, one of the fastest growing application sectors of this metal is Lithium Ion Batteries, where EMM has shown promise as a material for development of high storage "Manganese Rich Cathode". These technologies have already been commercialized by leading car manufacturers such as GM's Chevy Volt and Nissan's Leaf. Presently, almost all global EMM supply is from China (98%); India is having the 6th largest Mn-ore reserves, however, till date, it does not produce EMM commercially.

CSIR-NML through sponsorship from MOIL Ltd., Nagpur has developed know-how in bench scale for production of high pure (>99.85%) EMM from both low and medium grade siliceous Indian Mn ores. The developed know-has has the following advantages:

- Low & medium grade ores can be processed.
- Metal deposition current efficiency ~70%.
- EMM purity is higher than 98.8% (better than many commercial grade EMM)
- Overall Mn recovery ~95%.
- Specific energy consumption 5.2 KWh/kg, is comparable to global benchmark.

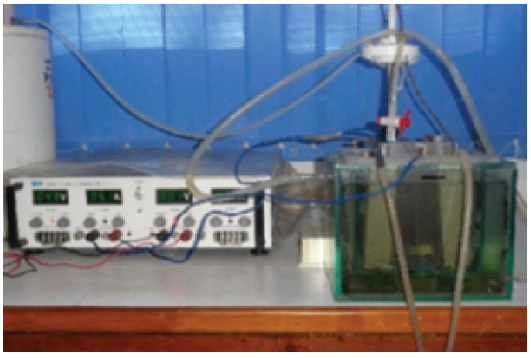


Figure 1: Bench scale set-up for EMM production



Figure 2: Produced EMM

Recovery of vanadium as ammonium metavanadate and vanadium pentaoxide from spent sulfuric acid catalysts

Spent sulfuric acid catalysts are included in Schedule - 1 list of hazardous wastes by USEPA and CPCB (India). Based on leachable concentration limits analyzed by CPCB by TCLP (Toxicity Characteristic Leaching Procedure for Soluble Threshold Limit Concentration (STLC), the maximum permissible limit of vanadium in the waste should be $\leq$ 24ppm. Keeping this in view, it would be appropriate to utilize the spent catalysts of contact process to extract vanadium. However, it consumes large amounts of acid since the alumina carrier, the bulk of the

catalyst, also dissolves and the downstream processes to produce separate products of high purity are relatively complex. In view of the high price of vanadium (128USD/lb for AMV and 380USD/lb for V_2O_5) and the toxic effects a technology is developed jointly with Hindustan Zinc Limited, Udaipur to synthesize >98-99% pure vanadium as ammonium metavanadate (AMV) and vanadium pentaoxide (V_2O_5), with <0.9% impurity as per international high pure grade specifications. With acid leaching using 20-30% solids, 96-98% V could be extracted. The leach liquor was subjected to selective sequential precipitation route to extract 98.6% pure vanadium as ammonium metavanadate and >99% pure as vanadium pentaoxide (V_2O_5). High pure silica is a derivative product of the process. This technology can save landfill costs for this hazardous waste and earn green certifications apart from monetary benefits of producing this high cost strategic element in most desired marketable form.

The technology encumbers salient features like :

- Low cost acid leaching and low temperature process
- High pure (>98%) vanadium product(s)
- High pure (>99%) silica is a by-product
- Easily replicable on large scale
- Closed loop recycling of reagents
- Low Incubation time and high returns



Induction Active Sole Plate for Iron Press

CSIR-NML has developed a Energy efficient Iron Press. The developed sandwiched sole plate has the following features like - (I) 3 mm thick Al plate (non-ferrous) which can be used at the bottom of the sandwiched plate, (ii) Heat retention capacity is high, heat loss < 5°C /min and (iii) ~50 % energy saving compared to electro-heating iron press. The Sole plate cost ~ 100 / piece.



Figure 4: Induction Active Sole Plate

Impact Making Technologies / Technologies Commercialized

Piloting of the process for Production of Pigment Grade Iron Oxide from Waste Ferrous Chloride Generated from Steel Pickling and Ilmenite Processing Units

Iron oxide finds major applications as paints because of its high tinting strength, hiding power, color fastness, chemical and heat resistance, infrared reflectance, ultraviolet absorption and easy dispersion. India's overall demand for iron oxide pigment is about 2.0 L MT and more than 50% of its requirement is fulfilled by imports from China, Japan and Germany. CSIR-NML developed a process for production of high end pigment grade iron oxide from waste ferrous chloride steel pickle liquor. Ferrous chloride from steel pickling as well as Ilmenite processing units are generated in huge quantities, which is usually neutralized and disposed. However, CSIR-NML's iron oxide process can utilize these wastes as potential resource for production of high end pigment not only to generate revenue but also to minimize environmental hazard. Mono-dispersed and uniform size particles in nano/submicron ranges were produced by utilizing the process. The pigmenting properties of the iron oxides were found to be promising and are comparable to few rare grade red pigments available in the international markets. The process was demonstrated at a kilogram scale and transferred to Tata Pigments Ltd, Jamshedpur and M/s Rang Sarjan Chemicals, Gujarat. Realizing the potential of the process, CSIR-NML decided to pilot the process at 50 kg scale under CSIR's Fast Track Transformation (FTT) scheme to build confidence amongst interested entrepreneurs.

About 1000 L of waste ferrous chloride from steel pickling process and 2000 L from ilmenite unit were collected. The impurity content in Ilmenite processed solution was found to be higher than steel pickling solution. Initially the ferrous chloride solution was converted to ferric state by passing chlorine gas in a setup of 10 L capacity cylindrical FRP reactors in series. Chlorine gas oxidation was done in counter current mode using a fine bubbler at the bottom of the reactor. Several batches of precipitation experiments at 5 kg scale were conducted to produce both lighter and darker variety of iron oxide. The products were tested for their pigmenting properties and were found to be comparable to various standard grades of iron oxide. The process takes care of impurities in



Figure 1 : Iron Oxide filtered cake

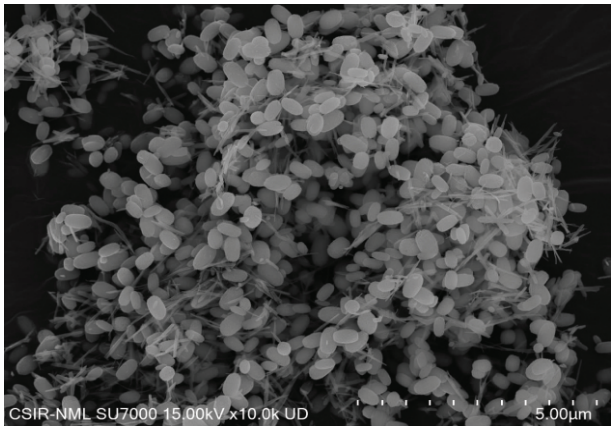


Figure 2: Micrograph of iron oxide produced

solution and therefore the ferrous chlorides from both the sources were found to give desired quality products. Precipitation experiments at 50 kg scale were also carried out successfully using a 500 L autoclave and the products are being tested for their pigmenting properties. M/s Rang Sarjan Chemicals has already set-up a commercial plant for iron oxide production from pickle liquor using CSIR-NML's process.

Improvement of Manganese Recovery from Reduced Manganese Ore

In recent years Electrolytic Manganese Dioxide (EMD) has emerged as one of the major ingredient of lithium ion and other rechargeable batteries. The components of lithium ion batteries are expected to increase from ~0.7 million MT in 2018 to over 10 million MT in 2030. India is producing only about 0.2% of the global demand of ~4.5L MT for EMD. M/s MOIL Ltd., is the only producers of EMD in India with an installed capacity of ~1500 MT. Looking at the future demand for EMD, MOIL Ltd. is planning to set up a 10000 MT EMD production plant by 2020 and subsequently to increase production capacity to 40000 MT with enhanced product quality in terms of purity.

M/s MOIL Ltd. is using a reduction roasting - leaching and electrowinning process for production of EMD and their Mn recovery during leaching is about 60-65%. It was also observed that some MnO_2 remains unreduced in the matrix and does not dissolve during sulphuric acid leaching. This resulted in low recovery of manganese. The unreduced manganese dioxide present in reduced ore was targeted to improve manganese dissolution. MnO_2 can easily be dissolved by in-situ chemical reduction during leaching. Therefore various low cost reductants such as saw dust, molasses and ferrous sulphate pickle liquor were added during dissolution maintaining similar leaching environment and it was observed that certain additions give the highest improvement in Mn recovery. The additive was available cheaply. Under optimized condition about 18-20% improvement in Mn recovery was achieved during leaching. High purity EMD containing <30 ppm Fe was produced from purified Mn leach solution. The grade is suitable for lithium ion battery application. The improved process requires lower roasting temperature and therefore can avoid the chance of over-roasting, which is also a cause for lower Mn recovery in the pre-existing process. The process was demonstrated at a kilogram scale to MOIL and Ministry of Steel personnel with about 20% higher Mn recovery. The process was also demonstrated at MOIL Dungri plant with similar improvement in Mn recovery.

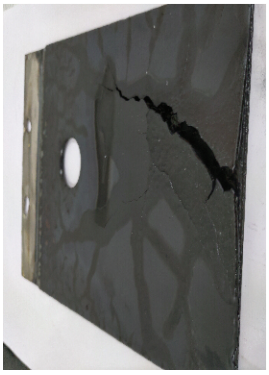


Figure 3 : EMD deposited anode



Figure 4 : Demo at kg scale at CSIR-NML



Figure 5 : Plant scale demo at M/s MOIL plant

Based on the success achieved, M/s MOIL Ltd. and Ministry of Steel decided to set-up 1500 MT high pure EMD production by the end of 2020 with the help of M/s MECON Ltd., which will subsequently be scaled-up to 10,000 MT.

Development of Indigenous Technology for production of Sodium Metal at Commercial Scale

Sodium never occurs in the free-state due to its high reactivity. Sodium metal has extensive technical and industrial applications in drugs, pharmaceutical, petroleum, plastic and atomic sectors. The total demand of sodium metal in India is very high and the demand is being met by import only. CSIR-NML is working to develop and commercialize sodium metal production technology in India. CSIR-NML has started the activity for production of sodium metal from 2008 onwards through designing the closed sodium cell at 500A capacity. The 500A closed cell was successfully commissioned and operated continuously for 20 days and produced significant amount of high pure sodium metal. Based on the success of the CSIR-NML's sodium metal production, a pilot plant of 3000A capacity was installed and commissioned at the site of SRHHL, Kurnool in 2019 to meet their captive demand of sodium metal. The 3000A closed cell was fabricated and successfully commissioned and operated continuously for a month and produced significant amount of required grade of sodium metal with cell efficiency of 82% and with a minimum purity of 99.8%. Based on the pilot scale operation, the setup of industrial plant is under progress at the site of SRHHL, Kurnool at their premises in association with CSIR-NML's technical expertise. In this regard an engineering consultant has also been associated. The proposed plant is aimed to produce 2 ton/day sodium metal and the plant is expected to be commissioned by 2021.



Figure 6 : 500A cell (1)



Figure 7 : Chlorine treatment (2)



Figure 8 : Sodium tank (3)



Figure 9 : Sodium storage (4)

Scale-up design, Fabrication and operation of 3000A close cell at M/s SRHHL, Kurnool



Figure 10 : Sodium plant (5)



Figure 11 : Cell (6)



Figure 12 : Sodium collection (7)



Figure 13: Sodium metal (8)

Impact on Society

Preparation of need based DPR for five Bell, Brass and Utensils clusters of West Bengal.

Brass and bell metal handicrafts are traditional cultural heritage of the Indian society. The brass and bell metal artisans are still following age-old traditional process for making brass artifacts, utensils, etc. The process flow is presented below. Aesthetic and utilitarian values of the product are the underlying forces that encouraged continuation of such traditional products and production process. However, lack of innovation and modernization, led to a variety of problems ranging from raw material to marketing of products. The artisans, at present, collect the raw materials like brass and bell metal in the form of scrap from "Mahajans" and deliver finished goods to the same "Mahajans". In return, the artisans receive the "conversion charges" from the "Mahajan". As the entire process is individual centric, it was felt that the earnings of artisans can be improved substantially by proper technological intervention through creation of common facility centre (CFC), efficient process and equipment with minimal alteration of their traditional practices.

CSIR-National Metallurgical Laboratory, Jamshedpur, was identified by the Directorate of MSME, Government of West Bengal, to prepare Detailed Project Reports (DPRs) for setting up Common Facility Centre (CFC) for the following clusters :

1) Brass and Bell Metal Utensils Cluster Kashipur, Purulia, West Bengal.
2) Bell Metal Cluster, Suklai, West Bengal.
3) Bell and Brass Cluster, Lalbazar, Shyamnagar, Bankura West Bengal.
4) Brass and Bell Metal Utensils Cluster, Khagra, Murshidabad, West Bengal.
5) Brass and Bell Metal Utensils, Kaliganj, Nadia, West Bengal.



Figure 1: Process flow for making utensiles

Based on the inputs from the General Manager (GM)/ Industrial Development Officer (IDO) of District Industry Centre (DIC), artisans, site survey, and discussion with vendors at their site as well as at CSIR-NML, the DPRs have been prepared which contain present art (survey data), SWOT analysis, requirement of Common Facility Centre (CFC), technology intervention, details of CFC including proposed business model, cost analysis, and impact on environment and health.

Female Literacy Drive Program

CSIR-NML in association with Central Board for Workers Association, Ministry of Labour and Employment, Government of India, organized a three months literacy program for 30 illiterate/semi-literate women staff of the laboratory. These women staff were in contractual as well as permanent positions in the laboratory as Multi-Tasking Staff, Janitorial Staff and Office-Peons. The women Scientists, Technical Officers and other S&T staff took on the responsibility of tutors for the program. After 3 months of continued teaching the students appeared for the exam and those who could clear the exam received certificates as well.



Figure 2: Inauguration program on 3rd June 2019



Figure 3: Valedictory program on 3rd September 2019

Jigyasa-School-NML Interactive Programme

Under the mission programme of societal development, the Jigyasa-School-NML interactive programme was initiated at CSIR-NML. Since 2011, a total of 20,000 students and faculties have already participated in this programme. During 2019-2020, the programme became extremely popular among school students. CSIR considers this activity of high importance and significant social benefits. During the reporting period, 770 students and 45 teachers visited CSIR-NML from 15 schools in and around Jamshedpur. The program prioritizes schools that are directly governed by the Ministry of Human Resources & Development. Kendriya Vidyalaya, Ranchi zone has sent a total 200 students and 6 faculties in three different batches.



Figure 4: Jigyasa - SNIP Programme

CSIR-Integrated Skill Training Initiative

Manual Metal Arc Welding and Gas Cutting

A total of 5 trainings were organized on the above subject in the laboratory. A total of 50 participants were imparted trainings for 1 month duration.

The objective of these trainings were to enable candidates for the job of a "MMAW Welder", in the "Capital Goods" Sector and also to build the following key competencies

- Carry out preparations for performing MMAW & Oxy-Fuel gas cutting operations using Welding Machine
- Carry out MMAW & Oxy-Fuel Gas cutting- Welding operations
- Work safely following health and safety standards

The course was so designed to cover manually weld carbon and low alloy steels using Manual Metal Arc Welding, Shielded Metal Arc Welding, Oxy-fuel gas cutting, Basic health and safety practices at the workplace

The trainees were mostly from Tentla, Chandpur Ghrampanchayat of East Singhbhum district of Jharkhand and from Purulia district of West Bengal. The participants were unemployed youths from financially weak sections.



Figure 1: Manual Metal Arc Welding

Most of them finished ITI / Diploma. The aim of the training was to increase their employability or to equip them to start their own business in this sector. After completing the training program 18 out of 50 participants showed interest to start their own business. According to them people in rural area are moving towards concrete houses which involves significant amount of welding work. If they open a welding shop at their village they will get adequate customers.

Entrepreneurship Development Program on E-Waste Collection and Deconstruction

A total of 4 trainings were conducted at CSIR-National Metallurgical Laboratory, Jamshedpur; while one training was organized at National Institute of Foundry and Forge Technology, Ranchi; and Purulia Polytechnic, West Bengal. The training duration varied from 5 days to 10 days and 203 participants were trained. Participants were mostly from ITI / Diploma and BBA students. This program aimed at training candidates for the self-employment as an e-waste collector and promoted environment friendly e-waste disposal, by imparting adequate knowledge of handling e-waste and their hazardous effect.

In these programs the participants were given training on communication skills and professional skill; basic knowledge about e-waste & its hazardous effect on human health and environment; lectures by NML Scientists on



Figure 2: E-Waste Collection and Deconstruction



Figure 3: Participants in EWCD Programme

Additionally, an "In Plant Training on Deconstruction and Up cycling of E-Waste" was also conducted. In this training 26 diploma girl students from Ghamaria Women's Polytechnic Institute had participated. The training was designed to train young and aspirant students in the areas of basic electronic components, circuit designing, and soldering skill. The students were also given hand on deconstruction of old CPU (e-waste) and on how the parts can be utilized in other electronic device to increase the life span of the parts.

Management Development Program on Export Marketing of Metal Craft

CSIR-National Metallurgical Laboratory in collaboration with MSME (Micro, Small and Medium Enterprises) Development Institute, Ranchi, organized a 5 days training program on "Management Development Program on Export Marketing of Metal Craft" during 16th December 2019 to 20th December 2019. A total of 27 participants attended the training program. The trainees were from Tribal Indian Chamber of Commerce & Industry, Jharkhand (TICCI). In this training, the participants were imparted knowledge about MSME, Government scheme for MSMEs, Dokra Casting, Export procedure and Schemes, Energy Efficient Furnace and Anti Tarnishing Lacquer.



Figure 4: Export Marketing of Metal Craft

Industrial Training on Materials and Metallurgical Engineering

Three Trainings were conducted for 112 participants in the areas of materials and metallurgy. The participants were students of Purulia Polytechnic, West Bengal, Adityapur polytechnic college, and Beheragora Polytechnic College. In this training program they worked with different scientists.

EDP on Innovative Product Prototyping for MSME (IPPMSME)

Two Trainings were conducted on Entrepreneurship Development attended by 47 participants. These 5 days training programs focused on the following aspects.

- Developing core and professional skills necessary for entrepreneurship development
- Product ideation, design and development
- Advertising and active learning on product selling
- Facilitating innovation in the tinkering laboratories in schools, colleges and other institutions

The participants were mostly college students, job aspirants, entrepreneurs, researchers and young professionals. They were introduced to various government schemes which can support them financially as well as constitutionally. As the result of this program some participants registered their business in Udyog Aadhar portal.



प्रभात खबर

इ वेस्ट रिसाइक्लिंग है समय की मांग

एनएमएल

लाइफ रिपोर्टर @ जमशेदपुर

काउंसिल ऑफ साइंटिफिक एंड इंडस्ट्रिल रिसर्च की ओर से एनएमएल जमशेदपुर में पिछले एक माह से चल रहे दो ट्रेनिंग प्रोग्राम का समापन गुरुवार को हो गया. एनएमएल के वैज्ञानिकों ने गम्हरिया वीमेंस पॉलिटेक्निक कॉलेज के कुल 96 प्रतिभागियों को एक माह तक मटेरियल एंड मेटलर्जिकल इंजीनियरिंग की इंडस्ट्रियल ट्रेनिंग के साथ इ वेस्ट रिसाइक्लिंग का प्रशिक्षण दिया. उन्हें बताया गया कि आज के दौर में किस प्रकार पर्यावरण संरक्षण के लिए दोनों ही चीजों का महत्व है. प्रोग्राम को-ऑर्डिनेटर और एनएमएल की चीफ साइंटिस्ट डॉ मीता तरफदार ने कहा कि हर किसी को प्लास्टिक के इस्तेमाल से परहेज करना चाहिए. इ वेस्ट किस तरह लोगों के स्वास्थ्य पर कुप्रभाव डाल रहा है. कार्यक्रम में डॉ राजनीश कुमार गुप्ता, डॉ एस सागर, डॉ ए विद्यासागर, डॉ ममता शर्मा, डॉ संचिता चक्रवर्ती, अशोक कुमार, डॉ केएल हांसदा समेत कई अन्य ने अहम भूमिका निभायी.



हिन्दुस्तान

तरक्की को चाहिए नया नजरिया

युवाओं को किया कौशल विकास सीखने को प्रेरित

एनएमएल

जमशेदपुर। सीएसआईआर एनएमल और एमएसएमई डेवलपमेंट इंस्टीट्यूट रांची की ओर से सोमवार को एनएमएल में पांच दिवसीय प्रबंधन विकास कार्यक्रम की शुरुआत हुई।

कार्यक्रम में मुख्य अतिथि के रूप में एमएसएमई विकास संस्थान रांची के सहायक निदेशक सुदीप पाल और टीसीसीआई पूर्वी क्षेत्र के उपाध्यक्ष बैद्यनाथ मंडी उपस्थित थे। कार्यक्रम में आदिवासी भारतीय चैंबर ऑफ कॉमर्स एंड इंडस्ट्री के 29 प्रतिभागियों ने भाग लिया। कार्यक्रम में मुख्य अतिथि सुदीप पाल ने धातु शिल्प के निर्यात तथा उसके विपणन से संबंधित मुद्दों पर चर्चा की। वहीं, बैद्यनाथ मंडी ने प्रतिभागियों को प्रशिक्षण में कौशल सीखने के लिए प्रोत्साहित किया। कार्यक्रम में मेटल क्राफ्ट के विपणन के बारे में जानकारी दी गई। कार्यक्रम का उद्देश्य गुणवत्तापूर्ण उत्पाद प्राप्त करने के लिए अबतक की तकनीक के बारे में जागरूकता पैदा करना है। इस दौरान नए उद्यमियों को धातु उद्योग तथा धातु शिल्प के क्षेत्र में काम करने के लिए प्रेरित किया गया। मौके पर वैज्ञानिक डॉ. सौमित्रो ताराफर ने कार्यक्रम में आए सभी प्रतिभागियों का स्वागत किया।

Performance Targets Achieved in 2019-2020

S.N.	Objectives	Planned	Achieved
1.	Total External Cash Flow (ECF)^	42 Crores	30.25
	Grant-in-Aid	17 Crores	4.43
2.	Industrial ECF (a part of Total ECF)	25 Crores	25.62
	a. Foreign Sponsored	2 Crores	0.13
	b. Public Sector Units (PSUs)	17 Crores	17.97
	c. Private Industries including Testing	10 Crores	7.72
3.	Customer Satisfaction Index	4.7	4.8
4.	SCI Publications	120	123
5.	Patents	25	23
6.	Copyrights	5	3
7.	Technologies Developed#	6	3
8.	Technologies Transferred*	5	3

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

Technologies Developed :

1. Electrolytic Manganese Metal (EMM) from medium and low grade Mn Ores
2. Recovery of vanadium as ammonium metavanadate and vanadium pentoxide from spent sulfuric acid catalysts
3. Induction Active Sole Plate for Iron Press

* Technologies Transferred :

1. Extraction of Cobalt and Manganese from the Black cathodic material of Li-cobalt batteries (SBCON Recycling Private Limited, Ahmedabad)
2. Extraction of cobalt and gold from the black cathode material of Li-Co batteries and gold coated surface of e-waste, respectively (EXIGO Recycling Pvt. Ltd., New Delhi)
3. Extraction of cobalt metal/salt from the black powder of Li-cobalt batteries (Evergreen Recyclekaro India Pvt. Ltd, Mumbai)

Major Technological & Scientific Targets Planned and Achieved in 2019-2020

Targets Planned	Targets Achieved
Advanced Ultra Supercritical Power Plant Materials evaluations 1. Hot corrosion study of 304H and IN 617 in simulated Indian coal AUSC condition	The hot corrosion studies completed at 500°-900°C for 1200hr in flue gas environment. XRD characterization completed for samples corroded between 600° to 900°C.
2. Creep data on Alloy 617 for Advanced Ultra Supercritical Technology	Creep tests are being carried out at 650°, 675°, 710° and 750°C. 500hr exposure completed at these temperatures. 1000 and 5000 hrs exposures in progress.
Optimization of annealing cycle for a Dual Phase Steel	Based on the designed annealing cycle desired properties were obtained including HER value (>50%), strength (>590 MPa), elongation (>30%) and energy absorption capability (~20GPa%). Actual plant trials based on laboratory simulated process parameters have resulted in improvement in HER property to > 50 % (from 20 - 30 %).
Technology for Dry Beneficiation of Non-coking coal for Application in Thermal power plant ● Conducting characterization, washability and dry beneficiation studies on coal sample from Ib Valley, Mahanadi Coal ● Development of technological process flow sheet for dry beneficiation.	● Characterization of Ib valley coal samples was carried out with respect to proximate analysis, ultimate analysis and coal petrography ● Washability studies at -50mm was carried out to assess the cleaning potential of the coal. ● Dry beneficiation studies were carried out under varied conditions. ● In view of high NGM different process schemes were examined. ● Developed process flow-sheet for dry beneficiation of coal.
Development of Process flow-sheet for Extraction of Tungsten from Hutti gold ore tailings Data analysis and development of technological process flow-sheet and computing material balance for beneficiation and hydrometallurgical extraction of tungsten.	Bench and pilot scale beneficiation of Hutti gold ore tailings sample and extraction of tungsten from pre-concentrate were carried out. The data were analysed and based on the pilot scale studies technological process flow-sheets were developed for beneficiation of tailings sample and extraction of high purity tungsten powder from pre-concentrate produced from the tailings. The final report was prepared and submitted to the sponsor.

Beneficiation of Low grade Limestone for Cement making ● Bench and pilot scale beneficiation studies on low grade limestone sample from Rajasthan. ● Development of flotation based process for reducing silica content to desired limit	● Bench and pilot beneficiation studies were carried out on reduction of silica in low grade limestone for cement making. ● Target of reducing silica content < 12% in the concentrate was achieved. ● Flotation based process was developed for processing limestone with final concentrate analyzing 11.3% SiO_2 with 47.4% CaO. The product yield was 88% with 96% CaO recovery.
Installation and Commissioning of 200 tonnes per day flotation column for fine coal flotation at Coal Preparation Plant of an Iron & Steel Major	Erection of flotation column was completed. Dry run of the installed equipment and trials using water was completed. 80% of the committed work was completed and trials using coal slurry is to be taken up shortly.
Installation and Commissioning of 100 tonnes per day flotation column for sillimanite flotation at Chavara, of Kerala Minerals and Metals.	Successful erection and commissioning of flotation column was completed. Target was achieved with return on investment realized within the period of trial runs, by Kerala Minerals and Metals, Chavara.
Use of briquettes from steel plant wastes as partial replacement of scrap as coolant in BOF ● Characterization of raw materials, optimization of briquette making, evaluation of briquette properties ● Preparation of briquettes at a pilot scale under optimized condition and their characterization ● Performance study in commercial BOF	● Characterized the raw materials, namely, mill scale and iron ore slime. Cold bonded briquettes have been prepared and evaluated. ● 40 tons of mill scale briquette and 60 tons of slime briquettes have been prepared with compressive strength of cured briquettes: ~ 200 kg and drop strength of 45-60 drops. The shatter index of cured briquette was 95.8% ● These briquettes were tested in the sponsor's LD furnace (160 ton capacity per batch). Critical parameters, like, turn down temperature, phosphorous content of steel, etc., were similar to that of the operations without mill scale briquettes. Both mill scale and iron slime can be alternate coolants in steel making.
Commercialization of DRI making in tunnel kiln ● Identification of interested entrepreneur ● Installation and commissioning of production units on a turn-key basis	● Seven enterpreneurs have been identified and the Technology has been transferred to M/s. SMRW, Ranchi. Onsite training was given to the personals of M/s. SMRW for smooth running and production of DRI in Tunnel Kiln.

• Hand holding for fine tuning of process	• Industrial size equipment like ball mill and disk pelletizer were installed under supervision of CSIR NML for preparations of raw materials and production of DRI in Tunnel Kiln. • Commercial production of DRI from mill scale and lean grade non coking coal @18 TPD scale was successfully demonstrated in June 2019.
Innovative material for restoration/repairing of heritage structure • Development of a new geopolymer material and its standardization • Identification of heritage terracotta and sandstone structure with the help of ASI • Repair/restoration of identified structure as per ASI protocol	• New geopolymer composition has been developed from metakaolin for restoration of heritage structure. • The samples of old teracotta structure have been collected from ASI for laboratory evaluation.
Extraction of rare earth metals from secondary resources • Characterization of raw materials • Development of process flow sheet • Separation of individual rare earth metals using suitable reagent and technique • Characterization of products • Process optimization	• Various secondary materials such as red mud, batteries, etc., have been characterized for rare earth elements • REE using hydrometallurgical process has been extracted using solvent extraction. Based on the process, a flow sheet has been developed. • The REE obtained in the salt form has been characterized.
Commercial production of Sodium metal using fused salt electrolysis • Preparation of package for upscaling of the process • Assistance towards selection, installation and commissioning of hardware • Technical assistance during commercial production and fine tuning of process parameters	• The pilot scale 3000A sodium cell was operated successfully. Based on the success, the scale-up design of the commercial scale 12000A (12 nos., totaling 1,44,000A) sodium electrolytic cells are under progress. • NML has provided Technical assistance to the sponsor for selection of the engineering consultant for this project. • Technical assistance will be provided by NML. NML will also monitor and will attend during commission of the cell as and when required.

Production of EMD and EMM from Manganese ore ● Characterization of ore samples ● Study on reduction and dissolution of samples ● Purification of manganese leach solution ● Deposition of EMD and EMM ● Characterization of products	● Detailed physico-chemical characterization of two Mn ore samples were carried out ● Reduction of Mn ores with solid (Coke) and gaseous reductant (LPG, Producer's gas, etc.) were optimized for >90% reduction efficiencies. ● Purification methods of leach solutions were optimized at 10 - 20L batch scale to achieve Fe content <1 ppm, and total other trace impurities <50 ppm. ● Electro-deposition of EMD in bench scale was optimized. Process demonstration at 10-20 kg/day scale EMM deposit to MOIL has been initiated (MoU signed) ● Chemical characterization of several samples of both EMD and EMM carried out. Few samples have been sent to CECRI, Karaikudi for their electro-chemical characterization.

Performance Targets Planned for 2020-2021

Sl. No.	Objectives	Planned
1.	External Cash Flow (ECF)	32 Crores
2.	Industrial ECF (a part of ECF)	24 Crores
3.	ECF from Private organization including testing activity (a part of Industrial ECF)	12 Crores
4.	Customer Satisfaction Index	4.8
5.	SCI Publications	130
6.	Patents	25
7.	Copyrights	5
8.	Technologies to be Developed	5
9.	Technologies to be Transferred	5

Human Resource Targets Planned

- **Recruitments :**
  - Gr (IV) scientists: 15 nos
  - Gr III, Gr II: 15 nos
- **Training & development of higher and advanced skills of scientists/employees**
  - Workshop & conferences: 50 scientists and 10 staff
  - In house: 15 employee
  - Through HRDC: 10 employee

Major Technological & Scientific Targets Planned

- Separation characteristics of chromite tailing using Falcon concentrator, Water- only- cyclone and shaking table. Development of process for concentration of chromite tailings sample.
- Magnetic Separation of Limestone and Clay samples for the removal of Iron bearing and other Magnetic impurities.
- Studies on Beneficiation of Low grade Manganese ores involving gravity and magnetic separation techniques.
- Installation and Commissioning of 200 tonnes per day flotation column for fine coal flotation at Coal Preparation Plant of an Iron and Steel Major.

- Industry (plant) scale trials (5 tonnes per hour) of newly developed environment friendly flotation reagents for sillimanite.
- Pilot plant scale trials (1 tonne per hour) of newly developed environment friendly flotation reagents for limestone beneficiation.
- Determination of trace and rare earth elements in Indian soil and sediment samples.
- Development of 3 CRMs of Brass, Alloy cast iron and H_2 pin standards.
- Initiate major projects on critical metals including rare earth elements.
- Establish Li extraction technology from end of life batteries.
- Develop new Q&P processed steel.
- Develop Material data base for fatigue crack propagation characteristics of Ti-6Al-4V under cyclic loading .
- Technology for on-board spacecraft life detection.
- Sensor & device for damage assessment of components exposed to high temperature.
- Development of biodegradable alloys for orthopedic implants and coatings for the implants.
- Development of process for MAX phase synthesis for large application of metal carbides/ nitrides based 2D materials.
- Skill Development benefitting 1000 Trainees and apprentices.



Shivaji's 'Coronation' Gold Hon

Shivaji was crowned king of the Marathas in a lavish ceremony at Raigad on 6th June 1674. Nearly fifty thousand people gathered at Raigad for the ceremonies. Shivaji was bestowed with the sacred thread, was bathed in an abhisheka and entitled Chhatrapati ('paramount sovereign'). It is said that as part of the coronation rituals, Shivaji was lustrated by his ministers with hundreds of Hons (gold coins) which were poured the over his body as he sat on his throne !

Source: http://www.suvarnamohur.com/articles/7-incredible-facts-about-indian-coins.php

MISSION PROJECTS



Jahangir 'Wine Cup' Gold Mohur



Gold Suvarna of Gupta Dynasty of Skandagupta (455-467AD).



Chandragupta II horse type

Indian Coin 'Suvarna' - the weight in gold of a full grown cow !

Indian coins are more than 2500 years old. Even the Vedas make a mention of gold coins in the form of 'Nishkas' and 'Suvarnas'. India is thus home to some of the oldest coins in the world

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Source: http://www.suvarnamohur.com/articles/7-incredible-facts-about-indian-coins.php

Flagship Projects

Evaluation of Materials for Advanced Ultra Super Critical (AUSC) Power Plants

The combined demand on providing abundant, cheap electricity and maintaining coal as the chief power generation option with reduced CO_2 emission, necessitates development of Advanced Ultra Super Critical (AUSC) power plants, worldwide. Aimed to operate with steam temperature above 700 degree centigrade and steam pressure of 25MPa, the AUSC power plants will considerably reduce the emissions and waste products, and fuel costs. In India, a National Ultra Supercritical Technology Mission has been set up with a goal to establish indigenous 800MW supercritical power plants. One of the agenda and challenge before this Indian Mission is to develop and evaluate appropriate advanced high temperature materials. CSIR-National Metallurgical Laboratory (NML) being the leading R&D organization in the field of metallurgical engineering has been entrusted with the responsibility of characterizing such materials for design, and, development of NDE tools for life prediction.

Worldwide the material research for AUSC power plants has resulted in numerous advanced high strength alloys for heavy section piping, boiler tubes and rotors, for the casing, bolting, and for the blading required to build steam turbines. In the Indian Mission, the choice of material has been defined on the basis of science, technology, performance assessment and experience. It has been decided to concentrate on codified materials for this purpose; some of the materials have been indigenously developed and produced. One of the important issues in the selection of materials is the appropriate evaluation of their mechanical behaviour so that the component can be designed and operated at the desired steam conditions safely. CSIR-NML is involved in the following activities

- evaluation of creep properties of Alloy 617M (forging), Alloy 625 (casting) materials
- evaluation of fatigue crack growth and fracture behaviour of 304HCu stainless steel
- evaluation of fatigue crack growth and fracture behaviour of 10Cr-Alloy 617 bi-metallic weld joint
- characterisation of creep crack growth behaviour in 304HCu stainless steel
- characterisation of creep crack growth behaviour in 10Cr-Alloy 617 bi-metallic weld joint
- fireside corrosion behaviour of 304HCu and Alloy 617M in simulated Indian coal fired AUSC boiler conditions
- development of advanced NDE-based techniques for creep damage evaluation of AUSC power plant materials

Investigations have been carried out on as received as well as aged materials.

Creep properties of Alloy 617M (forging), Alloy 625 (casting) materials

This activity involved 32 creep tests with an expected life in the range of 500h to 10000h in order to develop (i) creep strain - time curves, (ii) stress

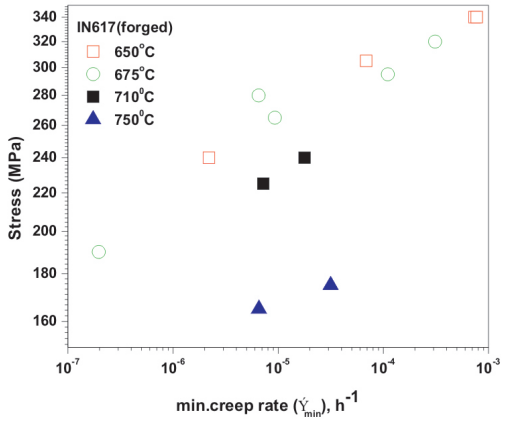

Figure 1 : A typical minimum creep rate

(i) creep strain - time curves, (ii) stress rupture time, (iii) isochronous strain-stress data, (iv) time to 1% creep- strain curve and (v) Norton-Bailey coefficient. A majority of the tests far exceed the anticipated duration and are still continuing. A typical minimum creep rate data is provided in Figure 1.

Fatigue crack growth and fracture behaviour of 304HCu stainless steel

Evaluation of fatigue crack growth rate (FCGR) and the fracture behaviour at room and various elevated temperatures on as received and aged 304HCu are the primary objective of this work. Typical FCGR and fracture data for selected test conditions are shown in Figure 2.

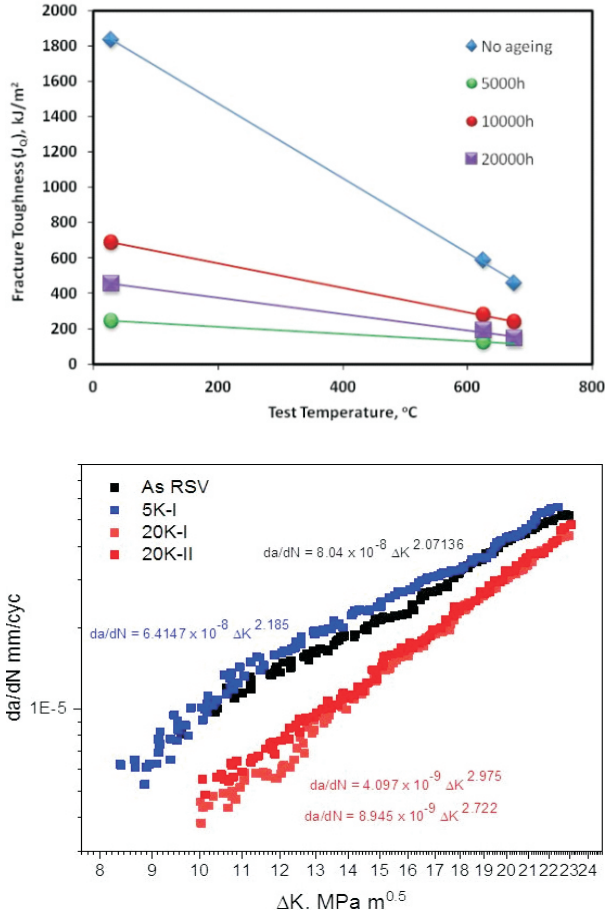

Figure 2 : Typical fracture and FCGR data

Fatigue crack growth and fracture behaviour of 10Cr-Alloy 617 bi-metallic weld joint

The interface of 10Cr and Alloy 617 buttering layer is the region of interest in this study. Different material conditions - as received, and, aged to different durations, are considered for the investigation. Investigations were made at both room temperature and elevated temperatures.

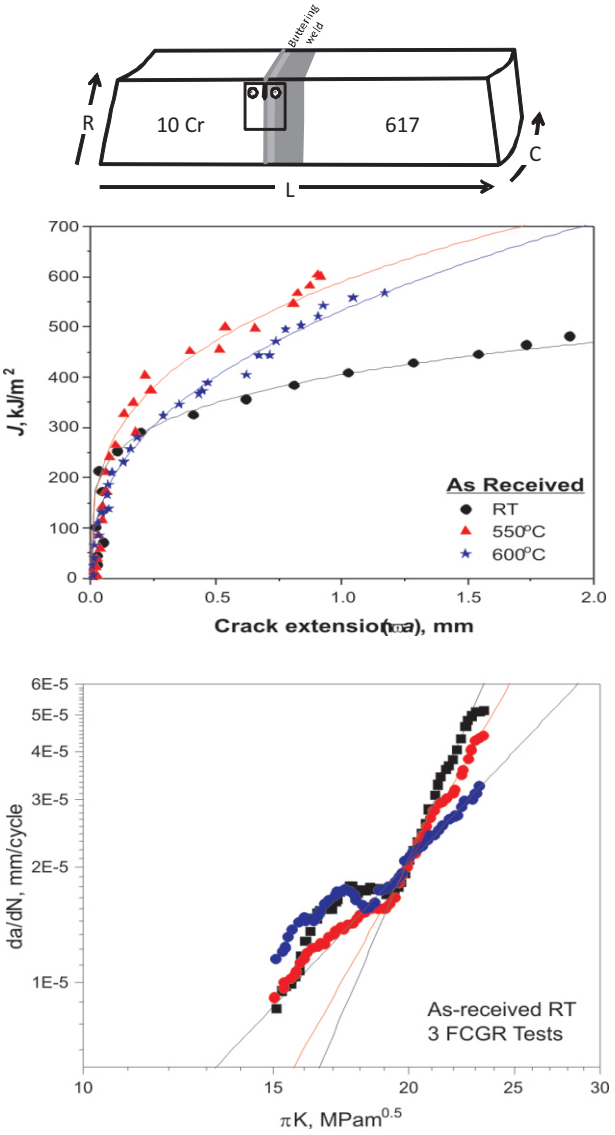

Figure 3 : JIC and FCGR data for bimetallic joints

Creep crack growth behaviour in 304HCu stainless steel and 10Cr-Alloy 617 Weldment

This activity is primarily to investigate the crack growth behaviour of above materials under creep deformation conditions. The creep crack growth rate is characterized by crack growth data (da/dt) as a function of time dependent fracture parameter, C*. As in the fatigue and fracture activities, the materials tested included as-received as well as aged alloys and the test temperatures were room and elevated temperatures, including the service temperature. This is a relatively new fracture mechanics concept and not many test facilities are available in the country. One of the primary requirement thus is to create a creep crack growth test facility at NML. Figure 4 shows the facility created at NML for this purpose.



Figure 4 : Testing facility created at NML

Fireside Corrosion Behaviour of 304HCu and Alloy 617M in simulated Indian coal fired AUSC boiler conditions

The primary objective of this activity is to generate Hot corrosion/oxidation data in the selected materials and evolve corrosion mechanism by oxide and microstructural characterization. The hot corrosion study of 304HCu and IN617 has been performed at 500-900°C for 1200 h in corrosive media such as coal ash and salt mixture in flue gas purged tube furnace. A large weight gain corresponded by severe thickness loss and depth of attack is observed in salt containing medium as illustrated in Fig. 5. The weight gain by specimens in coal ash medium were significantly low (<30 g/m^2) as opposed to that in the salt medium. The Cr-rich oxide close to base alloy (both 304HCu and IN 617) was observed in all the corrosive conditions while outer oxide was rich in Fe and Ni in 304HCu and IN 617 alloy, respectively.

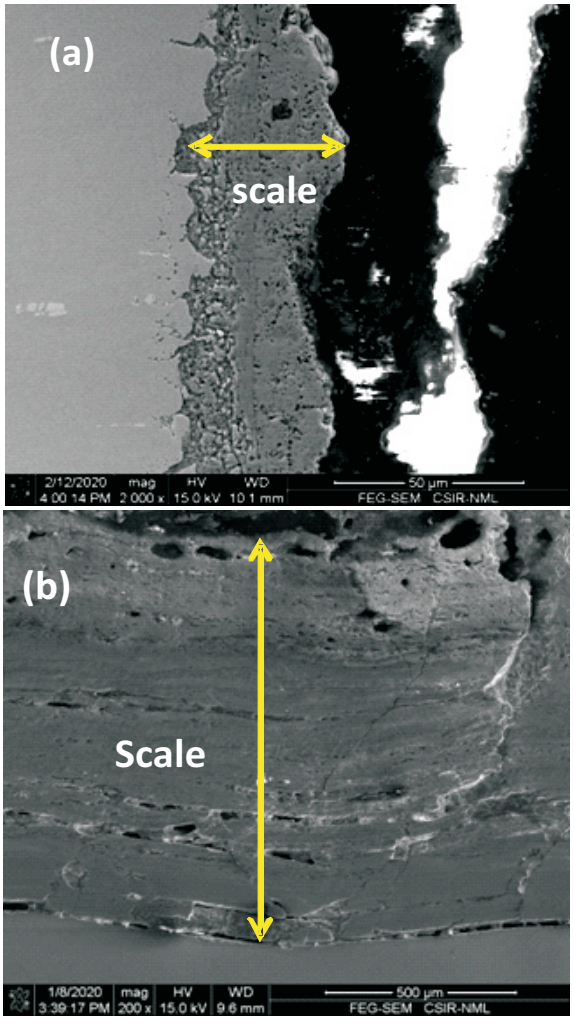

Figure 5 : SEM (BSE) Cross-Sectional image of In617 and 304 HCu

Development of Advanced NDE-based techniques for creep damage evaluation of AUSC power plant materials

This activity aims to understand the inter-relationship between the NDE parameters and the material microstructure during creep by applying various non-destructive techniques with an emphasis on velocity and attenuation of ultrasound wave, non-linear ultrasonics and electromagnetics in the two candidate alloys, Inconel 625 and alloy 617M. Special attention will be given to the development of on-line monitoring and inspection methodologies to assess life-limiting aspects (material degradation, creep-fatigue damage, etc.). Design and development of high-temperature sensors, techniques and procedures for online monitoring of damage and continuous life-prediction, will be important activities..

As of now, after initial NDE signature measurements using ultrasonic (UT), Non-linear Ultrasonic (NLU), UT imaging (UTI) and Eddy Current (EC) on as-received samples, interrupted creep tests at two different creep conditions are running. At each interruption, UT, NLU, UTI and EC measurements are being carried out. For EC measurement, couple of contact sensors and a scanning system have been fabricated In-house and tested and are being used for the measurement. Substrate for eddy current sensors susceptible to high temperature (~1100°C) has been imported.

National Centre for Development of Advanced Materials and Manufacturing Processes for Clean Coal Technologies for Power Applications

There are three projects from CSIR-NML under the consortium programme "National Centre for Development of Advanced Materials and Manufacturing Processes for Clean Coal Technologies for Power Applications", sponsored by Department of Science & Technology, and co-ordinated by ARCI, Hyderabad. The first project is on Creep-fatigue interaction behavior of ODS-austenitic steels and ODS-iron and nickel aluminides. The objectives of this project are to study the material damage due to creep-fatigue interaction in ODS-austenitic steels and ODS-iron and nickel aluminides, to evaluate the influence of various waveforms and dwell times on damage accumulation to understand the mechanism(s) of damage accumulation. From these studies, the applicability of various creep-fatigue (CF) damage assessment models will be examined. This project aims to deliver complete database ofLCF and Creep-fatigue of ODS-austenitic steels and ODS-iron and nickel aluminides.

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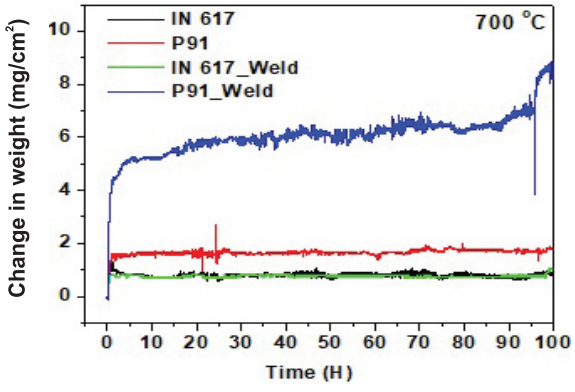


Figure 6 : Oxidation kinetic plot of as-received and laser hybrid welded alloys exposed to 700°C for 100 h

The second project is on "High Temperature Oxidation and Hot Corrosion behavior of selected materials for Clean Coal Technologies for Power Plant Applications". The objective of this project is to study the oxidation and hot corrosion of boiler materials IN617 and P91 under varied salt proportions and cyclic loading effects during short and long term exposures. The oxidation studies were carried out on as-received IN 617, P 91 alloys and laser hybrid welded IN 617 (W) and P 91(W) alloys at 600-800°C for 100 h in air containing environment (Figure 6). The oxidation kinetic curve indicates similar trend of weight change at all the temperatures, it however increased with the temperature from 600 to 800°C. The P91 weld has considerably lower oxidation resistance than that of its as received counterpart while insignificant difference is observed between IN 617 in as-received and weld condition.

temperatures, it however increased with the temperature from 600 to 800°C. The P91 weld has considerably lower oxidation resistance than that of its as received counterpart while insignificant difference is observed between IN 617 in as-received and weld condition.

The third project is titled "Development of Advanced NDE-based Diagnosis and Prognosis Protocols for Clean Coal Technologies for Power Plant Applications". This project aims to develop a predictive model to evaluate the remaining life of the components based on various NDE parameters, development of portable devices for in-service component damage assessment and quality assessment of laser and hybrid laser welding, non-destructively. Simulation to optimize the parameters for high temperature sensor fabrication was completed. Automation of furnace with impedance analyser for high temperature electrical property evaluation has been done. Couple of sensors, applicable up to 850°C have been fabricated. Quality assessment of hybrid laser welded P91 sample has been evaluated using Phased Array Ultrasonic technique (PAUT), and is shown in Figure 7.

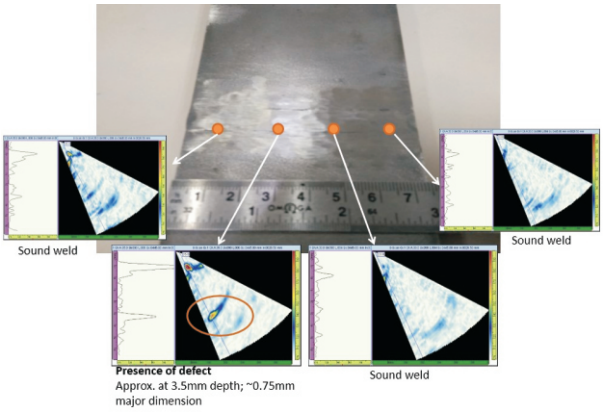


Figure 7 : Quality assessment of laser hybrid welded P91 sample using PAUT

Urban Ore Recycling Centre

The urban ore recycling centre was formally inaugurated by Director General, Dr. Shekhar C Mande on 20th April, 2019. The centre will be the focal point for treatment of different urban wastes with metallic values. Since inception, the following activities have been carried out:

Recovery of Co, Li, Mn and Cu from Discarded Li-ion Batteries of Mobile Phones

The cathodic material present in the lithium ion batteries was first separated using mechanical pre-treatments. Black cathodic material containing Co, Li, Mn, Cu and Ni, was further treated with diluted acid in presence of an oxidant at elevated temperatures. About 95-99% Co, Mn, Li, Cu and Ni were leached under optimized conditions. Leach liquor generated was further processed through solvent extraction to selectively separate Cu and Ni. Raffinate containing Co, Mn and Li was processed through either solvent extraction, precipitation or electro-winning techniques to recover Co, Mn and Li as salt or as metal. In addition to metals recovery, graphite is also produced as a saleable by-product.







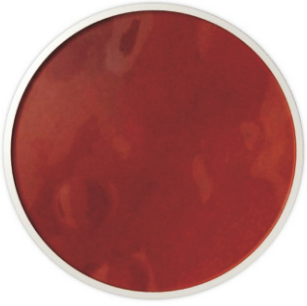


Figure 8 : Lithium Ion Batteries (LIBs); Cobalt sulphate salt; Cobalt metal sheet; Lithium salt.

Recovery of precious metals (Au, Ag, Pd, Pt) from discarded Printed Circuit Boards (PCBs) of personal computer and mobile phones

A novel hybrid process was developed to recover precious metals from small depopulated components of e-wastes and scrap mobile phones. Connectors and integrated circuits (ICs) liberated from printed circuit boards (PCBs) were pulverized and processed for Au leaching using suitable lixiviant at elevated temperatures. More than 95% Au was found to be leached out in a single stage. Adsorption/ cementation with subsequent heating was used to recover Au. Apart from Au, the Pt, Pd and Ag were also recovered using different leachants followed by solvent extraction/ precipitation studies. Obtained leached residue was further processed for non-ferrous metals recovery and finally disposed-off after treatment and TCLP test. The effluent left after leaching could be easily treated in ETP using standard environmental procedure.

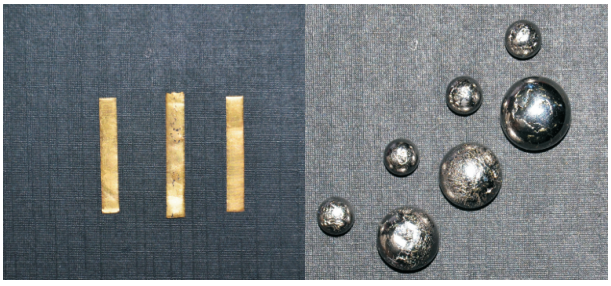


Figure 9 : Metals & Salts of precious metals

Recovery of rare earth metal, Neodymium (Nd) as value added product from waste hard disk of personal computer

A process for the recovery of neodymium (Nd) as value added product from permanent magnets of hard disk was developed. Recycling of magnets involves the methods of demagnetization, crushing and leaching for 30 min using sulfuric acid. About 99.9% Nd, 97% Fe, 60% Ni were successfully dissolved. Acid leaching was followed by selective

precipitation of Nd and leaching of the precipitate with 5-20% hydrogen fluoride solution.

Recovery of rare earth metals from coal ash

A novel process flow-sheet was proposed for the effective recovery of highly pure rare earth metals salt from coal ash. Initially, the coal ash was leached in hydrochloric acid for 2 hrs at elevated temperatures to dissolve maximum amount of REMs present in coal ash sample. The obtained leach liquor was further processed for selective precipitation of REMs at pH < 2. The process developed at a laboratory scale has the potential to be commercialized after scale-up and feasibility studies.

The list of industries to which these technologies for e-waste recycling were transferred are as follows:

- M/s Evergreen Recyclekaro, Mumbai : "Precious metal recovery from e-waste"&"Extraction of cobalt from Li-ion batteries"
- M/s SBCON Recycling, Ahmedabad : "Extraction of Cobalt and Manganese from scrap batteries"
- M/s EXIGO Recycling, New Delhi : "Extraction of Co and Au from e-waste"
- M/s UNQ Ind Pvt. Ltd., Firozabad : "Extraction of Co from varieties of batteries"
- M/s WalleInfotech, Ranchi : "Extraction of Co from lithium ion batteries"

Twinning on Capacity Building to Transform Metal Industry Development Institute (MIDI), Addis Ababa, Ethiopia

The Council of Scientific and Industrial Research (CSIR) had entered into an agreement with the Metal Industries Development Institute (MIDI), Ethiopia to implement a "Twinning Programme on Capacity Building to Transform Metal Industry Development Institute (MIDI)". The agreement was signed by the Director of NML, Jamshedpur on behalf of CSIR, and the Director General of MIDI on 7th June 2017.

Five CSIR laboratories (i.e. NML, CMERI, CEERI, CSIO and CLRI) are involved in implementing the program and NML is the Coordinating Nodal Lab for the program. The principal objective of this transformation programme is to enhance the competitiveness of the metal and engineering industry through speeding up the transformation and development of the sector, through a transformation of MIDI into a globally competitive centre of excellence in the field of metals and metals manufacturing.

Following activities and trainings were conducted by NML experts at MIDI in Ethiopia during 2019 :

(i) Metallography / Materials Characterization Laboratory creation activity (lay-out and equipments planning, specifications and budgeting, etc) was carried out from January 19 to February 02, 2019.

(ii) Chemical Analysis Laboratory creation activity was carried out from January 19 to February 02, 2019.

(iii) Welding Laboratory creation activity was carried out from January 19 to February 02, 2019.

(iv) NDT Centre creation activity was carried out from January 19 to February 02, 2019.

(v) Assessment & evaluation of Reorientation and restructuring of MIDI and academic activities related to 'Master's Programme' for forth-coming semesters were carried out from February 11 to February 24, 2019.

(vi) One month retraining activity on "Heat-treatment" was carried out at MIDI, Addis Ababa, Ethiopia from 01 August to 31 August 2019 [Figure 10].



Figure 10 : Participants along with the CSIR-NML Instructors for the training on "Heat Treatment" conducted at MIDI, Addis Ababa

(vii) Core Committee Meeting was conducted at MIDI, Addis Ababa from 26 August to 30 August 2019 for assessing the progress of the twinning program and prioritizing the twinning activities. Designated representatives from all the five CSIR labs (CSIR-NML, CSIR-CMERI, CSIR-CEERI, CSIR-CSIO and CSIR-CLRI) and MIDI participated in the meeting.

(viii) Apex Meeting was conducted during 14-19 September 2019 at Addis Ababa, Ethiopia to evaluate the completed and on-going activities under the twinning program. All the five directors of participating CSIR labs, program coordinators and nominated representatives from Ethiopian Ministry of Trade & Industry, Academies and Industries attended the Apex Committee meeting and endorsed the future course of action and activities as suggested by the core committee.

Amorphous Electrical Steel (AES) for Energy Applications

CSIR-National Metallurgical Laboratory (NML), Jamshedpur is working on a pilot scale project titled "Amorphous electrical steel for energy application" sponsored by Ministry of Steel (MoS), Government of India, at a financial outlay of Rupees Thirty Six crores.

The project is targetted towards establishing a 100kg pilot scale melt spinning facility for the production of FeSiB based amorphous electrical steel sheet, 100mm wide and 25-30m thick. The master alloy for the electrical steel sheet would be produced using a vacuum induction melting furnace using commercial alloys. Subsequently, the alloy will be melted and poured over a rotating water cooled quenching wheel of Cu alloy. The technical specifications have been drawn and procurement process for the integrated planar flow casting system for productions amorphous sheet is in progress. The renovation of our old stores for post processing facility and site development is in progress. Based on soil test reports, the industrial shed plan is being made. In the activities pertaining to materials development, high induction amorphous alloys with phosphorus incorporation in Fe-based systems have been prepared and characterized. The properties of amorphous ribbons prepared using existing laboratory prototype system are compared with commercially available ones, in Figure 11. Research work is also being carried out on other applications of amorphous sheets, such as. electromagnetic interference (EMI) shielding and microwave absorbing material.

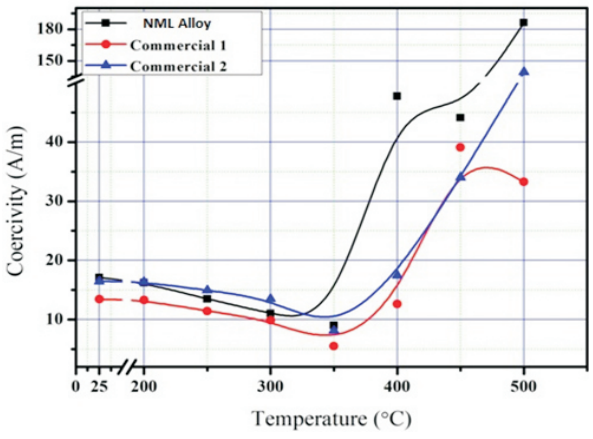


Figure 11 : Comparative soft magnetic property of NML prepared Amorphous electrical steel ribbons with reference to available commercial materials

Akbar 'Ram-Siya' silver half Rupee coin



This coin type with the 'Ram-Siya' legend is the only known type of Akbar to feature human figures. Akbar followed policies of reconciliation between Hindus and Muslims.

Nur Jahan Gold Mohur



Most Expensive Coins of India

Nur Jahan became the 20th wife of Jahangir in the year 1615. Nur Jahan also used to run the Mughal Empire. She became the most powerful person in the Mughal Empire and even minted coins with her name. The coin legends read as follows : ***Obverse :*** *'nam e nur jahan badshah begum zar sanah 1034 / 19' (,when the name of Nurjahan, the badshah Begum was inscribed on it….') Reverse: 'ze hukm shah jahangir yaft shud zewar zarb surat' ('…by the order of Jahangir, then gold attained a hundred beauties')*

Source: http://www.suvarnamohur.com/articles/the-7-most-expensive-coins-of-india.php

RESEARCH AREAS



Queen Naganika



Queen of Kakatiya Dynasty

Indian Coins : First to feature queens

India's coins were among the first to feature queens as early as the 2nd century BCE. Over time, many Indian coins featured queens and Goddesses. In fact, Razia Sultana was the first Muslim queen, anywhere in the world to be featured on a coin minted in Delhi in the 13th century !

Source: https://www.vcoins.com/en/stores/coinindia/36/product/india_delhi_sultanate_radiyya_razia_sultana_123640_billon_jital_scarce/82178/Default.aspx

Advanced Materials and Processes

Advanced Materials and Processes (AMP) Division focuses on the development of advanced materials, processes and techniques for tailored applications in the form of advanced engineering components, devices, implants and coatings, covering a broad area of energy, space, oil and gas, iron and steel, biomedical and infrastructure. Newly developed coating processes, besides its functional application, also aim at mitigation of environmental problems related to the use of hazardous materials in various coating applications. The division comprises of three research verticals, Surface Engineering (SE), Non-Destructive Evaluation and Magnetic Materials (NDEMM) and Functional Materials(FM). The mission of the division is to provide end to end solution to the research problems being addressed. The three research groups are dedicated to conceive high science based ideas to solve industrial or strategic sector problems and thereafter developing a complete solution and its translation to the stakeholder. Such a business plan could only be put in place with constant and close interaction of science and industry. The important projects that the division has handled in 2019-2020 are categorized into two areas : Materials and Coatings and Non-destructive evaluation.

MATERIALS AND COATINGS

Materials and coatings for biodegradable implants

The project on the development of Mg alloys for biodegradable implant applications focused on development of high strength Mg alloys. A few Mg alloys exhibiting high strength (UTS > 200 MPa) in the as-cast condition were homogenized and extruded in an extrusion press. The input billets used for extrusion were of 127 mm diameter and the extruded rods were of 32 mm or 22 mm diameter. Extrusion temperature was selected as per the composition of the alloy and was varied between 275°C and 400°C. The extruded alloy rods exhibited an ultimate tensile strength of 276 MPa and an elongation of 26 % as compared to the UTS (236 MPa) and elongation (17 %) of as-cast alloy.

An adherent Zn coating was electrodeposited posited on the alloy from an eutectic mixture of choline chloride-urea to enhance the life of the implant material. The substrate was pretreated following industrial practices

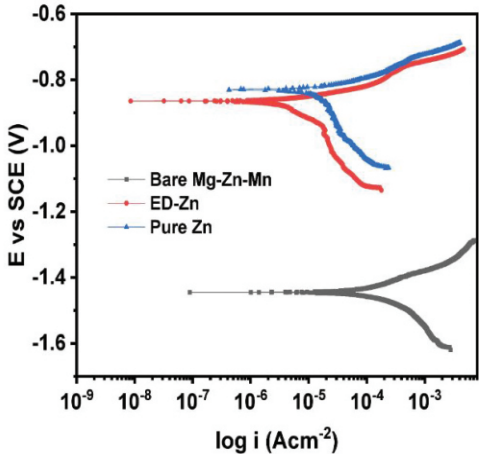


Figure 1 : Potentiodynamic polarization plot in SBF solution



Figure 2: Photographs of Zn coated Mg-Zn-Mn alloy exposed in SBF solution

without using hazardous Cr(VI) and HF. A thin Cu layer was deposited on the pretreated alloy prior to Zn electrodeposition. The electrodeposited Zn showed enhanced corrosion resistance of the Mg alloy in SBF solution similar to pure Zn (Figure 1). The electrodeposited Zn showed no sign of corrosion when exposed in SBF solution for 30 days (Figure 2).

Functional low dimensional materials and nanocomposites for energy applications

The objective of a project on collagen-graphene composites for energy devices, was to synthesize collagen-graphene composites doped with iron oxides, calcium hydroxy phosphates and silver nanoparticles, and to electrospin them with polymers to make nanofibres. These nanofibres were then heat treated and directly used as electrodes and the capacitance measured. Graphene-hydroxyapatite-poly(vinyl) alcohol composite showed much better results in comparison to graphene-iron oxide and graphene-Ag composite heat treated at 140°C. Mechanical tensile tests confirmed that the HA fiber is structurally more suited for prototypes. A prototype super capacitor was fabricated and demonstrated to the sponsor.

CSIR-NML, is working on a collaborative project with National University of Science and Technology (NUST), Moscow, Russia for the development of Energy Efficient Magnetic Nanocomposite Materials. The project is sponsored by the Department of Science and Technology, New Delhi and by the Russian Foundation for Basic Research (RFBR). The work on effect of stress on the Giant magneto-impedance (GMI) behavior of as-quenched microwires of CoFeSiBNbCr alloy system is quite interesting. The applied stress displayed transition of dual GMI peak to single peak owing to change in anisotropy field.

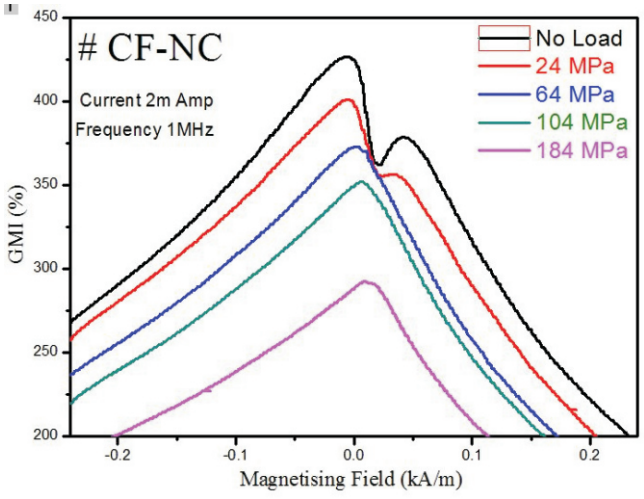


Figure 3 : Effect of stress on the Giant magneto-impedance (GMI) behavior of as-quenched microwires of CoFeSiBNbCr alloy

Advanced functional alloys

The Fe-based amorphous and glassy alloys are used for novel functional and surface coating applications. CSIR-NML in collaboration with the sponsor has successfully demonstrated the processing window and glass

forming ability of five different alloys. Based on the study, a range of FeCPMnSi alloys with Cr, Mo, Nb and B additions were found to have potential for surface coating applications. Specifically, the study of hydrogen permeation characteristics and damages to amorphous materials and coatings are of considerable interest for industries. The aim of this present project is to prepare an amorphous sample suitable for hydrogen permeation test using Devanathan-Stachurski electrochemical cell. The initial planar flow cast wide ribbons of above mentioned composition were highly brittle and were prone to crack during handling. Suction casting using water cooled Cu-mould technique was pursued. The die cavity and melt parameter optimization has been carried out and defect free coin samples have been prepared.

A new series of 18 karat gold alloys were designed and developed through arc melting furnace and casting in the form of rods by suction casting, which showed melting point in the range of 350 -470°C, and hardness between 210-310 Hv. Gold is extensively used for jewelry due to its golden color by varying its percentage purity. Due to superior physical properties like high corrosion resistance, thermal and electrical conductivity, gold and its alloys also have applications in electronic, aerospace, astronomy, medical and industrial applications. In European countries, 18 carat gold alloys are conventionally used for jewelry purposes unlike India where 22 carat is used. A new series of Au-Ag-Cu-Si alloys were designed and developed through arc melting furnace and casting in the form of 3, 4 and 6mm diameter rods by suction casting. The deliverable of this project was to process these low melting point gold alloys as rings and studs through specially designed rubber molds. The processing of high melting point rubber mold with a special shape is very critical, which was done by the industrial partner of this project. After several attempts, the alloys were successfully cast in the shape of ring without any damage of rubber mold. There are further trials going on to prepare studs.

In a project sponsored by the an oil and gas company, the objectives were met by successfully designing, fabricating and installing a "Closed loop corrosion test rig" for corrosion studies in flow simulated sea water with different controlled O_2 levels at constant temperature. The set-up was indigenously designed and fabricated by CSIR-NML, for the first time in India, and projected as an equipment for flow assisted corrosion study (Figure 4). It permits corrosion studies involving coupon exposure as well as electrochemical studies



Figure 4 : Flow Assisted Corrosion Test rig designed by NML

using online potentiostat, under flow conditions. During the work, two different Cr alloys having 0.5% and 1.0% Cr were prepared in addition to the base alloy and corrosion evaluation was carried out to monitor the effect of chromium addition towards the life extension of water injection pipeline. Based on the results, CSIR-NML recommended the addition of Cr (0.5%) in the sponsor's specifications.

Nondestructive evaluation and devices

NDE activities at CSIR-NML can be broadly categorized under two heads: [I] Development of methodologies for damage/quality assessment of engineering components and [II] sensors and devices for structural health monitoring. The following are the ongoing projects under the heads:

Development of methodologies for damage/quality assessment of engineering components

The CRGO (Cold Rolled Grain Oriented) steel is well known for its application as a core material for distribution and power transformers. The material is processed with a controlled heat treatment to achieve cube-on-edge Goss texture towards the rolling direction, enhancing the magnetic property. The structure and related properties of CRGO steel are very sensitive to the handling of steel as well as the service environment, which ultimately affect the performance of transformer at service. Accordingly, it is necessary to separate the good CRGO sheets from the bad one at the time of inspection. The aim of this project, sponsored by a power company, was to establish non-invasive electromagnetic measurement technique for the separation of CRGO steels, based on the quality. Four types of new (good) and three types of service exposed (damaged) CRGO sheets were investigated using various destructive (microscopy, texture, core loss) and electromagnetic non-destructive techniques. The service exposed CRGO sheets demonstrated higher core loss and coercivity with a grain boundary broadening compared to new CRGO sheets. The Goss texture is also less spread in case of new CRGO sheets compared to service exposed (damaged) sheets. This research work infers that the magnetic texture in terms of angular variation of coercivity is a good parameter to separate new and old CRGO sheets. It was found that the coercivity was higher transverse to the rolling direction due to the hindrance of magnetic domain movement.

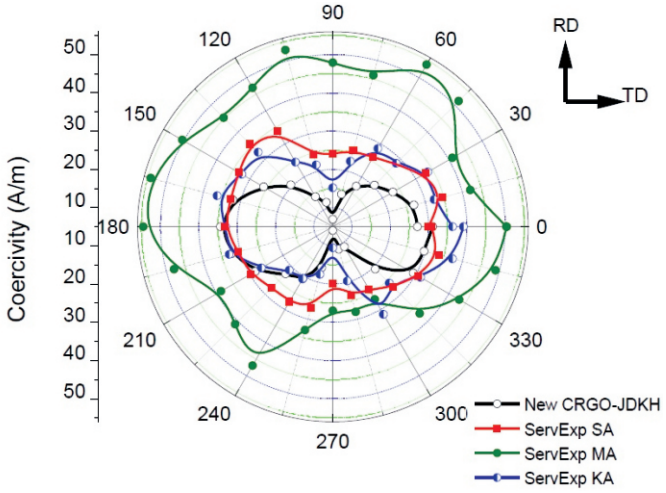


Figure 5 : Variation of Coercivity in virgin and service exposed CRGO samples

Processing steps of Tungsten-Carbide (TC) rolls may cause density variation and residual porosity. Generally, TC rings are received from various vendors having different binder % and are inspected at the shop floor for checking dimension and /or any physical damage before cutting/grooving required for rolling mills. In case of roll breaks or if there is poor pass life or if there is variation in wear pattern, it is very difficult to relate with the roll quality in terms of density, homogeneity etc. Moreover, any TC roll containing more than allowable levels of porosity results in a less dense product and will show inferior performance. Since density/ homogeneity measurements of a sintered product provide important information on sintering dynamics and porosity distribution in a product, the objective of this project is to develop ultrasonic based non-destructive test technique for homogeneity study of TC rolls on site. Before executing the project plan, as velocity is a dependent factor of density of any material, ultrasonic imaging for velocity mapping from the top surface was carried out on a few TC rings with various binder percentages. Variation in velocity with binder percentage was clearly visible in the ultrasonic images. After getting a clear variation in velocity with different binder percentage, ultrasonic tests in a contact mode were carried out on a large number of TC rings supplied by various vendors and having different binder percentage at the roll shops of two different organizations. From the measured data, a calibration curve for velocity against binder percentage was developed with a correlation factor of 0.98. It was found that the sound velocity decreases with binder percentage, which is expected. Calibration curve of ultrasonic velocity with binder percentage was generated from a series of experiments. After obtaining satisfactory results through repeated measurements, the sponsor has requested CSIR-NML to develop a portable site-worthy device for binder percentage detection at the shop floor. A joint patent filing with the sponsor is under process.

Pressure tubes, made of Zirconium 2.5% Nb alloy, houses the natural uranium fuel bundles and heavy water coolant flows through them at 300^{0}C and 10 MPa pressure, to extract the heat of the fission reactions. Out of the various components of the coolant channel assembly, the pressure tube operates under the most vulnerable environment. Structural failures in the coolant channel assembly occurred due to the limited knowledge of in-reaction performance of the materials used. The mechanical properties (YS, UTS and Elongation) of Zr2.5% Nb material were evaluated at site by the project sponsor, using circumferential and longitudinal specimens; but were not evaluated in the through thickness direction. This project aims to use ultrasonic wave propagation to determine 9 elastic constants in three orthogonal directions of the tube. To determine the yield stress along transverse direction of the tube, ring tension tests are performed. Suitable fixtures have been designed and made for performing the ring tension tests. Two types of designs in ring tension test samples have been adopted: single gauge and double gauge length to check the suitability of the design. Measurements of elastic constants using ultrasonic wave propagation have already been done and are being analyzed. Design for miniature tensile sample of total length of 4.5mm along thickness direction has been done. Finite element analysis will be performed on this sample to check the stress distribution on the sample during tensile loading.

CSIR-NML is working on a project "Development of Magnetostrictive Sensing Device for Structural Integrity Evaluation of Pipes", sponsored by the Department of Science and Technology (DST), New Delhi. The project has been granted under the scheme of Advanced Manufacturing Technology (AMT). The pursuit for the device development stems from the fact that magnetostrictive sensing (MsS) devices used for pipeline inspection

employ conventional crystalline material which are not only expensive but also need higher power for sensor excitation. CSIR-NML proposed the application of rapidly quenched amorphous ribbons as magnetostrictive sensor (MsS) element along with the development of instrumentation compatible with sensor element to generate ultrasonic guided waves through the pipe. The proposed project is aimed to study the effect of different types of defects like saw cut defects, corrosion, pits, holes and welds with a sensor configuration suitable for field application. Operating parameters like driving frequency, ac and dc current, are being optimized in the laboratory measurement system for a set of GI, mild steel and Aluminium pipes. Testing was carried out by varying the hole diameter on the pipe. The variation of back wall (BW) echoes and those obtained from the hole as a function of hole diameter were obtained.

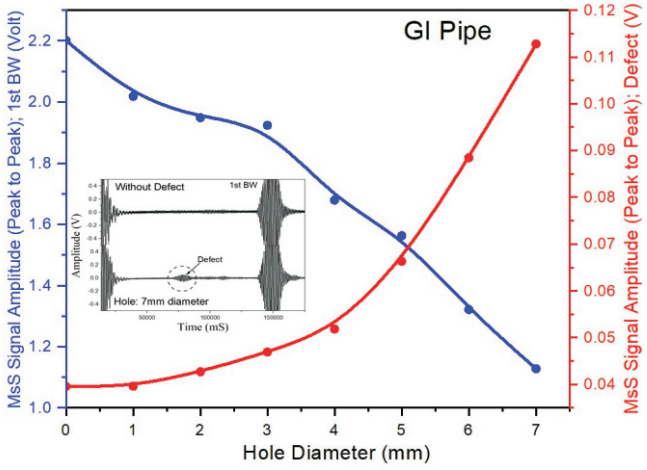


Figure 6 : Change in amplitude of back wall (BW) echo and of echo hole as a function of hole diameter

SAB tubes of Boilers made of HK-40 of the sponsor were failing during operation much before the expected service life. This was causing huge economical loss and also hampering plant operation because of unscheduled shut down. Under a sponsored consultancy project, CSIR-NML is trying to establish the correlation of UT scan data of new and failed SAB tubes. Under this project, personnel from the sponsor are also getting trained for proper measurement procedure.

Development of need-based Sensors and devices for Industrial applications

Billet casting is used worldwide for the production of long products such as concrete reinforcement bars (rebars), high carbon springs, mild steel wires and electrodes. Casting of rebar grades is today done in two sections of 130mm^2 and 150mm^2 at all three billet casters of sponsors LD shop. Rhomboidity (off squareness/ obliquity) and cracks are two billet defects noticed in this grade which accounts for most of the rejections. Previous studies have identified the solidification pattern in the mould to be the sole cause for the cracks and one of the primary causes for rhomboidity. It is aimed at studying the formation of these defects in more detail than already reported so far. Keeping this in view, the objective of the present project is to record live mould wall cold face temperatures of a billet casting mould, across the face and on all four faces, for at least two

moulds embedding FBG sensors. The activity consists ofi) FBG Sensor fabrication in suitable single mode fiber, packaging and temperature calibration, ii) Array of FBG sensor insertion, installation in the caster and real time data capturing iii) data compilation for further modeling. For the insertion of FBG sensors, machining of one mould is completed. Fibre optic (FO) cable with 5 FBGs written on it was inserted in the machined mould. The FO cable coming out from the mould face before fixing the top plate is showing in Figure 7, whereas Figure 8 shows the Image of top plate being tightened with the 5 live temperature readings on the computer display. The instrumented mould went through leak and pressure tests and is ready for installation.



Figure 7 : The single Fiber Optic cable coming out from the mould face before fixing the top plate



Figure 8 : Image of top plate being tightened with the 5 live temperature readings on the computer display

CSIR-NML technology for measuring the flow rate of fluid through a narrow tube has been transferred to Electronic and Engineering Co Ltd (EECI), Mumbai. This technology will be useful to design a device to measure the flow rate of propellant used in spacecraft and which is responsible for the life of spacecraft. Spacecraft propellant gauging is one of the important activities that allow estimating the amount of propellant available onboard in a spacecraft. The propellant availability dictates the life of the spacecraft; also the data related to the propellant availability determines the mission sequence and decisions. CSIR-NML along with the sponsor are in a project to fabricate four systems using flight qualified electronics for on-board propellant gauging of space craft. This project is the outcome of the success of CSIR-NML in fabricating and developing a system for measuring the flow rate of fluids through a narrow tube. Qualification tests of the devices for continuous and pulsating modes for further use in Indian spacecraft will be carried out on ground in space environment. The electronic package development involves pulser, receiver, onboard storage and signal processing so as to enable acquisition, analysis and delivery of data from spacecraft to the ground stations. A joint review board (JRB) has been formulated for the monitoring of progress of the project for its smooth running and timely completion.

Applied & Analytical Chemistry

AAC Division of CSIR-NML is equipped with state-of-the art analytical facilities for chemical analysis of metallurgical samples like coal, metals and alloys. AAC Division provides analytical services for the ongoing R&D activities at CSIR-NML and provides analytical services to external clients on chargeable basis. Some major analytical activities carried out in the last year were coal core characterization in association with CMPDI, analysis of soils and sediment samples in association with GSI. Research at AAC division focuses on utilization of non-coking coal for coke making and self-healing anticorrosion coating for steel. Additionally, AAC division prepares and markets certified reference materials (CRM) for metallurgical samples.

Conversion of Non-coking Coal to Coke

India's prolonged crisis of coking coal, with only 11% as our nation's reserve, has compelled many researchers to look into possibilities of making coke from non-coking coals. Absence of thermal plastic properties (coking property) in non-coking coals is the prime hindrance for coke making. To address this issue, researchers at AAC Division of CSIR-NML have isolated and identified the molecular structure of the coking component present in one of the Indian coking coals (Ashok Mohanty, Saswati Chakladar, Subhajit Mallick, Sanchita Chakravarty; *Fuel*, 249, 2019, 411-417). Moreover, several novel additives have been identified to induce coking properties in non-coking coals. The objective is to develop a process flow sheet to make coke from non-coking coal. CSIR-NML has developed three different processes to prepare coke from non-coking coal in laboratory scale. Three patents have been filed in India for these processes. In one process, coking component isolated from coking coals using organic solvent extraction is used as an additive to prepare coke from non-coking coal. In another process, expandable graphite is used along with molasses as additives to prepare coke from non-coking coal. In yet another process, use of natural gums followed by heat treatment process has been found to induce coking properties in non-coking coal. Low Temperature Gray King (LTGK) assay of non-coking coals modified with above additives yielded G_1 to G_3 grade cokes. Presently, we are in the process of upscaling the above coke making process (7 kg scale).

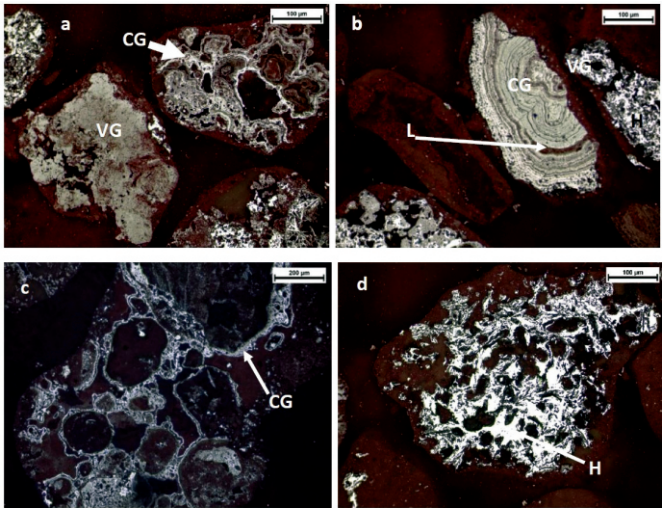


Figure 1: Photomicrographs illustrating different mineral phases and their textural features

Coal Characterization: Band by Band and Seam Overall Analysis of Coal Core Samples

Analytical & Applied Chemistry (AAC) Division has established a state-of-the-art coal characterization laboratory in collaboration with Central Mine Planning and Design Institute (CMPDI), Ranchi. The test facilities include : (a) Coal core logging and sample preparation, (b) Band by band analysis (Ash+ Moisture), (c) Proximate analysis (both conventional and instrumental), (d) Determination of Gross CV, (e) Ultimate analysis, Carbonate Co_2, (f) Moisture% at 60% RH & 40 C, (g) Phosphorus, (h) Ash Analysis , (i) AFT range (IDT, ST, HT&FT), (j) HGI , (k) Free Swelling Index , (l) LTGK Coke Type and (m) Plastometric test.

(a) Band by band analysis of coal core samples

The study of borehole coal cores involves visual separation of different bands present in the coal seams and its characterization for qualitative and quantitative estimation of exploitable reserves of the coal block. Band by band analysis of coal core samples collected from Ranigang, North Karanpura, Birbhum, Singrauli, Talcher and Rajmahal Coalfields to name a few, has been investigated to understand the quality of coal seams. The coal core samples are lithologically identified according to the depth and weight of the band. Ash and Moisture of each band is determined. Finally, the actual lithology of each band is calculated for each borehole. This is very important to understand quality of coal seam of individual borehole coal core. The collaborator CMPDIL after receiving the result of all the band by band coal core samples, conducts coal seam mapping using actual latitude and longitude data. This information is very useful for Coal India for price evaluation of each coalfield.

(b) Seam overall analysis

Seam overall analysis is the most important characterization of individual coal seams of each borehole after completion of band by band analysis. After receiving the advice of our collaborator CMPDIL different parameters like Ash, Moisture at 60% RH at 40°C, Gross Calorific Value, Ash Fusion Temperature, Ash composition analysis, Ultimate analysis, and Hard Groove Index are determined to understand the characteristics of coal. We use advanced analytical techniques like atomic emission spectrometry (AES), atomic absorption spectrometry (AAS), and X-ray fluorescence (XRF) spectrometry for determination of major, minor, and trace elements in coal and coal ash Seam wise variation of different parameters are investigated statistically. For quantitative analysis of coal ash (ashing temperature of 525 °C), the elements Cd, Cu, Li, Mg, Mn, Na, Pb, and Zn are determined by AAS, and Al, Ca, Fe, K, Mg, Mn, Na, P, S, Si, and Ti are determined by XRF spectrometry. Similarly, Hg is determined by cold-vapor AAS; Cl and P are measured by XRF spectrometry. Further study on Ash composition analysis and Ash Fusion Temperature reflect the staging and clicking probability of a particular seam which have a negative impact during combustion. All this information is very helpful for the behavior of combustion mechanism of particular coal seam. The results of all this information are deciding factor for the coal blending mechanism of thermal power plant. Therefore, a thorough study of the seam is required to produce a report of a particular seam of any mining area.

Analysis of Sediment Samples : Collaboration with Geological Survey of India

As a part of an analytical protocol development for analysis of inorganic matrix in real life samples, Analytical & Applied Chemistry Division of CSIR-NML has a collaboration with Geological Survey of India for quantification of trace elements in sediment samples. The study involved development of methodology for quantitative analysis of rare earth elements found in stream sediment samples using inductively coupled plasma mass spectrometer (ICP-MS). Geochemical Reference Material (GRM) for stream sediments from NIST were used to draw the calibration curve. Due to elemental discrimination by the mass of the elements, detection limits are among the lowest among other analytical techniques, thus making the sensitivity and ability of the instrument the most optimum among the different available spectrometers. The samples were prepared using multiple methods i.e. by fusion and digestion. The analytical results obtained for stream sediment sample containing rare-earth elements after experimentation using ICP-MS were communicated to Geological Survey of India.

Certified Reference Materials

CSIR-NML is pioneer in developing certified reference material for Raw Materials, Metals, Ferro-alloys and Spectrographic Standards in India. CSIR-NML has already developed 35 nos. of Certified Reference Materials (CRMs) with reference to Metals, Ferro-alloys, Ores, Coal and Spectrographic Std. Details of above CRMs are available in www.nmlindia.org website. In 2019-2020, CSIR-NML have developed 12 nos. of new CRMs as follows :

Sl. No.	CRM No.	CRM Name
1	213	Plain Carbon Steel (C=0.1%)
2	214	Plain Carbon Steel (C= 0.48 %)
3	221	Nickel Steel (Ni = 3.21 %)
4	231	Ferro-Silicon
5	233.1	L. C. Ferro-Manganese
6	233.2	H. C. Ferro-Manganese
7	234	Ferro-Titanium
8	235	Ferro-Vanadium
9	161.5A	Iron Ore (Fe= 53.86 %)
10	161.6A	Iron Ore (Fe= 62.86 %)
11	150	Coal (For Proximate & GCV Analysis)
12	151	Coal (For Ultimate & Ash Analysis)



Metal Extraction & Recycling

Metal Extraction and Recycling (MER) Division carries out basic research, technology development and provides industrial solutions in its core competence areas. The division concentrates its expertise primarily in the areas of ferrous and non-ferrous metals, value addition and value extraction from various secondary's and industrial wastes. The division is well equipped with lab scale to pilot scale facilities. The division consists of three major groups: Ferrous Processing, Non-ferrous Processing, and Secondary and Resources Utilization. The Ferrous Processing group is primarily involved in process advancement in agglomeration and utilization of iron ore fines and ferruginous wastes of steel plant, and preparation as well as quality improvement of different ferro-alloys. The Non-ferrous Processing 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 activities in Secondary and Resources Utilization group is directed towards use of secondaries for rare earth extraction and value addition to all types of industrial wastes by converting them to products for a variety of applications such as refractory, construction materials and cementitious products.

This division has charted out its future research in areas that are important for national economy, strategic sectors, mobility, and infrastructure. These include technology establishment for the extraction of critical metals including REE from secondary resources, development of hybrid materials for specialty applications, use of geopolymer matrix for immobilization of low level radioactive wastes, and others.

Development of Briquetting technique for utilization of steel plant solid waste

Several iron oxide fines such as Basic Oxygen Furnace (BOF) sludge, Blast Furnace (BF) sludge, Electro Static Precipitator (ESP) dust, sinter returns, BF flue dust, etc., are generated in different units of steel plant. All these fines have substantial quantity of iron oxide. A major portion of these fines are not used in steel plant because of their extreme fineness and inappropriate chemistry. These fines can be used as coolant in BOF converter if agglomerated properly. However, a suitable agglomeration technique is required. The present study aims at



Figure 1 : Briquettes produced at a pilot scale

utilizing steel making sludge and other wastes, like, blast furnace sludge, ESP dust and sinter return, generated in the steel plant, to produce briquettes. First, the process parameters for good quality briquettes were optimized at a laboratory scale. The mix ratio, suitable binder and its quantity of addition, have been optimized, and finally, cylindrical briquettes were developed, which had 280 kg/cm^2 cold crushing strength. Pilot scale study at 150 kg scale was also conducted to make good quality pillow shaped briquettes of 30x35 mm, which showed cold crushing strength of 130-150 kg/briquettes (Figure 1). In the second phase of the project, the large scale production of briquettes and subsequent plant trial to assess their performance will be carried out in an integrated steel plant.

Feasibility of Recovering of metal and spinel refractory from ferrochrome slag using vacuum arc furnace

Spinel type refractory material can be made, by changing the chemistry of ferrochrome slag, for direct utilization in high temperature refractory application. Ferrochrome slag is a waste discharged from ferro-chrome production, which can be used to produce spinel type ceramic sintered body by treating with a reducing agent, mainly coke, in an arc furnace. In the present study, high carbon ferrochrome slag was heated in a vacuum arc furnace under reducing condition at above 1800 °C. Moderate vacuum condition was applied to recover magnesia-alumina containing spinel material after removing silica (Figure 2). Apart from the Spinel (Al_2O_3 and MgO) from slag phase, the recoveries of the material/metal values such as Mg and SiO from vapor phase and Fe-Cr-Si alloy from metal phase have been done at a pilot scale (300 kg capacity). Thermodynamic calculation for various process parameters were carried out using FactSage to freeze the operating conditions such as pressure, charge mix and temperature, to minimize the silica content in the spinel and maximize the spinel product. This feasibility study proved that ferro-chrome slag can be fully utilised and the above mentioned value added materials could be recovered.

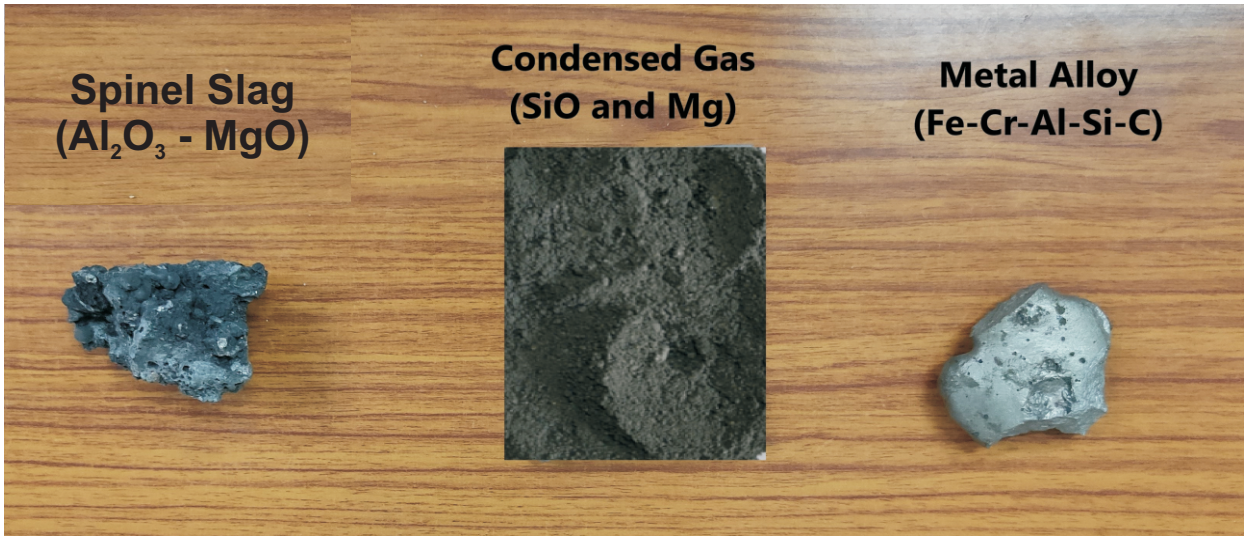


Figure 2 : Materials produced by reduction of ferrochrome slag

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

Indian secondary steel sectors contribute to about 1/3rd of the country's steel production. It uses induction furnace as melting media. Owing to the non-continuous power supply and other considerations, these furnaces use acidic ramming mass for furnace lining. It is well known that in the acidic lined furnace, no refining reactions particularly the removal of sulphur and phosphorous can be carried out. Almost all the melting furnaces located in Eastern, Southern and Central parts of the country use about 80% of DRI as charge material that contains phosphorous as high as 0.10%. Under basic or neutral lining conditions, refining reactions are possible with suitable slag cover, which is very difficult under acidic lining conditions. Therefore, the implementation of newly developed basic ramming mass in the industry is highly needed. Development of basic lining and their performance study in induction furnace with suitable slag will be carried out jointly by CSIR-National Metallurgical Laboratory, Jamshedpur, CSIR-Central Glass & Ceramic Research Institute, Kolkata and National Institute of Secondary Steel Technology (NISST) , Gobindgarh.

Transfer of know-how for a process for production of highly metallized DRI from mill scale and lean grade coal

The know- how as above, has been transferred to M/s. Shree Mahabir Refractories Works (SMRW), Ranchi (Figure 3). The know-how includes process data, raw materials and its specification, utilities required, flow sheet, list of equipment and machinery, materials of construction, cost details, scale of demonstration, etc. The industry has installed Pelletizer having capacity of 8 TPH and ball mill of 5 TPH capacity under the guidance of CSIR-National Metallurgical Laboratory. The industrial production of green pellets utilizing mill scale has been optimized and demonstrated successfully. Training has been provided to employees of M/s SMRW, Ranchi for stacking of the saggers on the trolleys and loading of the charge materials in the saggers. Commercial production of DRI from mill scale and lean grade non coking coal @18 TPD in the tunnel kiln was successfully demonstrated. Training has also been given on process control and on corrective actions during operation to ensure the quality of the product.





Figure 3 : Knowhow transfer to Shree Mahabir Refractories Works(a) Trolleys loaded with charge materials, (b) Trolleys entering in to the Tunnel Kiln, (c) Sampling of the product and (d) Testing of discharged product

Dip mold simulator based method for qualification of casting powders for crack sensitive grade steels

The principal problems in continuous casting of liquid steel are longitudinal cracking and sticker breakouts. Controlled heat transfers along with better lubrication provided by suitable mould powder prevent these problems. At present several plant trials are needed to obtain an understanding of the behavior of mould powder, however, these plant trials not only incur significant operational costs but are also associated with a great risk of caster damages (break out, mould wear and stoppages). Moreover, it has been noticed that a chosen mould powder behaves differently even within its known working composition range. Therefore, an experimental set-up, a dip mould simulator, was developed, to evaluate the performance of mould powder. The method addressed in this investigation will take into account the key properties of mould powder, steel to be cast and certain casting parameters like stroke, mould oscillation frequency, casting speed and cooling rate to evaluate the suitability of casting desired peritectic grade steel in the continuous caster. The schematic diagram of the dip mould simulator and water cooled Cu mould, designed and fabricated in-house , is shown in Figure 4. This simulator is an Indigenous development for mould powder performance assessment, and is globally the fourth such development, after USA, Korea and China. This will be one of the unique national facilities to study the initial solidification behavior of steel during continuous casting process.

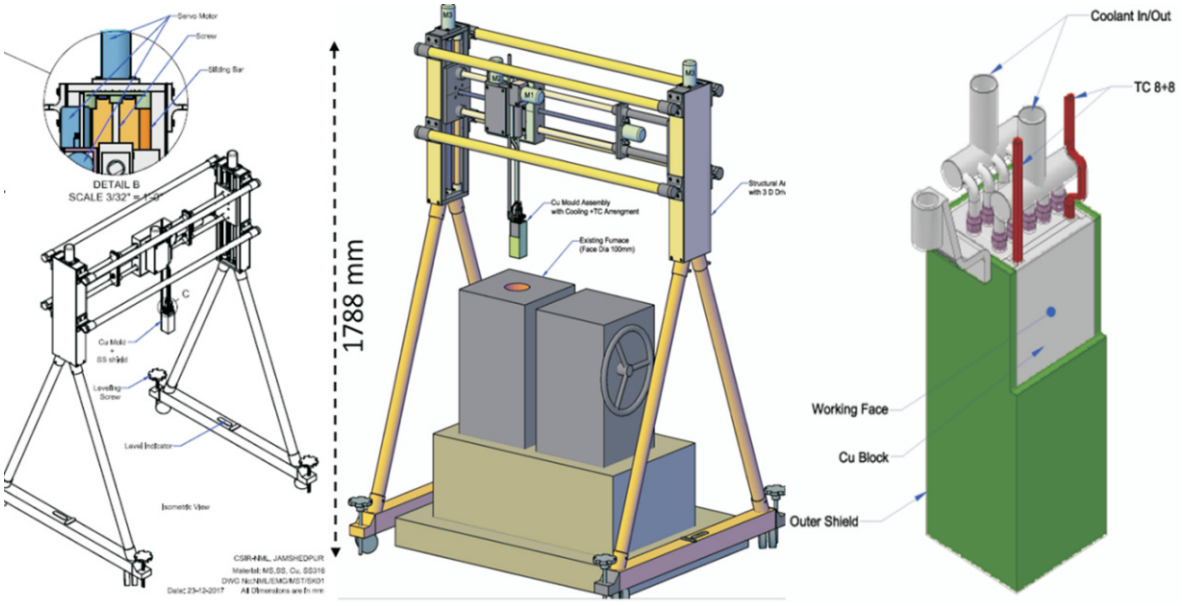


Figure 4 : Schematic diagram of dip mould simulator

Development and fabrication of cannon liners for explosive testing

The cannon available with CSIR-CIMFR, Dhanbad, are made up of three concentric steel parts, and are deployed for explosive testing to qualify the explosives used in underground mines. This cannon assembly and the liners were imported from UK during 1970s and the know-how for manufacturing the same is not available

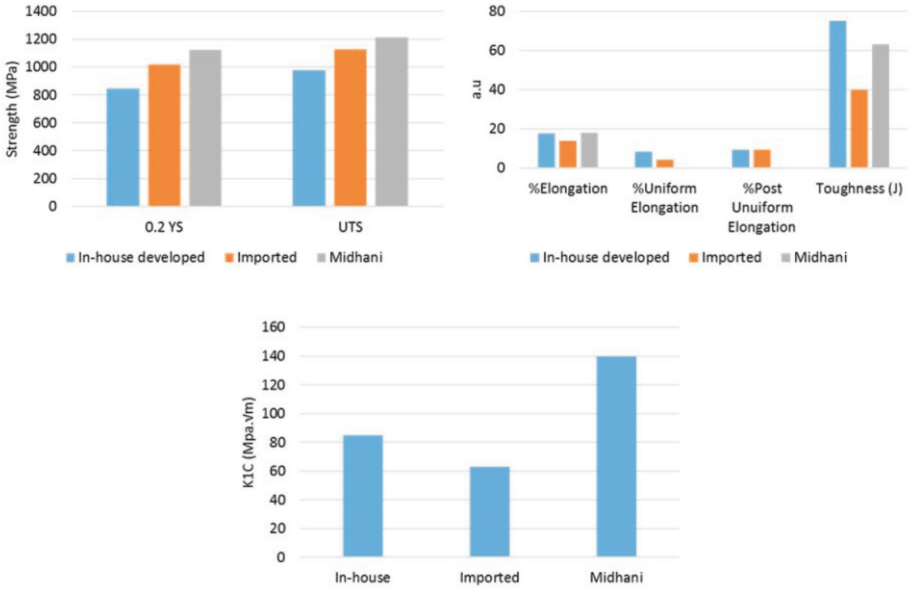


Figure 5 : Comparison of In-house developed canon liner

with CIMFR. The only technical information regarding the inner membrane available is "HADFIELDS HECLA 138H 2.5 NI CR Mo forged steel inner membrane in the oil hardened and tempered condition with a Brinell hardness of 340/360". With this information, CSIR-NML started the developmental activity for in-house design and development of cannon liner steel, followed by fabrication of cannon inner membrane through a reputed steel industry. The Know-how generated in-house was shared with M/s. MIDHANI Hyderabad and the cannon liner alloy steel of dimension 1600 length x 220mm diameter was manufactured and the mechanical properties were found to be superior than that of the imported steel as well as the steel developed at a laboratory scale (in-house) (Figure 5). These cylindrical rods will be machined to required cannon inner membrane dimension and shrink fitted at Hindustan Engineering Corporation (HEC), Ranchi. Thereafter the cannon will be placed for field trial, that is, explosive testing. This will help in production of steels for strategic applications in India.

Development of indigenous technology for production of sodium metal at a commercial scale

Sodium does not occur in the free-state due to its high reactivity. Sodium metal has extensive technical and industrial applications in drugs, pharmaceutical, petroleum, plastic and atomic sectors. The total demand of sodium metal in India is very high and the demand is being met by imports. To become self-reliant, CSIR-NML is working to develop and commercialize sodium metal production technology in India. CSIR-NML had started the activity for production of sodium metal 2008 onwards, through designing the closed sodium cell at 500A capacity. The 500A closed cell was successfully commissioned and operated continuously for 20 days and produced significant amount of high pure sodium metal. Based on the success of the CSIR-NML's sodium metal production, a pilot plant of 3000A capacity was installed and commissioned at the site of the sponsor in 2019 to meet their captive demand of sodium metal. The 3000A closed cell was fabricated and successfully commissioned and operated continuously for a month at the premises of the sponsor and produced significant amounts of required grade sodium metal(Figure 7). Based on the pilot scale operation, the setup of industrial plant (12000 A) is under progress at the site with the help of CSIR-NML's technical expertise. The proposed plant is designed to produce 2 ton/day sodium metal and the plant is expected to be commissioned by 2021.

The Lab scale 500A cell produced sodium metal with purity of 99% with cell efficiency of about 60%. The process efficiency of 3000A pilot plant was about 82% and the purity of sodium metal was about 99.9%.



Figure 7: 3000 A Close cell for sodium production

Processes for recycling of metals/ materials from E-waste

Under this activity a pilot plant is being set up. The developed pilot scale process and recommended protocol will provide the safe collection of E-waste, proper storage, dismantling and segregation for the recovery of valuable metals and materials along with necessary treatment of solid, liquid effluent and gaseous waste generated during processing of E-waste. Dr. Shekhar C. Mande, Director General of CSIR and Secretary of the Department of Scientific and Industrial Research (DSIR), Government of India, has inaugurated the Urban Ore (E-waste) Recycling Centre at CSIR-NML, Jamshedpur, on 20th April 2019(Figure 8). This center is dedicated to the development of feasible technologies to recover non-ferrous, precious and rare earth metals from urban ores. Recently, five technologies to recover precious and rare metals were transferred to various industries (Figure 9), including the Evergreen Recyclekaro, Mumbai; Exigo Recycling, New Delhi, SBCON Recycling, Ahmedabad, and, UNQ. IND.,



Curtain Raiser Ceremony of Urban Ore Recycling Centre by Director General of CSIR



Inauguration of Urban Ore Recycling Centre, CSIR-NML, Jamshedpur

Figure 8 : DG, CSIR Dr. S. C. Mande inaugurating Urban Ore Recycling Centre



Signing of MoU on "Extraction of Cobalt and Manganese from scrap batteries"



"Transfer of Know-How for the extraction of cobalt metal from the black powder of Li-cobalt batteries"

Figure 9 : Signing of E-Waste Technology Transfer Agreements

Firozabad. These technologies involve individual/ hybrid techniques like pyrolysis/ chemical pre-treatment for the beneficiation of e-waste followed by leaching and recovery of metals, viz., Cu, Ni, Zn, Al, Au, Ag, Pt, Pd, Nd, Co, Mn, Li, Pb, Sn, etc., using advanced separation processes like solvent extraction, ion-exchange, cementation, precipitation, electrolysis, electrowinning, etc., to obtain salts/ metals and other valuable by-products.

Development of an effective extraction and separation technology to selectively extract rare earth elements - Erbium (Er), Terbium (Tb), Europium (Eu), Praseodymium (Pr) Neodymium (Nd) and Dysprosium (Dy) from WEEE

Rare earth metals are one of the most important ingredients of modern technology. Due to their unique spectral and magnetic properties, rare earth metals are used in a wide range of applications from green technology to general household appliances to military systems. The global rare earth demand is increasing at the rate of 3.5% per annum. It is estimated that world reserves of rare earths are approximately 120 million tons and China holds more than 1/3rd of total world reserves. China was also the leading rare earth producer in 2018 with mine production of 120,000 MT. India holds 6.9 million tons of rare earth reserves, mostly associated with coastal beach sand, which contains fertile thorium. Therefore, mining and extraction of rare earths from this primary resource is challenging in terms of radio toxicity, waste management and separation of desired rare earths. Recently, China has also considerably reduced its rare earth export, which has created a large instability in rare earth market. In this scenario, secondary resources of rare earth such as scraps and end-of-life products may be considered as potential resource for the extraction of rare earths. Out of these, spent NdFeB magnets and waste fluorescent lamps contain significant amounts of rare earths. The NdFeB magnet industry is growing globally at a rate of 20% per annum, and there is huge generation of end-of-life NdFeB magnet from different applications. The spent NdFeB magnet contains ~30 wt.% of rare earths (Nd, Pr and Dy). The fluorescent lamps are coated with white phosphor powder containing ~40 wt. % of rare earths (Y, Eu, La, Ce and Tb). The objective of the present project is to develop an effective extraction and separation technology to selectively extract rare earth metals from spent NdFeB magnets/waste fluorescent lamps. For this, an international collaboration was established with Marcoule Institute for Separation Chemistry (R&D, France), Terra Nova Development (Industry, France) and TRDDC, Pune. This Indo-French project is sponsored by the Indo-French Centre for the Promotion of Advanced Research (CEFIPRA). The idea is to work in collaboration to develop an efficient extraction process and design a novel extractant for effective separation of rare earths. The role of CSIR-NML is focused on the development of process for the extraction of rare earths from spent NdFeB magnet and waste fluorescent lamps. In this collaboration, TRDDC is involved in the design and development of modeling techniques (such as Molecular Dynamic Simulations) for screening of extractants. The role of ICSM is to synthesize and characterize the novel extractant for the individual separation of rare earths. Under this project, work has been carried out for the selective extraction of rare earths from spent NdFeB magnet. Also, for the separation of rare earths, different force fields have been identified using molecular dynamic simulations and solvent extraction experiments were carried out to validate the results. The developed process under this project has the potential for commercialization for treating spent NdFeB magnets.

Development of alternate reduction process of Mn ore by using gaseous reductant

MOIL Ltd., Nagpur is the sole manufacturer of Electrolytic Manganese Dioxide (EMD) in our country; producing about 1000 MTPA (Metric Tone Per Annum) EMD at their Dongri-Buzurg green field project. The present EMD manufacturing process employs high temperature coal based reduction prior to acid leaching of Mn ore. The process is inefficient, and, environmentally polluting. In view of the projected expansion of EMD production by MOIL to 40,000 MTPA by 2022, it is necessary to develop an efficient reduction process which could be less polluting. In this context, gaseous reduction of Mn ore has been conceived and taken up for further studies.

Two different types of Mn ore samples; one having low MnO_2 (~ 26%) and another having high MnO_2 content, (~ 46%) have been taken up for thermal reduction at low to medium temperatures by using several gaseous reductants such as CNG, LPG and Producer gas. Bench scale feasibility and optimization studies of reduction of Mn ore(s) with these gaseous reductants have been carried out. It has been observed that, reduction of Mn ore(s) with LPG is techno-economically competitive with respect to the coal based reduction processes besides giving emission dividends. Low temperature (<800°C) thermal reduction of Mn ore with LPG was scaled-up to 20 kg/batch scale by using a rotary furnace. The results indicated more than 93% reduction efficiency at 800°C. Further studies on reduction of Mn ores with Producer gas are underway.

Improvement of Manganese Recovery from Reduced Manganese Ore

MOIL, is using a reduction roasting - leaching and electro-winning process for production of EMD and their Mn recovery during leaching is only about 60-65%. MOIL proposed to set-up a new production plant with improved Mn recovery and sponsored a project to explore higher recovery, to CSIR-NML. It was observed that some MnO_2 remained unreduced in the matrix and did not dissolve during sulphuric acid leaching. This resulted in low recovery of manganese. The unreduced manganese dioxide present in reduced ore was targeted to improve manganese dissolution. MnO_2 can be easily dissolved by in-situ chemical reduction during leaching. Therefore, various low cost reductants such as sawdust, molasses and ferrous sulphate pickle liquor were added during dissolution maintaining similar leaching environment and it was observed that ferrous iron addition gives the highest improvement in Mn recovery. Waste iron powder, which is available cheaply from various sources, was used as a source of ferrous iron for reductive dissolution. Under optimized condition about 18-20% improvement in Mn recovery was achieved during leaching with addition of about 30-40 kg waste iron powder per tonne of reduced ore. High purity EMD containing <30 ppm Fe was produced from purified Mn leach solution(Figure 10). The grade is suitable for lithium ion battery applications. The improved process requires lower roasting temperatures and therefore can avoid the chance of over-roasting, which is also a cause for lower Mn recovery in the existing process. The process was demonstrated at a kilogram scale to MOIL and Ministry of Steel personnel with about 20% higher Mn recovery. The process was also demonstrated at MOIL's Dungri plant with similar improvement in Mn recovery (Figure 11). Based on the success achieved, MOIL and Ministry of Steel decided to set-up the 1500 MT high pure EMD production by the end of 2020 with the help of MECON, which will subsequently be scaled-up to 10,000 MT.

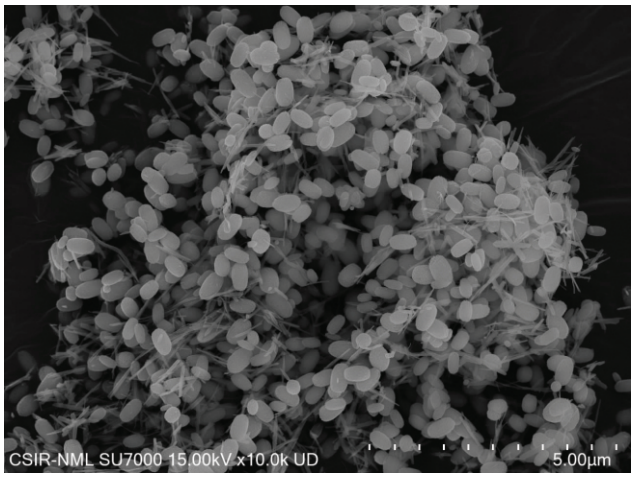


Figure 10 : EMD deposited cathode



Figure 11 : Plant demo at MOIL, Nagpur

Human Resource conservation through utilization of industrial waste

Natural resources are precious and finite. Many of the by-products during the extraction of natural resources are discarded carelessly for selfish motives of the generators. Regulations by various agencies to restrict such unacceptable practices so as to avoid subsequent long-term social and environmental impacts, is slowly changing the business as usual approach. Such activities lead to loss of precious natural resources as well. Suitable processing or preprocessing of such by-products makes them valuable resources leading to their conservation. Under this umbrella of resource conservation activities, the following projects were carried out:

(a) ***Light weight alumino-silicate refractory wastes from steel plants:*** Integrated steel plants use different types of refractory materials for lining of different furnaces, ladles, vessels, etc. Alumino-silicate based fiber is one such refractory material, which has high temperature insulation properties. Its discard, after its end of life, is a concern as it is a health hazard besides being very light (therefore occupies large space). Presently, it has no values or applications. Large usages (50 ton/year) compound the problems. Therefore, proper management and gainful utilization of this waste becomes necessary to mitigate pollution. At the behest of the sponsor, this problem is being addressed by NML with an objective to find proper applications after suitable processing. This waste has been characterized and explored for different applications, and its chemical composition was found to be suitable for refractory applications. Being lightweight, it has been explored for development of lightweight porous board/block for insulating purposes 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. Characteristics of the developed blocks (Figure 12) such as thermal conductivity (which is most critical characteristic for insulation application) are promising.

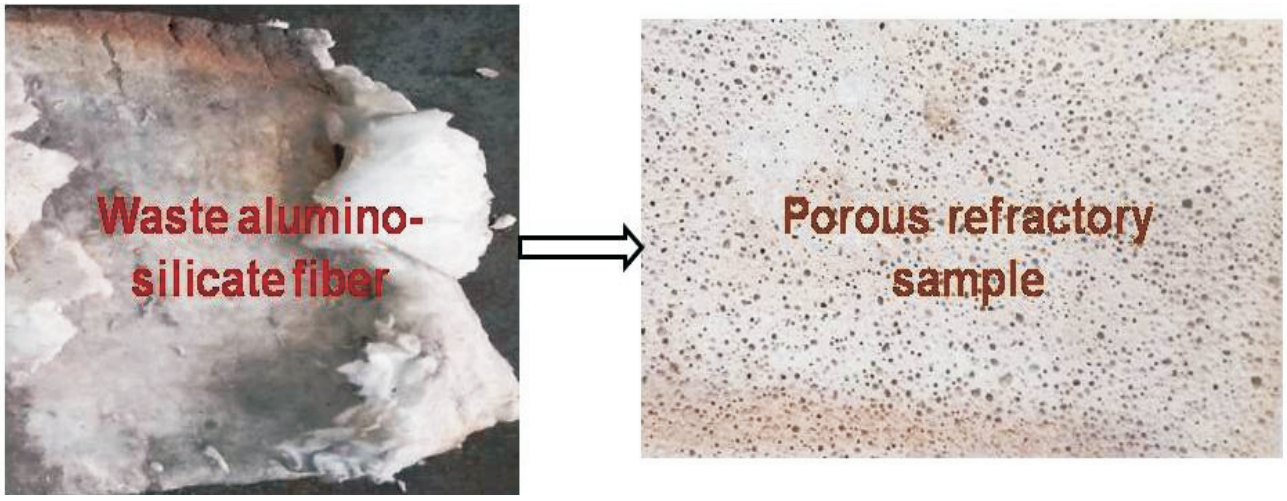


Figure 12 : Developed Lightweight aluminosilicate refractory

(b) ***Red mud Utilization:*** has been a concern of aluminium industries since the inception of the Bayer process of alumina production over a hundred years ago. Typical generation is of the order of 1 ton per ton of alumina produced. Typical nature of the red mud (fine size, alkalinity etc.) makes it unsuitable for most applications. As a result of continued generation with practically no reuse is causing the red mud inventory to pile up. Presence of soda content (6-7%) - deleterious for many applications- and alumina and silica in the red mud can be exploited in geopolymer based processes as these are the essential ingredients for geopolymerization. CSIR-NML has developed a process for utilizing this red mud in geopolymer paving blocks; essentially, part of the aluminosilicate used in the geopolymer process is substituted with red mud. Presently the process is being up-scaled to 10 tons per day. The studies included suitability of red mud from various alumina refineries, extent of substitution, binder ratios, binder concentrations, etc.

The project has targeted obtainment of a paving block (geopolymer) of M25 grade. Initial studies have been carried out by studying the properties of standard concrete blocks (70 mm size).Geopolymer paste prepared from red mud, fly ash, binder solution (a mixture of sodium silicate and sodium hydroxide solutions) was used instead of cement. Paver blocks with different shapes have been prepared (Figure 13). It was found that laid pavers, after exposure to the atmosphere for a few weeks, show white powdery material adhering to the exposed surfaces. This efflorescence, a consequence of sodium carbonate formation on contact with the atmospheric carbon dioxide has been minimized through a slight modification of its chemistry. Six months of exposure did not yield any sort of efflorescence; however, appearance of efflorescence is observed in extreme cold weather (which occurred after about eight months of exposure). Attempts are being made to minimize the efflorescence by different approaches. Durability studies and life cycle analysis of the products are being done.

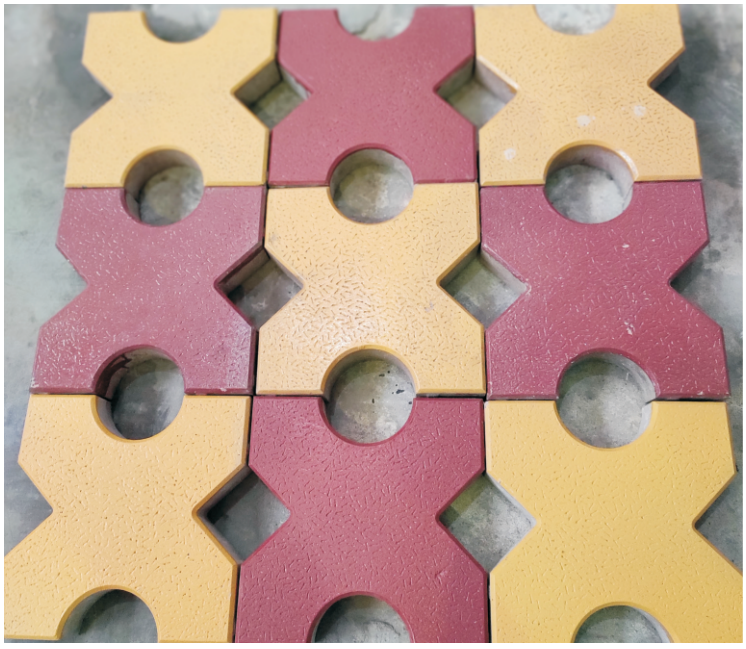


Figure 13 : Paving block from red mud

(c) ***Ultra Fine Grinding of Steel Slag for cementitious application:*** Steel slag, a byproduct of steel-making, is generated to the extent of about 15% of steel output. Unlike blast furnace slag, which has a good demand in blended cement, steel slag has not had any such demand other than that for mundane aggregate purposes. Increasing generation of steel slag (as a consequence of increasing steel production) together with that accumulated over the years is becoming a threat to the sustainability of iron and steel industries. Large amount of space requirement together with more and more stringent environmental regulations make its usage inevitable. Typical mineral phases in the basic oxygen furnace (BOF) slag include dicalcium silicate (C_2S) or both C_2S and tricalcium silicate (C_3S) which are the primary strength-contributing hydraulic phases in Portland cement. Despite the presence of C_2S and C_3S, BOF slag is not used in blended cement because of its inherent low reactivity. It can be made a supplementary cementitious material provided its hydraulic reactivity is enhanced. High energy milling - used for enhancing the reactivity of substances in solid state - is being explored at the request of the sponsor, a major player in the International iron and steel sector. Various devices under the purview of this investigation are attrition mill, planetary mill, eccentric vibration mill and jet mill, each of which has its own advantages. The study includes investigations of the grinding efficiency, and, the energy consumption for a particular product size. The high-energy milled product is characterized for particle size, morphological changes, structural changes and cementitious characteristics. Its effectiveness as a supplementary cementitious material is tested by comparing the compressive strengths of mortar samples made with various replacement of clinker with fine milled LD slag for different periods of time with that made with clinker alone (no BOF slag).

Rare earth extraction from granulated blast furnace slag

Extraction of rare earth metals from BF slag was sponsored by a major Iron and Steel company. As the majority of BF slag is in granulated form (GBFS), REEs extraction vis-à-vis retaining the cementitious property is considered. In view of this, CSIR-NML is exploring the possibility to extract the REEs from granulated blast furnace slag (GBFS), and further testing the treated material for possible applications. The GBFS samples obtained from the sponsor were for this study. Quantities of REEs present and their distribution were determined by Chemical methods (ICP-OES, Table-1) and by material characterisation tools (Figure 14)). It was found that GBFS has 49 ppm La, 66 ppm Ce, 10 ppm Er, 41 ppm Nd, 27 ppm Sm, 8.02% Al, 13.21% Si, 33.62% Ca and 4.03% Mg. The process was optimized to have higher release of REEs from the slag (while keeping the calcium dissolution to the minimum) during leaching. Based on this, the leaching conditions were optimized. 92% extraction of La, Ce, Nd, and ~78-80% extraction of Er and Sm have been achieved under these conditions whereas the release of Ca has not crossed more than 6%. The process has been upscaled to 1000 gm scale in a single and counter-current mode with minimal variation in the rare earth recovery. The residue generated is being explored further for development of suitable applications.

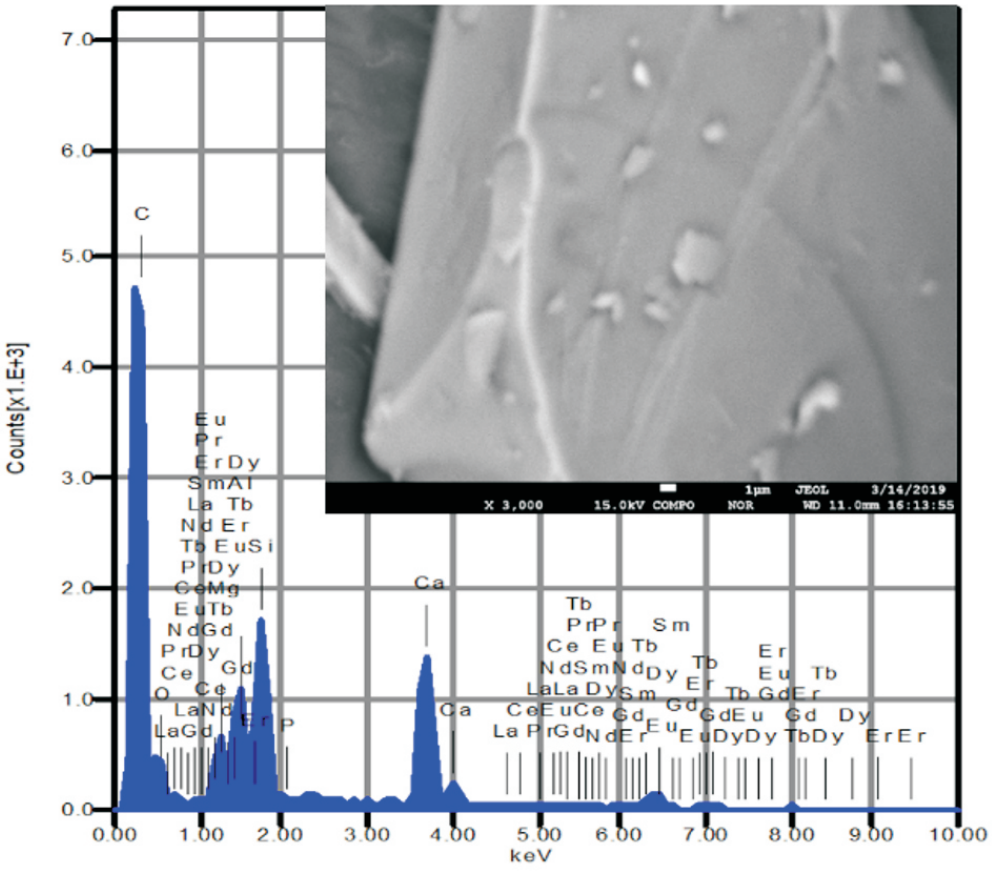


Figure 14 : EPMA showing distribution of REE in GBFS

Materials Engineering

Materials Engineering (MTE) Division has four groups; namely, Corrosion Engineering, Materials Mechanics, Materials Processing and Microstructural Engineering. The division also has large state of the art infrastructure: Creep facilities (2nd largest in Asia in terms of capacity), Fatigue-fracture related equipments, 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 FLD (Forming Limit Diagram) as well as HER (Hole Expansion Ratio) evaluation, Laboratory scale 2 high rolling Mill and various equipments for corrosion rate as well as evaluation of corrosion products. In the following, a few of the projects carried out in the previous year (completed as well as on-going) have been presented. Apart from these, the Division also carries out numerous testing jobs which are not reported here.

Establishment of suitable microstructure for improving high strain rate tensile behaviour of advanced high strength steel

Dual-phase (DP) steels are a class of high strength steels which are characterised by a good combination of high strength and ductility. Both the strength and ductility of a DP steel are directly related to the martensite shape, size, and distribution. This grade of steel has drawn the attention of steel researchers for more than three decades and resulted in the development of several variants ranging from DP600 to Dp1180. Probably this is due to the ease of industrial manufacturing process adaptability and also due to the demand in the automotive sector. Industrial continuous annealing process routes for dual-phase steels are mostly found to be non-isothermal in nature. The present study is an effort to understand the importance of non-isothermal annealing process parameters and their impact on the various metallurgical phenomena; such as recrystallisation and phase transformation behaviours of dual-phase steel. These, in turn, are expected to influence various structure parameters of the martensite phase which are critical in determining the strength of dual-phase steel.

The main objectives of the project proposal are to simulate different microstructure in high strength DP steel grade for the given compositions using annealing simulator and to optimize its high strain rate tensile deformation properties. Figure 1 shows true stress-strain plots for some of the developed steels.

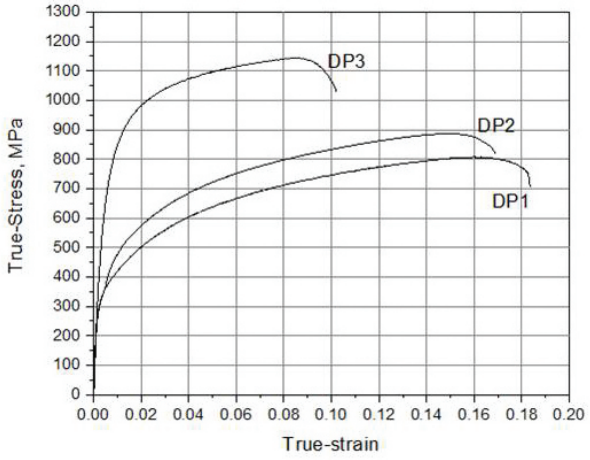


Figure 1 : True stress-strain plots for developed steels

Optimization of Al-based metallic foams production method and development of metal foam

The project aims at the development of Al- and Al-alloy based sandwich foams for crash energy absorption applications. Closed cell Al-based metal foams are seen as good shock absorbers and are light weight, having density of around 0.4-0.6 g/cc. The objective is to develop a process for aluminum metal foam with various compositions and optimized process parameters, with delivery of around 50 samples of 50 mm x 50 mm x (6-10) mm sandwich foams to the sponsoring agency for testing. The process being employed for this development is powder forging and rolling followed by sintering and foaming of the precursor material. The powder of a given alloy is mixed with a foaming agent, TiH_2 in the present case, followed by forging and rolling. The purpose of the process is to embed the foaming agent particles within the sintered alloy powder. Upon heating to the foaming temperature, the foaming agent decomposes releasing hydrogen gas. The sintering temperature needs to be kept below the decomposition temperature of the foaming agent so as to avoid decomposition and release of gas before full sintering. A uniform distribution of the gas evolution gives rise to uniformity in the pore distribution. The foam characteristics, in terms of porosity, pore size, and, density, depend upon the process parameters such as foaming agent content in the precursor, foaming temperature, foaming time and thickness of the precursor. In the present work, three different compositions are being attempted, pure Al, Al-Cu alloy and Al-Si alloy, and process parameters for each composition is to be optimized.

The Al-Si alloy sandwich foams supplied to the sponsoring agency showed shock attenuation of around 30%. The Al-(4-5wt.%)Cu sandwich foams gave better shock attenuation of ~ 37%. Samples of pure Al and Al-Cu alloy (both in as-foamed and solution treated condition), prepared with different compositions and foaming agent content, have been sent to the sponsoring agency for tests at their end. They are expected to show better shock attenuation properties. Figure 2 shows foams prepared and delivered with and without Face Sheets.

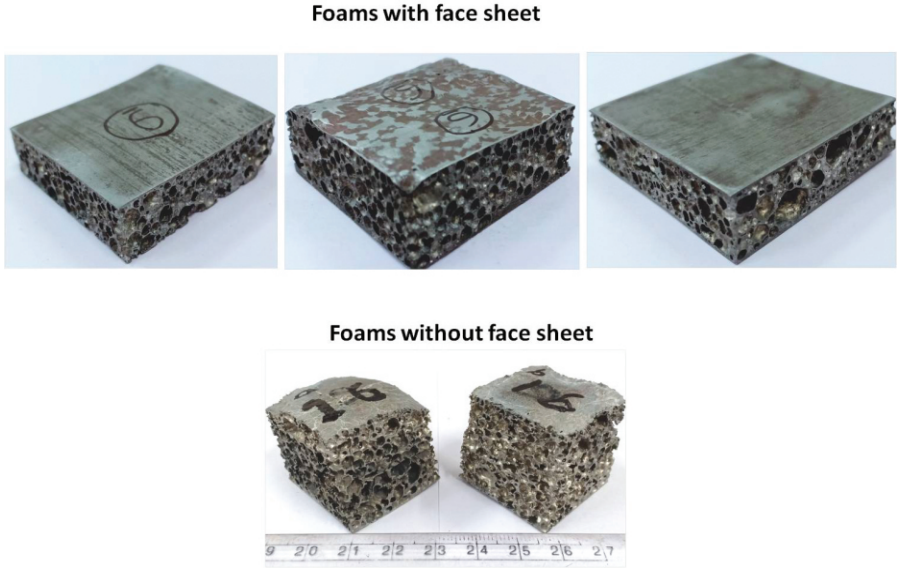


Figure 2 : Foams with and without face plate

Development of thicker section (> 6 mm) abrasion resistant steel with relatively higher coiling temperature

The sequential steps in quenching and partitioning (Q&P) process involves austenitization, hot rolling, quenching to a temperature between M_s and M_f, followed by isothermal holding for carbon partitioning and subsequent cooling to room temperature. The steels processed through quenching and isothermal partitioning have demonstrated better abrasion resistance along with enhanced impact toughness due to presence of retained austenite. However, isothermal partitioning step necessitates an additional heat treatment facility after hot rolling, which is difficult to introduce in a continuous hot rolling mill. As an alternative to isothermal holding, one exploits the fact that the remaining heat with the hot rolled coil after coiling is sufficient to stabilize some amount of retained austenite. In a previous collaborative work with the sponsor, on Q&P steel, a maximum of 8% austenite could be stabilized, despite having lower Si and Al additions. However, the optimum coiling temperature for maximum austenite retention was found to be in the range of 200-250°C. An increase in optimum coiling temperature is expected to enhance the austenite retention due to more heat retained with the hot rolled coil, which requires further efforts. In addition to this, the developed alloy in the previous work was aimed for low thickness ($\leq$ 6 mm). An increase in the thickness of the steel can lead to a gradient in the cooling rates across the cross section, which has a direct effect on the microstructure development and mechanical properties at different sections. In view of the above, the present project aims to recommend the best suitable chemistry and process parameters for the development of thicker section abrasion resistant steel (thickness: > 6 mm) targeting higher M_s temperature.

Development of medium Mn, high Al, low density, high strength steel

Stringent environmental regulations to control emissions in automobiles have been incorporated globally in recent years. This calls for weight saving in the body-in-white (BIW) of conventional vehicles and also to compensate the weight of batteries/cells in upcoming Electric/Hybrid vehicles. A weight saving of 10% in the steels used in automotive results in 6-8% improvement in fuel economy and eventually reduces emission. In this context, Al (density=2.7g/cc) has emerged as the chief alloying element for density reduction in steel. For every 1% addition of Al there is a decrease in density of 1.3%.

The present work investigates the microstructure-property evolution in Al-added medium-Mn (8 wt.%) steel. Alloys with varying Al content (4-8 wt.%) were investigated. Heat making of the alloys were done at a 20 kg scale. After homogenization, the alloys were hot rolled to ~3 mm thickness followed by air cooling to room temperature. Thereafter, it was re-austenitized followed by aging/annealing at different temperatures (650-900°C) for varying durations. The aged/annealed samples were characterized through SEM-EDS, XRD, EBSD and TEM to understand the microstructure evolution and to quantify the amount of retained austenite. Tensile tests were conducted to assess the mechanical property and work hardening behaviour of the samples.

The microstructure comprised of lath like and ultra-fine grained austenite-martensite islands and elongated δ-ferrite. A retained austenite of 40-55 vol. % was obtained at optimum annealing conditions. An excellent product of strength-ductility (~50 GPa%) was obtained in the alloy containing 4wt. Al.

One patent "Duplex nano-structured low-density steel sheet with strength ductility product exceeding 50 GPa% and preparation method thereof" has been submitted for filing.

Development of process technology for third generation Advanced High Strength Steel (AHSS)

The project aims to develop third generation advanced high strength steel through quenching and partitioning process with the output steels having high strength with enhanced ductility and good formability (T.S. X %El. >= 25 GPa % with 800-1200 MPa TS). The study involved design of alloy chemistry, thermodynamic analysis of the alloys, heat making at laboratory scale, hot rolling, cold rolling, dilatometry test, quenching and partitioning experiments followed by detailed characterization and mechanical property assessment.

In this work, two alloys, alloy 1 (with low Mn, 1.72wt%) and alloy 2 (with high Mn, 3.51wt%) were designed and taken up for the Quenching and Partitioning (Q&P) studies. Detailed thermodynamic and kinetic studies of the alloys were done. Empirical models were used to predict the annealing temperature range that would give maximum amount of retained austenite at room temperature. Based on the thermodynamic studies in alloy 1 and alloy 2, dilatometry test and Q&P simulation were designed and conducted in Gleeble to investigate the phase transformation and microstructure evolution of the alloys. Thereafter, intercritical Q&P treatment cycle on cold rolled samples were designed and carried out. The corresponding tensile properties and microstructure of Q&P treated samples were evaluated. In Alloy 1, a good combination of strength and ductility was obtained. An elongation as high as 20% was obtained with YS: 570 MPa, UTS: 870 MPa. In alloy 2, the Q&P treated sample at 695°C for 1hr and 2hr showed exceptionally high product of strength and elongation (PSE) of 29406 Mpa% (YS 573 MPa, UTS 1067 MPa, %EL. 27.56) and 26468 Mpa% (YS 526 MPa, UTS 1101 MPa, %EL. 24.04) respectively. The strength-elongation obtained in various Q&P cycles (cycle 1-6) in alloy-2 is shown in Fig. 3. An estimated 16-20% retained austenite was found to be present in the microstructure, which showed exceptionally good TRIP effect during deformation.

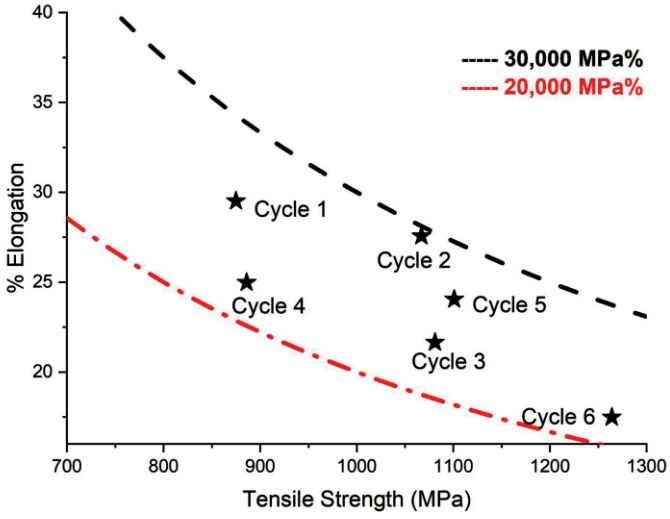


Figure 3: Tensile strength - %elongation plots of developed steels

Investigation on hydrogen trapping characteristics of precipitate/matrix interfaces in microalloyed steel

Hydrogen is a ubiquitous element that enters materials from many different sources. Hydrogen is well known for its deleterious effects on the mechanical properties of high strength steels. Hydrogen penetrates from the surface, diffuses into the matrix of the steel and tends to accumulate in the regions of high strain and various crystallographic defects. It can assist in fracture by generating vacancy type defects, by increasing the mobility of dislocations and by weakening the grain boundaries. Given that it is the diffusible hydrogen which degrade the mechanical properties, any method that renders the hydrogen immobile should allay its harmful effect. To this end, various microstructural trapping sites are known which can effectively immobilize the diffusing hydrogen. The trapping sites in the crystal can be any disturbance in the crystal, dislocation cores, second phase interfaces or any departures from the ideal lattice. In this context, substitutional alloyed carbides and nitrides are known to effectively trap hydrogen and help in mitigating its harmful effects on the mechanical properties.

An investigation on the ability of Nb and V carbides to act as the trapping sites for hydrogen in a micro alloyed steel was proposed. The precipitate size and volume fraction was to be varied keeping the other microstructural entities constant. The subsequent effect of different nature of precipitates (size and volume fraction) on the mechanical properties of the hydrogen charged specimen was to be investigated.

Five different alloys were prepared with varying amount of Nb and V, other elements being in the range of API grade steels. Two of the five alloys possessed varying Nb content (0.05 and 0.1 wt.%), other two were with varying V content (0.05 and 0.1 wt.%) and one with no Nb and V. Thermodynamic calculations were performed in order to predict the optimum temperature for precipitation in different alloys. Thermomechanical processing (TMP) was carried out based on the predictions made by thermodynamic calculations. TMP, consisting of solutionizing treatment, controlled hot rolling, heat treatment experiments at various temperatures and times, were carried out with an aim of obtaining precipitates with different sizes and volume fractions. A variation in the precipitate size was obtained after suitable TMP; one such instance for the 0.1 Nb steel is presented in Figure 4.

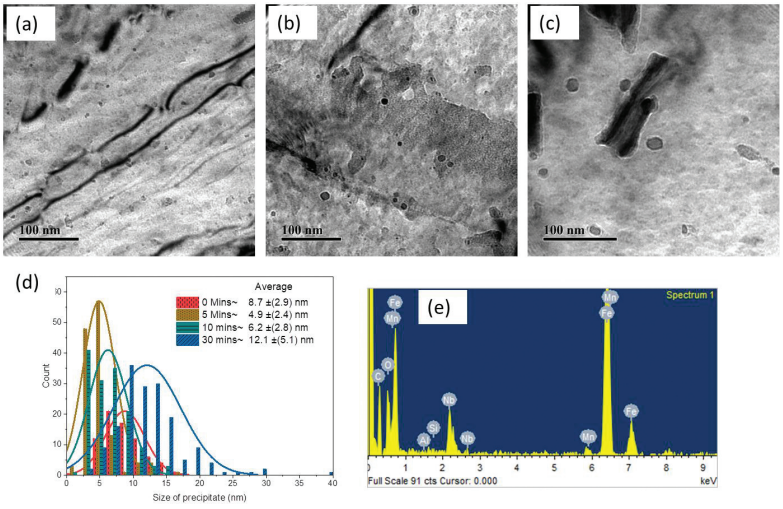


Figure 4 : (a-d) Variation of precipitate size in 0.1 Nb steel thermomechanically processed and subsequently held at the precipitate formation temperature for different time durations (e) EDS spectrum confirming the precipitates to be that of Nb.

Furthermore, accomplishment of variation in the volume fraction of the precipitates in different alloys was ascertained by preparing alloys with increasing microalloying elements. This resulted in an increase in the volume fraction of precipitate when the steels were thermomechanically processed under identical conditions. Fig. 5 presents the volume fraction of Nb containing precipitates in the steels containing 0.05 wt.% and 0.1 wt.% Nb. A clear difference in the kinetics of the precipitate formation is apparent

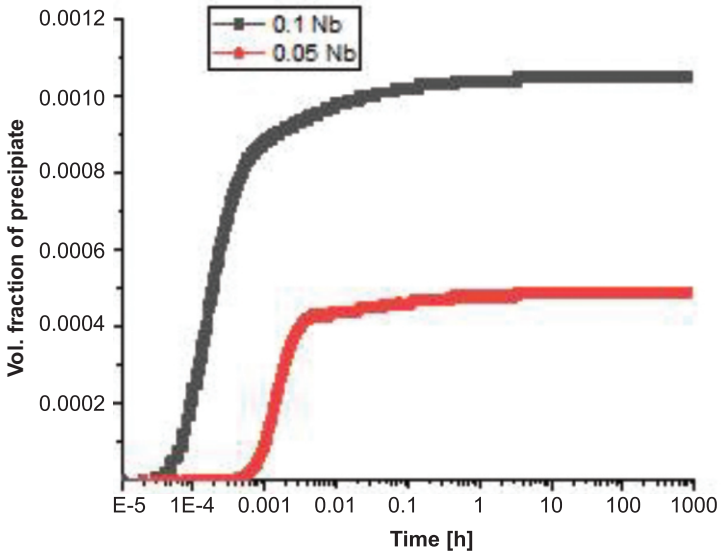


Figure 5: Temporal evolution of Nb precipitates

Optimization of the continuous annealing cycle for improvement of the mechanical property and microstructure of continuous annealed cold rolled dual phase (DP 590) steel

The objective of the project is to develop DP590 steel with high formability, ductility and stretch flangeability from cold rolled full hard sheet. The study aims to optimize the continuous annealing cycle. Automotive grade dual phase (DP 590) steel sheet produced in sponsors' process line from full hard cold rolled strip typically involves several stages of thermal treatment during continuous annealing process. The plant produced DP 590 grade steel sheet meets the requirements of mechanical properties with respect to yield strength (YS), tensile strength (UTS) and elongation (El) as per customer specifications. However, stretch flangeability property of the steel sheets was seemingly inconsistent, which results in crack formation at various stages of forming. To eliminate crack formation tendency during forming, a project for appropriate selection of important annealing process parameters in the continuous process line by conducting a systematic study, so that consistency in microstructure and mechanical property can be obtained, was initiated. It is noted that DP microstructure is a strong function of annealing process parameters. The final microstructure with uniform distribution of fine hard martensite in soft ferrite matrix is desirable in obtaining the targeted mechanical properties. Therefore, it is important to understand the correlation between microstructure and property with varying annealing process parameters (temperature, time, etc.).

Keeping these in view, continuous annealing simulation of cold rolled full hard strip (220 mm x 110 mm) was carried out using Hot Dip Process Simulator (HDPS), which can exactly mimic industrial continuous annealing conditions, at a laboratory scale. A systematic study was performed to understand the influence of annealing parameters on microstructure and properties by dividing a plant designed complete annealing cycle into several stages. All the specimens, obtained at different thermal stages, were characterized in detail, with respect to microstructure and mechanical properties with the purpose to develop a better understanding of various mechanisms taking place at each stage. Based on the understanding developed at each thermal stage, the annealing parameters, which have larger influence on HER property, were identified and new thermal cycles were designed. Based on the laboratory designed annealing cycle, desired properties were obtained including stretch flangeability(experimentally measured as hole expansion ratio (HER);HER value 50%), tensile strength (>590 MPa), elongation (>30%) and energy absorption capability (~20 GPa%). The optical and SEM micrographs obtained based on the optimized thermal cycle are shown in the Figure 6. Both micrographs represent uniform distribution of fine hard martensite along the ferrite grain boundaries. Table 1 shows a comparison of mechanical properties obtained from laboratory simulated results and plant trial. Both the specimens obtained from laboratory simulation as well as plant trials met the requirement of targeted mechanical properties. Actual plant trials based on laboratory simulated process parameters resulted in improvement in mechanical properties with enhanced HER performance, which is more than 50 % (from 20- 30 %). The improvement of the mechanical properties in DP590 steel will help the industry to minimize the rejection at the customer end.

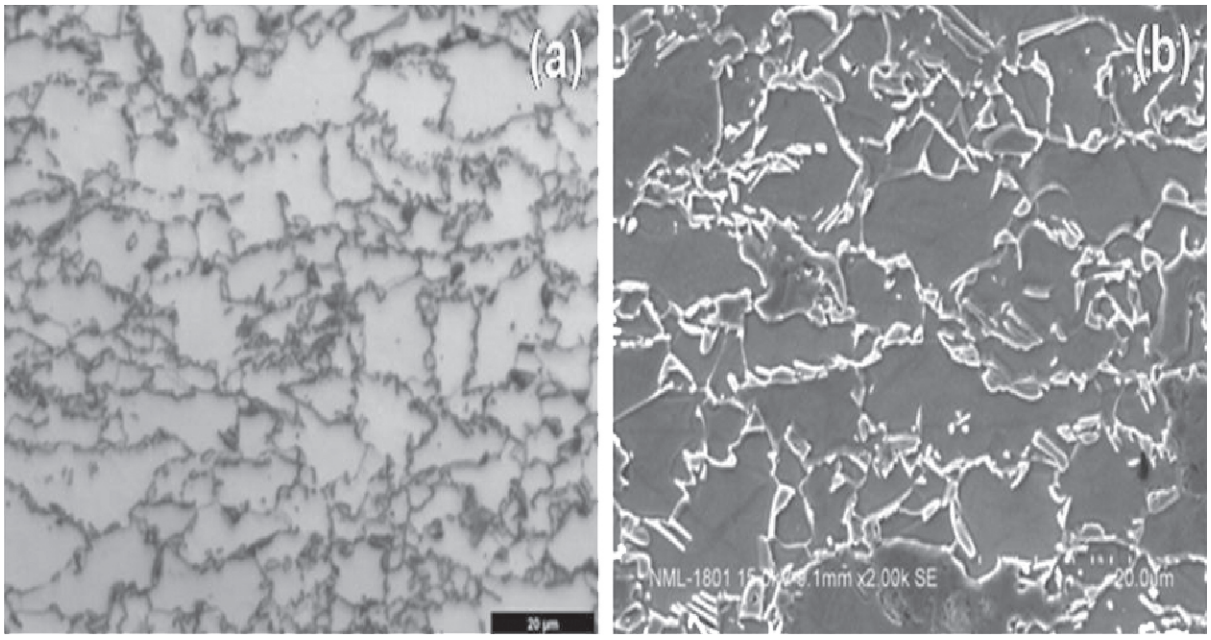


Figure 6 : Optical and SEM micrographs of 1.4 mm thickness specimen obtained based on optimized annealing cycle

Table 1 : Comparison of mechanical properties obtained from laboratory simulated results as well as from plant trial (1.4 mm thickness specimen)

Property	Lab simulation	Plant Test	Aim for
Hardness (Hv)	186		
YS(MPa)	270	360	
UTS(MPa)	610	595	590
%EL	32.07	34.5	
Energy absorption parameter (MPa%)	19563	20527	
Martensite %	13	18	
YS/UTS	0.44	0.6	-
Lankford value	1.04	1.24	1
Stretch flange-ability	71%	54%	>50%
Work hardening exponent (n)	0.25	0.212	>0.2

Creep rupture and Creep deformation

Creep characterisation of materials has been an imperative element of component design procedures for high temperature applications. Technological advancement in the field of nuclear and thermal power generation, petrochemicals, and others, often demand higher operational temperatures and pressures. The Creep Laboratory of CSIR-NML has been serving nation's interest in this regard for more than five decades. The laboratory is actively involved in creep characterisation of newly developed alloys and service-exposed alloys for design and fitness-for-service assessments. The laboratory has generated extensive amount of knowledge about creep behaviour of Iron, Nickel, Zirconium and Magnesium based alloys. The test facility of the lab include 80 single-lever-arm type creep machines, with achievable test temperature of 900°C and elongation measurements having resolution of 1 micron. The laboratory has also ventured into the research of Creep Crack Growth behaviour of base and weld metals.

Study of stress-rupture behaviour of 304L steel

This work aimed at evaluating the tensile and stress-rupture behaviour of SS 304L material at high temperatures, for base metal and weld metal. The tests were conducted in the temperature range of 600°C to 1000°C using constant load creep testing method for stress-rupture behaviour evaluation (Figure 7). A better understanding of the stress-rupture behaviour of the steel will help in assessing the integrity of the component under extreme temperatures. Tensile testing was carried in the temperature range of 25- 1100°C. From the tensile curves, Ramberg-Osgood Parameter was evaluated. Tested specimens were subjected to metallurgical investigation such as micro-structural characterization and fractographic examination.

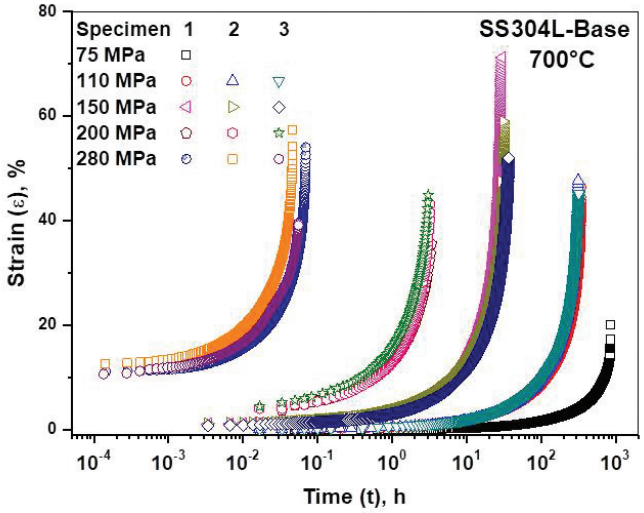


Figure 7 : Creep curves for SS304L base metal specimens tested at 700°C: total plastic Stain% vs. Time

Creep behaviour of as-Cast Mg-Sn(T10) and Mg-Sn-Al-Zn (TAZ1031) alloys

This study highlights the creep deformation and rupture behaviours of indigenously produced as-cast TAZ1031 and T10 alloys. Conventional creep tests were conducted in the stress range of 30-45 MPa and in the temperature range of 150-180°C for both the alloys. The creep resistance of the TAZ1031 alloy was better than the T10 alloy. The former exhibited reduced minimum creep rate and enhanced creep rupture life under identical creep test conditions with respect to the latter. The change of minimum creep rate followed a power-law relationship with a change in applied stress (σ) for both the alloys with a significant change in stress exponent (n) value (Figure 8). Fine secondary Mg_2Sn precipitates within the α-Mg matrix and primary Mg_2Sn, $Mg_{17}Al_{12}$ and $MgZn_2$ precipitates along

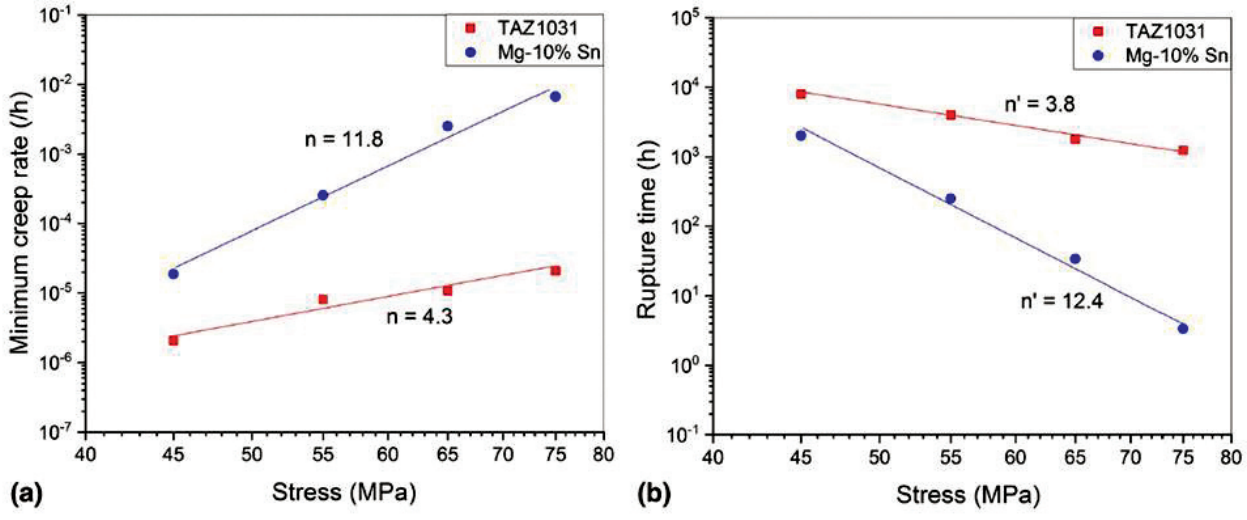


Figure 8 : Variation of (a) minimum creep rate and (b) rupture time

the grain boundaries improved the creep properties of TAZ1031 alloy (Figure 9). On the contrary, the threshold stress required for creep deformation was found to be significantly low in TAZ1031 alloy due to the presence of $Mg_{17}Al_{12}$. SEM studies revealed the absence of creep cavities along grain/dendritic boundaries for the investigated alloys, which substantiated the formation of dimpled fracture surfaces during creep deformation.

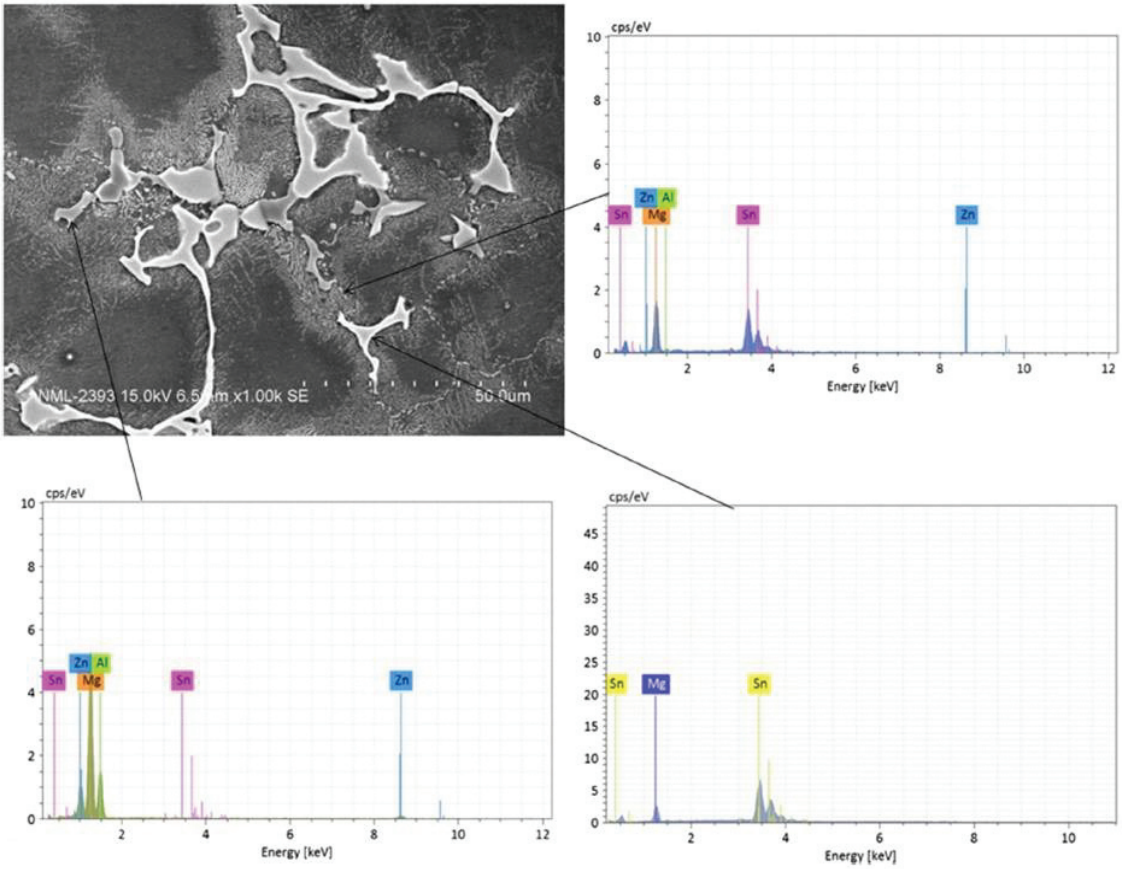


Figure 9 : SEM micrograph of as-cast TAZ1031 alloys after creep deformation at 45 MPa/423 K (150°C) with EDS on the precipitates

Effect of chemistry & processing parameters on mechanical properties of HS 800 steel

The objective of the project is to explore the reasons for embrittlement during processing of Ti-Mo micro-alloyed HS800 steel and to achieve the consistency in mechanical properties along with satisfactory hole expansion ratio (HER).

The total work was attempted in two phases. Phase-I consisted of complete microstructural characterization and evaluation of mechanical properties of five different heats prepared at a commercial scale. This was followed by Gleeble simulation of selective heats to identify the appropriate soaking temperature. Subsequently, trial runs

were attempted with changed soaking temperature for two heats, followed by microstructural evaluation and determination of mechanical properties. The major observations of Phase-I were :

- To keep the volume of Fe_3C below ~1%, FRT ~910 and CT ~640°C were preferable
- Heterogeneous distribution of micro-alloyed precipitates along with TiN were mainly responsible for variation in mechanical properties
- Heterogeneity in precipitate distribution within HR coil initiated from incomplete dissolution of second phases during slab re-heating
- To control the precipitate size during thermo-mechanical processing, soaking temperature and time were important; in this respect soaking ~1250°C ensured complete absence of second phase in single phase austenite

Based on these findings, Phase-II is being attempted with the objective as mentioned above. The benchmarks are,

- Single Phase ferritic microstructure with grain size of <5 microns,
- Mechanical properties with YS/UTS ratio <0.90
- Stretch flangibility (HER) of >80% in punched hole

In this phase, three heats have been selected from plant trial with processing parameters close to the recommendations of Phase-I. Ferrite grain size is in the range of 3.5-5.0µm. YS and UTS are 730-790 MPa and 830-900 MPa, respectively with YS/UTS ratio 0.85-0.89. The consistency in microstructure and mechanical properties

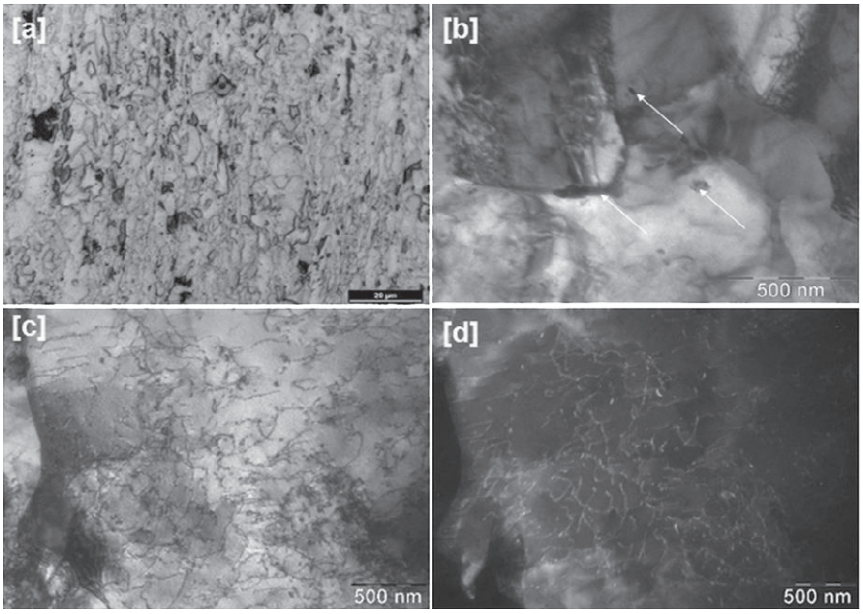


Figure 10 : Microstructure of one of the trial heats of Phase II exhibiting (a) polygonal grain structure of ferrite, (b) scattered Fe_3C(arrowhead), (c) precipitate-dislocation interaction within α-Fe matrix and (d) nano precipitate of (Ti,Mo)C

are attributed to fine grain ferrite (Figure 10a), complete dissolution of second phases during slab re-heating, presence of negligible quantity of tiny cementite (Figure 10b), absence of bulk phase transformation near FRT and precipitation of ≤ 10 nm size (Ti,Mo)C (Figures 10c-d) at the time of coiling. These heats are waiting for HER tests at the collaborators end. HER testing on ≥ 7mm HR sheet will be attempted at collaborators end.

Microstructural characterization & Fractographic analysis of nuclear grade graphite

This activity involved detailed qualitative / quantitative microstructural characterization of virgin nuclear grade graphite. Fractographic characteristics were also included for the specimens, tested under compression and bending stress to explore the characteristics of failure.

Three different sets of virgin graphite specimens (A, B and C) were received from collaborator. Each grade contained multiple specimens. Detailed qualitative / quantitative microstructural characterization was carried out for them. In the Graphite matrix the binder and coke could not be identified separately; however, filler particles could be observed owing to their different contrast with respect to matrix (Figure 11). Discontinuities, like pores and cracks, can be observed within the matrix (Figure 11). The area fraction of filler particles and discontinuities were highly variable between different specimens of Grade-A and B. In this respect, Grade-C

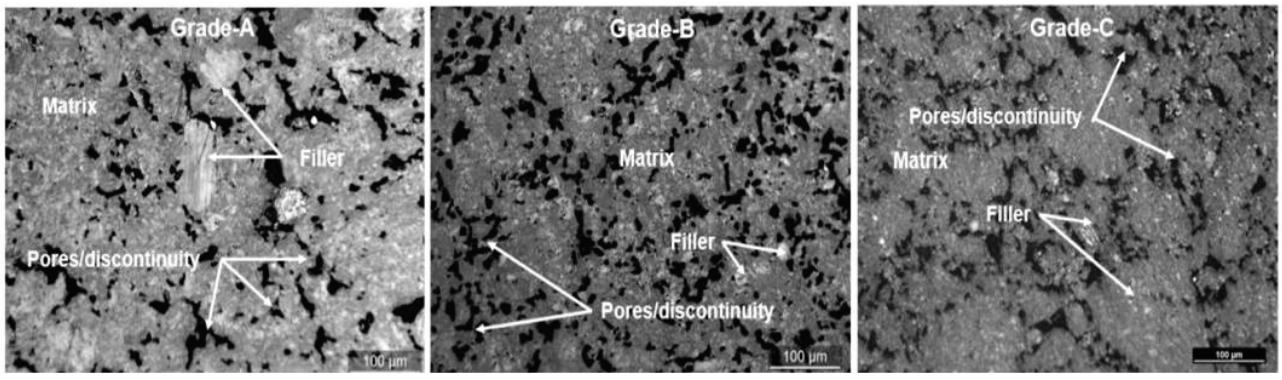


Figure 11 : Optical microstructure of nuclear grade graphite exhibiting filler and pores within matrix

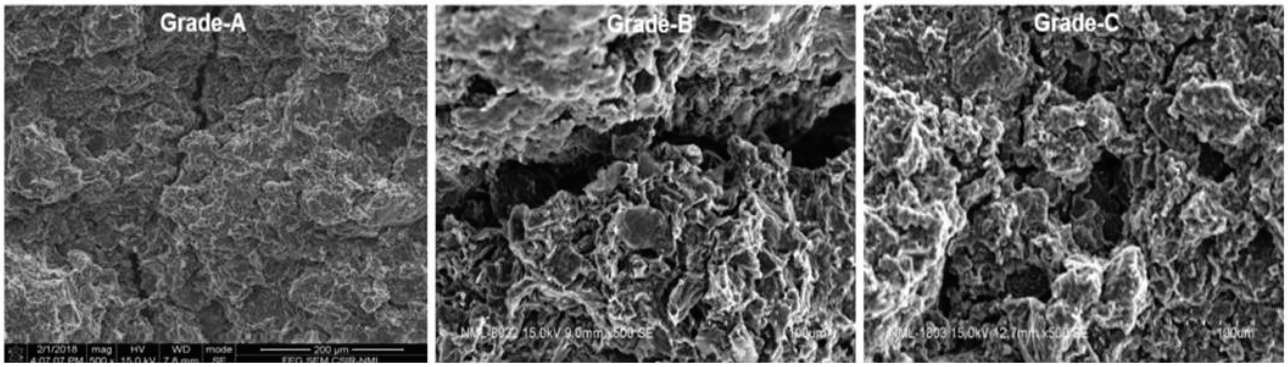


Figure 12 : Fractography of NGG tested under compression

showed consistent values. The average individual area of filler particles was much smaller (~10 μm^2) for Grade-C with respect to Grade-A and B. Average length of discontinuities was smallest for Grade-C (~5 µm), then Grade-A (~10 µm) and finally Grade-B (~60µm). Under any kind of mechanical deformation, nuclear grade graphite exhibited inter-particulate brittle fracture (Figure 12). At some locations, clustered dimples indicated limited ductility. Exposed filler particles in the fracture surface showed abrasion, which might be caused by fragmented particles during test.

Metallurgical and fractographic examination of 304LN and its weld under cyclic and monotonic loading in air/water and air environment

To understand the fatigue crack growth phenomena in advanced heavy water reactor (AHWR), under water conditions, requires detailed metallurgical and fracture analysis of the piping steels (SS304LN). Quantification of metallurgical characteristic features of piping material has been carried out for the assessment of fatigue crack growth life of piping components subjected to cyclic loading under water and air environments. Microstructural data base have been generated with respect to grain size, inclusion rating, phases, oxides for base material in different environment conditions and different FCG loading frequencies, temperatures and strain rates. The parameters which have significant role on fatigue damage of material under water environment are dissolved oxygen (DO), strain rate (or loading frequency), temperature, pH, sulfur content, Electrolytic Conductivity (EC), etc. Fatigue and fracture toughness tests in different test conditions and environment condition (as mentioned above) for the main heat transport system piping of the AHWR were conducted at BARC. The knowledge and data generated from this study will be useful for the structural integrity and life related issues of the main heat transport system piping of the AHWR.

Structure and magnetic properties of ball milled iron powders

The project aims at development of nano-sized iron powder for magnetic applications.Nano-sized iron powder particles have been synthesized by high energy ball milling of pure iron powder (crystal structure: body centered cubic (BCC), average particle size: 25 µm) in a cryogenic atmosphere. Milling time has been varied from 3 hrs. to 36hrs. and the lowest average particle size of 20nm has been achieved. Phase analysis of the as milled powder has been carried out by X-ray diffraction (Figure 13(a)) and the microstructural characterization of ball milled iron powder has been carried out by scanning electron microscopy (SEM) (Figure 13(b)) and transmission electron microscopy (TEM) (Figure 13(c)). During milling, the iron powder particles underwent plastic deformation and high density of lattice defects (i.e. vacancy, dislocation etc.) were generated inside the powder particles. Both qualitative and quantitative characterization of these lattice defects have been carried out with the help of X-ray diffraction (XRD) line broadening analysis and the positron annihilation spectroscopy (PALS) of these nano-iron powder particles. Magnetic characterization of the iron nano-powder particles has been carried out using the vibrating sample magnetometer (VSM) and superconducting quantum interference devices (SQUID) (Figure 14(a)). Increasing lattice defect density with higher milling time has led to higher coercivity (Figure 14(b)) of the nano iron powder particles with higher value of 'energy (BH) product' (B ~ magnetic induction, H ~ magnetic field) which is typically needed for the development of the 'Hard magnetic' materials.

XRD pattern of 36 hours milled iron powder shows tetragonal distortion of the BCC lattice of iron (i.e. BCT structure of iron) which is also confirmed from the results of PALS (not presented in this report).

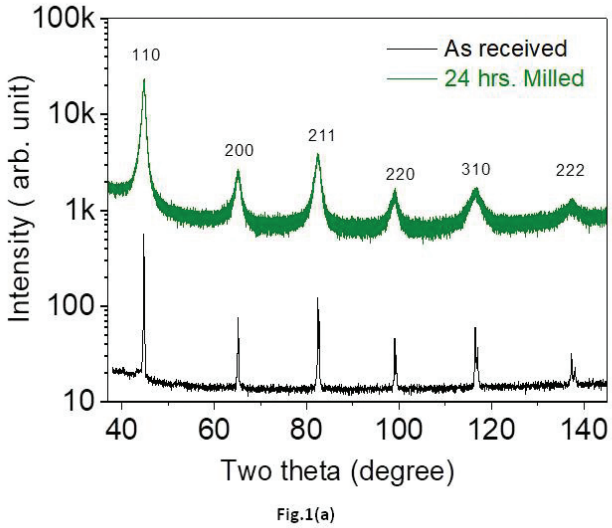


Figure 13(a) : XRD pattern showing both unmilled pure iron powder and iron powder after 24 hours milling. Broadening of diffraction peaks clearly indicates nanometersized iron particles after 24 hrs. milling.

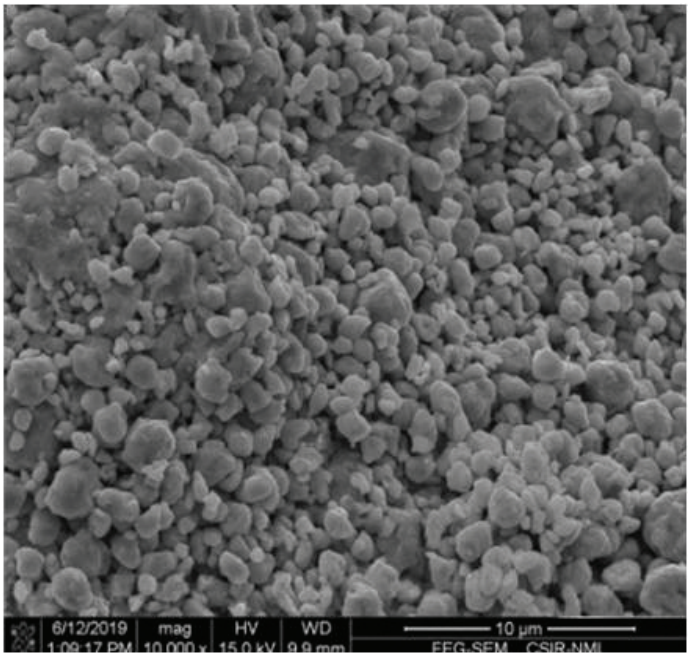


Figure 13(b) : SEM image of 24 hours milled iron powder particles.

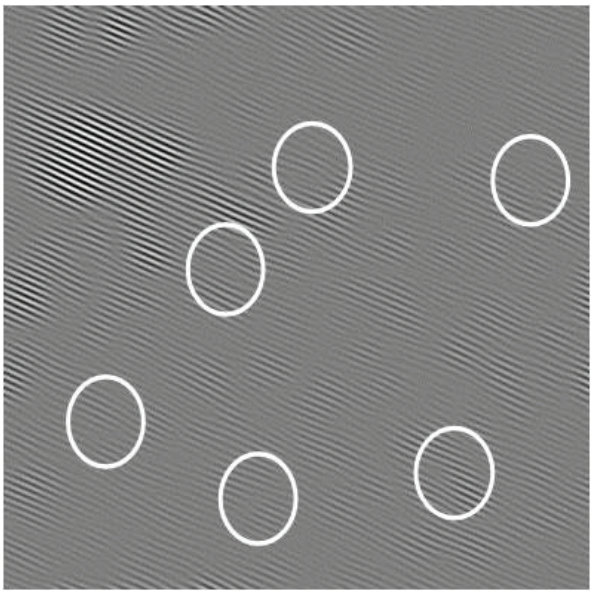


Figure 13(c) : High Resolution TEM image of high density of dislocations in 24 hours ball milled iron powders. Encircled regions are clearly showing the edge dislocations.

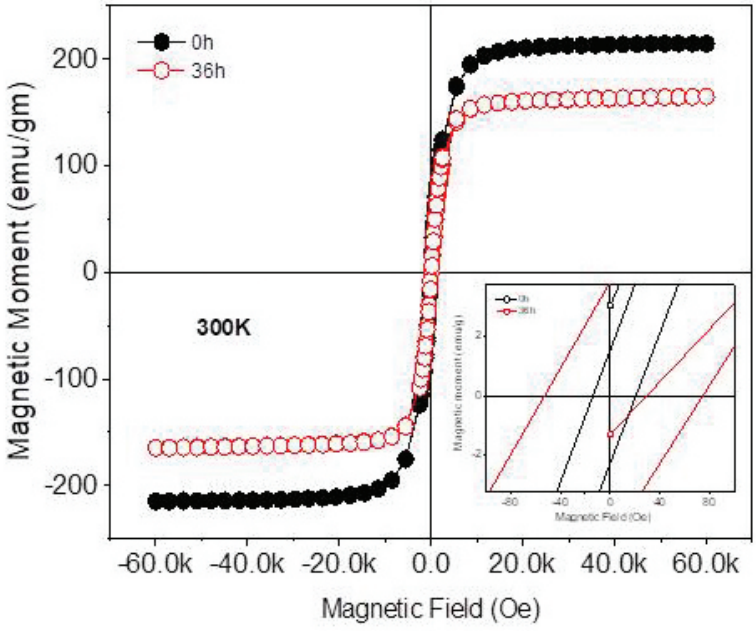


Figure 14(a) : Plot of room temperature magnetization (M Vs. H) of iron powder, both as received (0 hrs. milling) and 36 hours milling. M: magnetization; H: magnetic field.

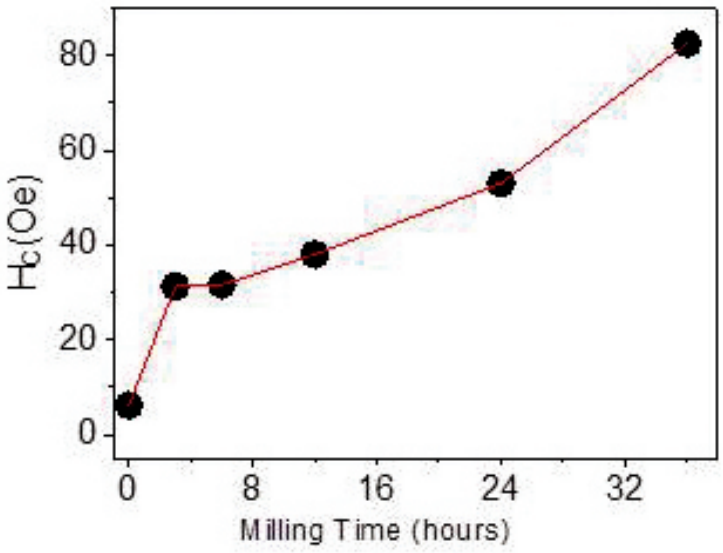


Figure 14(b) : Plot of coercivity (Hc) of iron powder as a function of milling time.

Thermo-Mechanical processing of Low carbon Steel

Different grades of low carbon steels were thermo-mechanically processed to around 65-70% and 85-90% deformation in the austenitic region, the finish rolling temperature was around 900°C and the coiling simulation temperature was around 700/400°C. Coiling simulation was carried out in a salt bath furnace.

After hot rolling, coarse grain structure were observed when the steel is deformed to around 65-70% whereas fine grain structures were observed when the steel is deformed to 85%. Pan cake type very fine structure was observed in phosphorus grade extra low carbon steel. Coarse TiN precipitates are found in some grades of low carbon steels. Size of the precipitates is around 4-6 m, which are very coarse. Segregation of phosphorous is not observed at grain boundaries. Hot band texture of extra low carbon steel is moderately strong; the maximum intensity of texture is 6.0. The main texture components of -fiber are (001)[1-1 0], (113)[1-1 0], (114)[1-1 0] & (115)[1-1 0] and the weak texture component of -fiber is (332)[1-1 3] orientation. After 85-90% thermo-mechanical processing, hot band texture of Cu in extra low carbon steel is strong and the maximum intensity is 5.3. The main texture components of α- fiber are (001) [1-1 0] and (113) [1-1 0] whereas texture components of ε - fiber is (332)[1-1 3] orientation but it is very weak.

Development to improve corrosion performance and service life of aluminium alloy bracket

The objectives of the project were: i) to investigate failure of Al-Si alloy bracket; ii) to develop corrosion resistant coating for Al-Si bracket alloy; and, iii) to modify the Al-Si alloy to increase corrosion resistance.

Corrosion investigations were performed in four different corrosive media as desired by the sponsoring industry. The Al-Si alloy supplied were coated with different polymeric coatings and subjected to the tests at 65-95°C for 250 hours in different corrosive media from pH~ 2 to 13. These included hard water test (containing

(containing calcium chloride and magnesium sulphate at 90±5°C/ 250h), descaler test (in sponsor's descaler at 90±5°C/ 250h), salt solution dip test (1.5% common salt at 90±5°C/ 250h) and caustic soda test (1% caustic soda at 90±5°C/ 250h). Two coatings out of five passed the tests, and these were sent to the sponsor for further corrosion evaluation at their site. The appearance of the two such coatings (A) and (B) in the figures below indicates passing and failing the test respectively after exposure to caustic soda (Figure 15). Besides coatings, the alloy modification of Al-Si alloy was also performed with the addition of various strontium contents, the alloys containing Sr from 0.25 - 0.1 % were found to have better corrosion resistance (by immersing in 3.5 % NaCl for about 2-4 month duration) than the other variants. These, however, performed worse than the virgin material, as the laboratory prepared alloys contained large porosity.

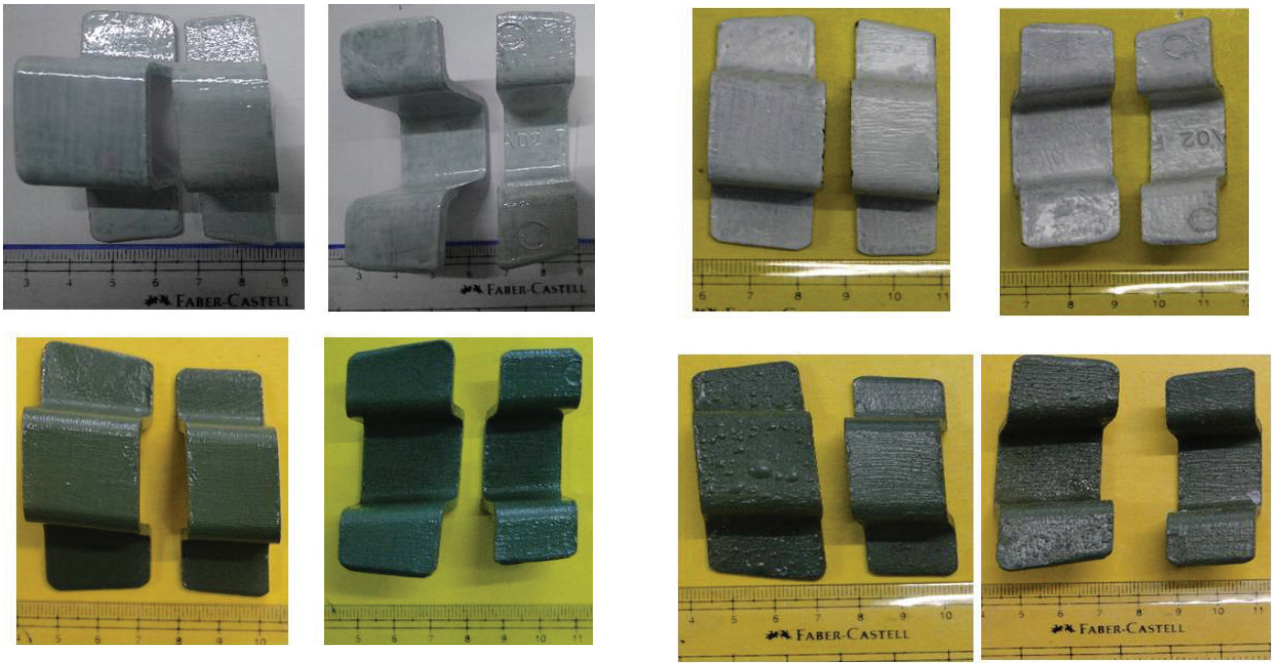


Figure15 : Effect of coating on Al-Si specimens after exposure to caustic soda at 90°C for 250h
(a) before exposure; (b) after exposure

Structural Health Monitoring and Failure Analysis

CSIR-NML has been carrying out remaining life assessment as well as failure analysis of various industrial components for decades. A few of them, carried out in the reporting period, are highlighted below

Metallurgical Failure Investigation of Fractured Rails

The metallurgical failure analysis of fractured rails (Derailment of Train no. 12741, VSG-PNBE Express at Manikpur station of Allahabad) from North Central Railway, Allahabad, was assigned to CSIR-NML, Jamshedpur. As received broken rails were subjected to visual observation, chemical composition analysis including hydrogen content determination, NDT, optical and scanning electron microscopic examination, and

mechanical properties evaluation (tensile, hardness and impact). Various qualifying tests like tensile, hardness, inclusion analysis, chemical composition, hydrogen content, etc., were carried out as per IRST-12-2009/Gr.880 standard for conformity. The results of qualifying tests conform to the standard requirements with slight deviation only in case of hydrogen content. The transverse fracture between certain rail pieces occurred due to fatigue aided by fretting action and thinning of foot at rail-clip location because of severe corrosion. The combined action of corrosion and thinning led to fatigue crack initiation and growth. The fractography showed that the initial crack propagation was due to fatigue loading leading to smooth fracture surface at thinned foot location followed by cleavage fracture propagation across the web and up to the head leading to transverse fracture. The longitudinal fractures between certain other pieces were showing cleavage facets with river pattern due to overload. Therefore, it is recommended to inspect rails at rail foot clip locations at regular interval for thickness reduction, and replacement of rail may be undertaken for critical conditions. Suitable paint/coating in the affected regions (clip locations) may be applied to prevent corrosion.

Complete analysis of failed water wall tubes of a boiler

Failure investigation of water wall tubes of unit #1 of Maithon Power Limited, Dhanbad, was carried out. Failure occurred in the form of puncture in the tubes. Chemical composition analysis of the failed tubes conformed to the standard SA 210 grade C steel. Mechanical properties and microstructure of the failed tubes conformed to the designated grade. SEM-EDS analysis of outer surface around the puncture and of the deposits showed the presence of elements such as P, S, Na, K, Ca, Al, Si, etc. High amounts of phosphorous (P) and sulfur (S) in the coal ash deposits might have caused corrosion by forming phosphoric acid and sulfuric acid at (dew point) lower temperatures or phosphate and sulphide corrosion at higher temperatures. Severe ash corrosion thinned down the wall thickness of the tubes, which eventually punctured when the hoop stress became equal or exceeded the yield stress at the thinned region. It was concluded that the tubes failed because of ash deposition followed by ash induced corrosion.

It was recommended that periodical checking, cleaning and removal of ash depositions on outer surface especially the pocket regions of the tubes should be carried out to prevent/reduce ash induced corrosion failures. Better quality coal may be used to prevent/reduce the amount of corrosive elements such as S, P, Cl, Na, K, Ca, Al, Si, etc., in the ash.

Remaining Life Assessment of pigtail of hydrogen reformer

Pigtail tubes made of Alloy 800H failed in a hydrogen reformer unit of the sponsor's refineries. The tube section with the entire portion below the failure location in the pigtail assembly was sent for RLA study. Dimensional measurements, XRD analysis of surface scale, optical microscopy, electron micro probe analysis, hardness evaluation, tensile strength evaluation and accelerated stress rupture testing were carried on samples cut from the tube. Based on the results it was concluded that pigtail tubes had predominantly corrosion induced damage and that no significant creep damage had set in. Tube section closer to the collector manifold end having 5% OD expansion and less number of surface cracks had good rupture life. It is recommended to have another inspection after 3 years of further service.

Root cause analysis of defective galvanized switchyard gantry structure component

The Galvanized Gantry structure of M/s. Damodar Valley Corporation (DVC), Maithon, developed multiple surface cracks in one year during storage, and was followed by failure of these components during service. The nature of these failures could not be found out at their sites. A detailed laboratory investigation was carried out through various techniques including visual inspection, Non Destructive test (NDT) analysis to locate cracks/defects in the specimen, chemical composition analysis, optical microscopy, Scanning Electron Microscopy (SEM) and Electron Probe Micro Analyzer (EPMA) studies to reveal the microstructural features and inclusion characteristics. Tensile and impact testing was done for comparison of the mechanical properties with the required specifications. Chemical composition of the steel was in agreement with the standard. Tensile properties of the material conform to the standard. The impact property of the materials did not meet the impact energy standard and were much less. There was large inconsistency in the impact energy of the specimens. This was mainly due to presence of complex oxides inclusions of Si, Mn, Ca and Fe caused by slag entrapment during the steelmaking process. The qualities of the Zinc coating on steel surface conform to the standard. However, the presence of white rust indicated improper post treatment practice after dipping process.

Root cause failure analysis of radiant tubes of furnace

In this investigation a case of premature failure of multiple radiant heater tubes of a reheating/ soaking furnace used to heat the steel strips prior to their entry into the hot deep galvanizing bath, was performed. The heater tubes were made of Inconel 601 alloy and failed in the form of multiple punctures/holes after three months of installation and commissioning. Based on various experiments, it was concluded that the radiant tubes failed due to the sulphidation reaction from the inner side of the tubes and not by metal dusting phenomenon, the latter is mostly reported in the literature for similar kind of failures wherein excess carbon deposition leads to the metal dusting failure. In the present investigation, deposition of excess sulfur on the inner surfaces was the root cause of failure of the tubes. The sulfur originated from the mixed gas containing H_2S gas, tar and ash. Mixed gas was used to provide the combustion heat to these heater tubes. WDS mapping of various elements at the reaction front with the tube metal indicated Cr-S rich phase formation thus confirming sulphidation attack. It was recommended that deposition of sulfur on the inner surfaces of the radiant tubes should be prevented by controlling the sulfur present in the fuel mixture.

Mineral Processing

Mineral Processing Division (MNP) of CSIR-NML has been engaged in R&D in characterization, beneficiation and agglomeration of ores and mineral fines. The Mineral Processing Division comprising Characterisation, 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 on modern lines to carry out planned research and development work on all types of ores and minerals for their rational utilisation and conservation.

Working closely with industry partners, Mineral Processing 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 ferrous, non-ferrous, strategic and industrial minerals and coals (coking and non-coking) through the design and optimisation of processes. It has created confidence in the industry towards developing technology for converting waste to resource thereby enhancing mining life duly maintaining raw materials quality.

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-Eat, Africa and Europe. In recent times the Mineral Processing Division is focussing on Fine particle processing, Dry beneficiation, Mathematical modelling and simulation, Plant performance auditing and improvement, and Equipment development.

Technological Process flow-sheet for beneficiation & extraction of Tungsten from Gold ore tailings

Tungsten is a hard steel-grey shiny metal with highest melting point (3422°C) of all metals. Due to its high temperature properties, it is used for lamp filaments, electrical contacts, high temperature steel used for construction, mining equipment, turbines, and as structural material in nuclear, defense and space technology. Tungsten carbide is used for cutting tools. The world reserves of tungsten in terms of metal content are 3.2 million tonnes, distributed broadly amongst China (64 %), Russia (9 %), Canada (4 %) and the US (5 %). India's reserve of tungsten ore is 224 million tonnes assaying over 0.1% WO_3, 44 million tonnes of lean grade ore assaying 0.01-0.08% WO_3. Thus, the tenor of the Indian ore is much less than the discards of milling plants in other countries. Presently, there is no tungsten production in India and the domestic demand has been met through imports. The domestic tungsten demand is increasing steadily. Due to the increasing global demand of tungsten and export restrictions from the major producers, indigenous production to meet at least a part of the domestic demand is inevitable.

CSIR-National Metallurgical Laboratory is working on development of indigenous technologies for production of tungsten metal from domestically available resources. The objective of the present research is to develop

technological process flow-sheet for beneficiation and extraction of tungsten metal from scheelite bearing gold ore tailings sample. With detailed characterization and process mineralogical studies, the mine waste was subjected to beneficiation and hydrometallurgical extraction at bench scale and at a large scale. The mine waste sample was observed to be extremely fine grained, 73% passing through 12µm with scheelite as the only tungsten bearing mineral. It contains gangue minerals including silicates like quartz, plagioclase, perthite, biotite, amphibole, oxides such a spinel, rutile, chromite, magnetite, and sulphides like arsenopyrite, pyrite, chalcopyrite, pyrrhotite. Detailed bench scale/large batch beneficiation studies were carried out involving different techniques towards pre-concentration of plant tailings sample suitable for subsequent hydrometallurgical extraction of tungsten. Bulk pre-concentrate was produced through pilot scale campaigns of about 100 tonnes material for subsequent hydrometallurgical extraction studies through large scale leaching experiments.

The pre-concentrate was subjected to hydrometallurgical processing involving alkali leaching followed by solvent extraction and stripping producing ammonium para-tungstate (APT). Tungsten metal powder with 99.9% purity was produced from APT. Based on the beneficiation and hydrometallurgical extraction studies carried out, technological process flow-sheet was developed for beneficiation and extraction of tungsten from gold ore tailings sample. Figure 1 shows tungsten metal powder produced from the gold ore tailings sample.



Figure 1 : Photograph showing tungsten metal powder produced from gold ore tailings sample.

Technology for dry beneficiation of thermal coal

High ash thermal coals are not suitable for power generation. Use of high ash coals reduce boiler efficiency and has adverse impact on the environment. The Ministry of Environment and Forests and Climate Change

(MoEFCC), Government of India, has promulgated Gazette Notification on the use of beneficiated/blended coal containing ash not more than 34 % in the power plants located beyond 500 km from the pit head, in critically polluted areas, urban areas and in ecologically sensitive areas. Therefore, it is imperative that non-coking coals, especially the coal samples having more than 34% ash, are beneficiated. Wet methods of coking coal beneficiation used for application in metallurgical industries has high cost and has other disadvantages, such as, high surface moisture in the washed coal, generation of slime water, requirement of dewatering systems, etc. Thus, less than 20% of thermal coals are beneficiated by wet methods for use in power generation. Dry processing of coal has attracted the attention because it offers certain obvious economic advantages. It can be applied at the mine site prior to loading and transportation to the end user, and for processing of high ash, low-rank and lignite coal, and coal processing in the arid regions.

CSIR-NML has developed expertise and facility for dry beneficiation of high ash coal. With this expertise CSIR-NML has undertaken a collaborative R&D project with CMPDI and MCL on the development of technology for dry beneficiation of non-coking coals from MCL. Detailed mineralogical/maceral and chemical characterization, washability study and dry beneficiation studies were carried out on the two high ash thermal coal samples from MCL. Based on the dry beneficiation involving air fluidized vibrating deck, technology was developed for dry beneficiation of thermal coal assaying 42-46% ash producing clean coal with 34% ash, suitable for application in thermal power plants. Typical results on dry beneficiation of two non- coking coal samples having diverse petrological and washability characteristics using air fluidized vibrating deck are depicted in Figure 2.

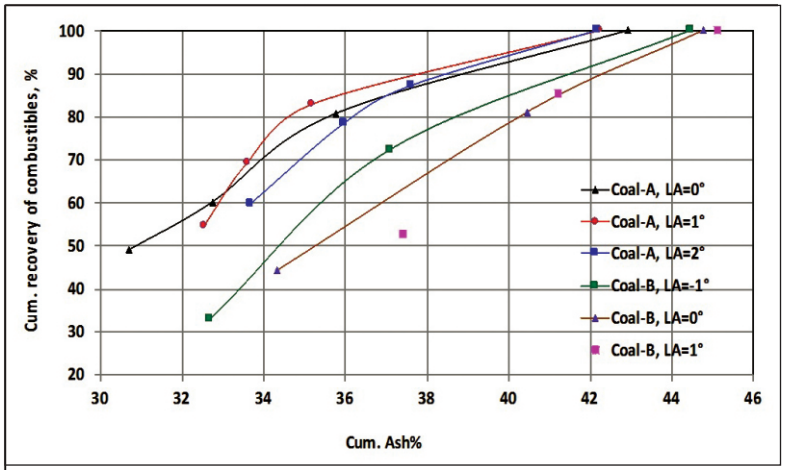


Figure 2 : Results showing effect of transverse angle of the separating deck on dry beneficiation of two high ash non-coking coal samples.

Pilot scale beneficiation of low grade limestone for cement making

Limestone is the raw material widely used by various industries like cement, metallurgical, sugar, textile, paper, etc. As the major raw material for cement making industry, its chemical characteristic is important specifically

in terms of silica. Limestone is a sedimentary rocks and the grade deteriorates on intercalation of shale, which is the main contributor of silica in the form of silicate minerals. In order to meet the required specification for its utilization in cement industry, low-grade limestone needs to be beneficiated.

The present study was carried out on a low grade siliceous limestone with representative characteristics / assay / of CaO 43.57%, MgO 0.69%, SiO_2 17.35%, Al_2O_3 1.21% and LOI 34.72%, with a view to reduce silica content in limestone below 12% for use in manufacture of cement. The mineralogical study revealed calcite to be the major constituent with laminae of shale consisting of microcrystalline quartz, kaolinite and muscovite (Figure 3). Earlier, a detailed bench scale beneficiation study was carried out and a flotation based process was developed for beneficiation of low grade siliceous limestone sample. In the present study, the results of bench scale beneficiation were validated through pilot scale studies and process flow-sheet was designed and material balance was computed. A limestone concentrate assaying 47.4% CaO with 11.3% SiO_2 and 96% recovery was achieved. The know-how provided will be used for commercial scale application by the sponsor.

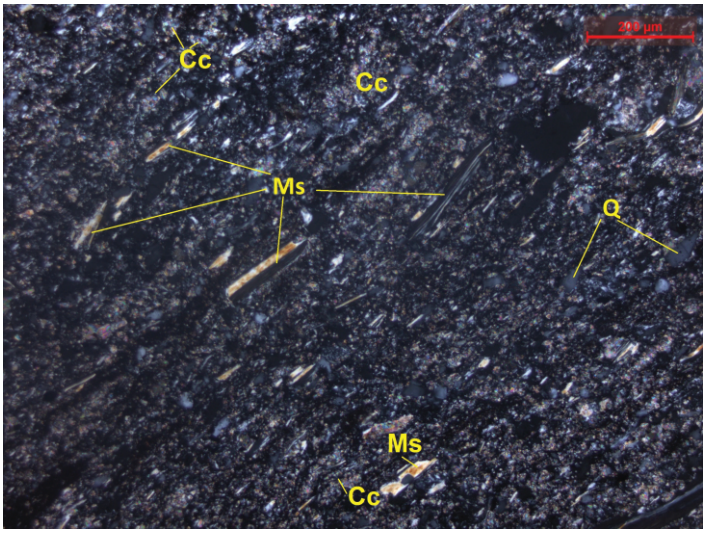


Figure 3 : Photomicrographs of limestone sample under petrological microscope. Muscovite (MS), Quartz (Q) and calcite (Cc) under plane polarized light (PPL)

Plant performance audit of Lawa Gold ore concentrator

The sponsor is operating one TPH Gold Ore Processing Plant at Saraikela, Jharkhand. ROM contains 10-12 ppm gold. Figure 4 shows photomicrograph of electrum and magnetite in gold ore from Lawa Gold Ore mines studied at CSIR-NML. Performance of the plant has not been satisfactory. The gold extraction process basically includes concentration of gold ore by physical separation followed by smelting. The tailing of physical separation is treated through hydrometallurgical process (leaching, CIP). The survey involved collection of samples from different streams followed by calculation of percent solids, assay and sizing of each stream. Mass balancing around the circuit was performed using the sizing, percent solid and assay data.

In order to understand the reason behind low recovery, a survey was undertaken for the physical separation unit. The survey involves collection of samples from different streams followed by calculation of percent solids, assay and sizing of each stream. Various bottlenecks and the reason behind low recovery was identified towards addressing the problem.

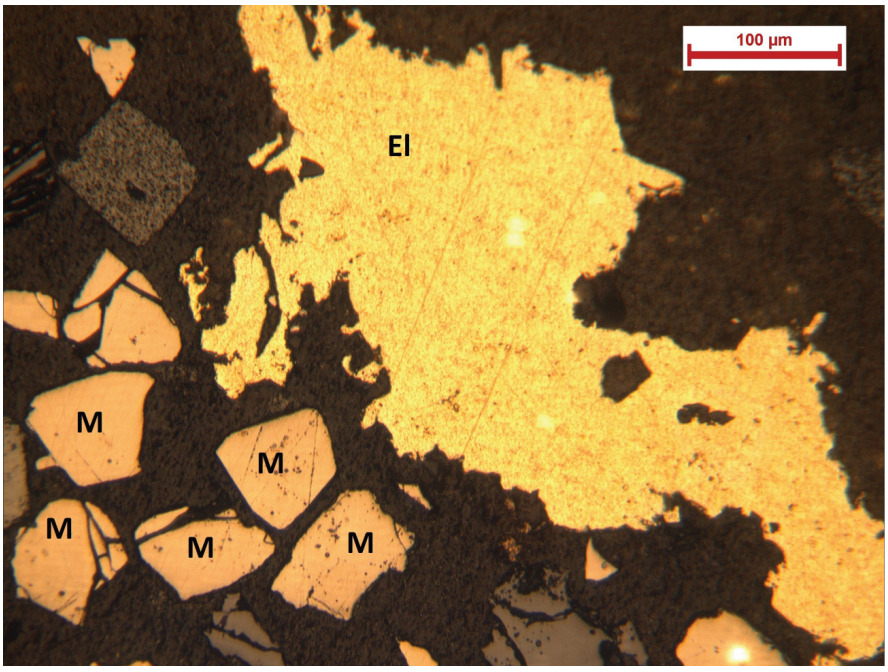


Figure 4 : Photomicrograph of electrum and magnetite ore from Lawa Gold Ore Mines

Advanced gravity concentration of Chromite ore beneficiation plant tailing

During beneficiation of low grade chromite ore (assaying about 25% Cr_2O_3), around 50-55% of material is discarded as a tailing with Cr_2O_3 content of 12-18. It leads to the loss of chromite values and also has an adverse impact on environment. The storage, handling and challenges in processing of fine tailings are the major concerns of the operating process plants. As per the new guidelines of IBM the assay of chromite tailings is to be less than 10% Cr_2O_3. Thus there is need to develop suitable process for pre-concentration/concentration of tailing for subsequent value addition. In this context CSIR-NML is making an attempt to recover the chromite value at fine size class by utilizing new generation gravity processing device. Objective of the work is to develop process for recovery of chromite values from chromite ore beneficiation plant tailing.

The initial efforts were put in to characterize the plant tailings by chemical and mineralogical analyses using optical microscope, X-ray diffraction and SEM. The study revealed that goethite, magnetite, hematite, chromite, kaolinite, gibbsite are the major minerals with minor amount of magnesio-ferrite (Figure 5) in the chromite plant tailing sample. Chromite occurs interlocked within silicate mineral or martite and requires liberation. Chromite tailing was beneficiated by using Falcon concentrator.

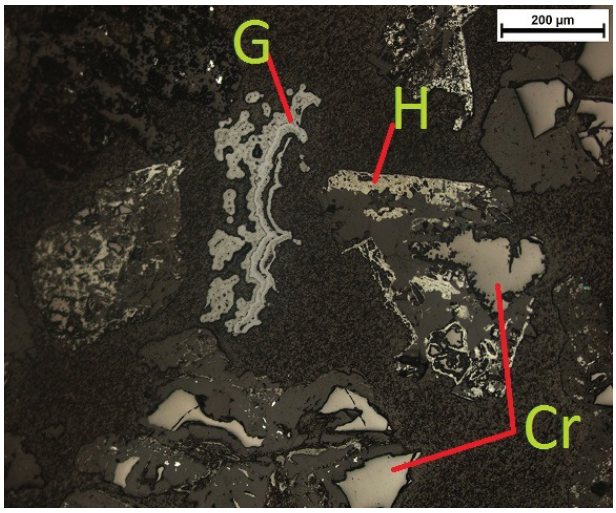


Figure 5 : Photomicrograph showing chromite interlocked in silicate and hematite, and grain of goethite with interlocked clay

Flotation studies on low grade rock Phosphate sample from Jordan

Bench and large scale flotation studies were carried out on rock phosphate sample from Jordan with an objective to generate data towards finalization of basic and detailed engineering package. The desirable criteria was to upgrade ore with 52% tricalcium phosphate (TCP) to 70% TCP with silica content below 8%. Initially, the sample was subjected to scrubbing, screening/classification and desliming for preparing feed for flotation. The deslimed two size classes, coarse and fines, were subjected to concentration by froth flotation, separately. Sodium silicate along with emulsion of sodium oleate and diesel oil was used as depressant and collector, respectively. Finally, the result obtained during the bench scale test was validated at a large scale. Solid and water balance was established for each flotation scheme.

Reduction of reactive Silica in Bauxite for use in Alumina production

Bauxite is the rich source of alumina used for production of aluminium. Aluminium being a light weight material and with its ability to resist corrosion, find tremendous application in the field of aerospace and transportation and building industries. It is also an essential material for refractory and chemical industries. India has bauxite ore reserves of 3.896 billion tonne as against world reserves of 30 billion tonnes. Bauxite ore is processed by Bayer's process to produce alumina, which is subsequently used in aluminium manufacturing process. Presence of reactive silica in bauxite is detrimental in production of alumina by Bayer's process. It is of concern to lower reactive silica content of bauxite by simple/ economical process for this purpose. In the present investigation, studies were carried out on processing of bauxite for possible reduction in reactive silica content to below 4% from a feed containing reactive silica ~6%. The beneficiation study included bench scale scrubbing and washing followed by pilot scale validation of the bench scale results. Bench and pilot scale beneficiation studies were carried out at CSIR-NML and demonstrated that there was appreciable reduction in the reactive silica content (<3.6%) with increase in total available alumina content in the beneficiated product.

Processing of Limestone and Clay Samples for White Cement

In order to make clinker for white cement, it is necessary to minimize the amounts of iron and other transition elements (titanium, chromium, manganese, nickel and zinc) in the raw mix composition. Precautions have to be taken to minimize contamination with dark materials at all stages of the process. The Fe_2O_3 content in limestone and clay studied are 0.068% and 0.45%, respectively. Attempts were made towards removal of mineral contaminants from limestone and clay by processing samples involving wet high intensity magnetic separation. Processing of the samples by wet high intensity magnetic separation has given encouraging result. It is proposed to optimize the process parameters to get maximum yield of limestone and clay with high rejection of gangue materials. The detailed study is in progress.

Beneficiation of waste dump Manganese ore fines for production of Ferro-alloys

Manganese ore is an important raw material for ferro-alloys like ferromanganese / silico-manganese. It is used in steel making and for production of dry battery electrode manufacture apart from its use in chemicals and pigment. In earlier mining practice in India, the ore of +10mm was used for ferromanganese application while the -10mm was stocked as low grade fines waste dump. 25-30% of the ore mined being of fine category, the stock of mines waste occupy a huge space. It is of interest to recover manganese values from the -10 mm waste dump fines for its industrial application. In the present investigation it was aimed to develop beneficiation process flowsheet for upgradation of the low grade manganese ore for use in ferromanganese / silico-manganese application.

Three different low grade manganese ores were studied through physical, chemical and mineralogical characterization. The mineralogical study revealed the presence of hematite, goethite, pyrolusite, psilomelane/ manganomelane, todorokite, kaolinite, gibbsite, quartz (Figure 6 and 7). Goethite, pyrolusite and psilomelane/ manganomelane are intimately associated at very fine scale. The response of the ores to different beneficiation methods is under study.

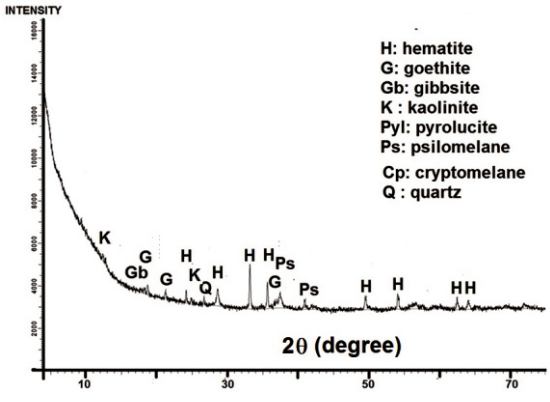


Figure 6 : X-ray diffraction pattern showing the mineralogy of manganese ore

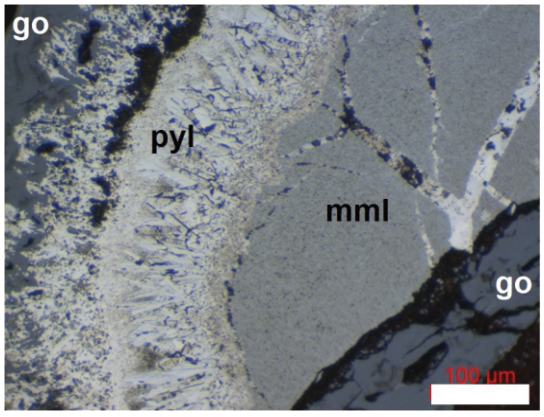


Figure 7 : Photomicrograph of manganese ore under reflected light. Go-goethite, pyl- pyrolusite, mml-manganomelane

Beneficiation of low grade Dolomite ore

The dolomite ores are used as flux material in iron and steel making application; however, the ores should have desired grade. Higher alkali content in the ore enhances the basicity of the slag and has deleterious effect on refractory liners and in BF operation. The sponsor has a captive mine of dolomite ore in Odisha. A collaborative R&D project has been undertaken to study the characterization and beneficiation of three different types of dolomite samples having different chemistry towards the reduction of alkali and silica contents for application in iron and steel making. The desired grade raw material should have K_2O content of maximum 0.3% for iron Al_2O_3 together should be less than 1.5%. In view of the above, the study aims at developing process for reduction of K_2O level to preferably less than 0.2%.

Characterization studies of all the three samples were carried out by megascopic, optical microscopic and XRD studies to identify the mineral phases in the as-received samples, their textural relationship, optical characteristics, mode of occurrence and distribution. Dolomite is the dominant mineral with occasional calcite. Muscovite, biotite, K-feldspar, and quartz were observed as the major gangue minerals [Figure 10 (a & b)] and the abundance increases as the SiO_2 and K_2O increase. As the liberation of gangue minerals are found in finer size for all the three types of ore, beneficiation studies have been carried out by froth flotation technique to reduce the K_2O and silica level in the product. Froth flotation study was conducted with varied process parameters. The results are encouraging. Further work is in progress.

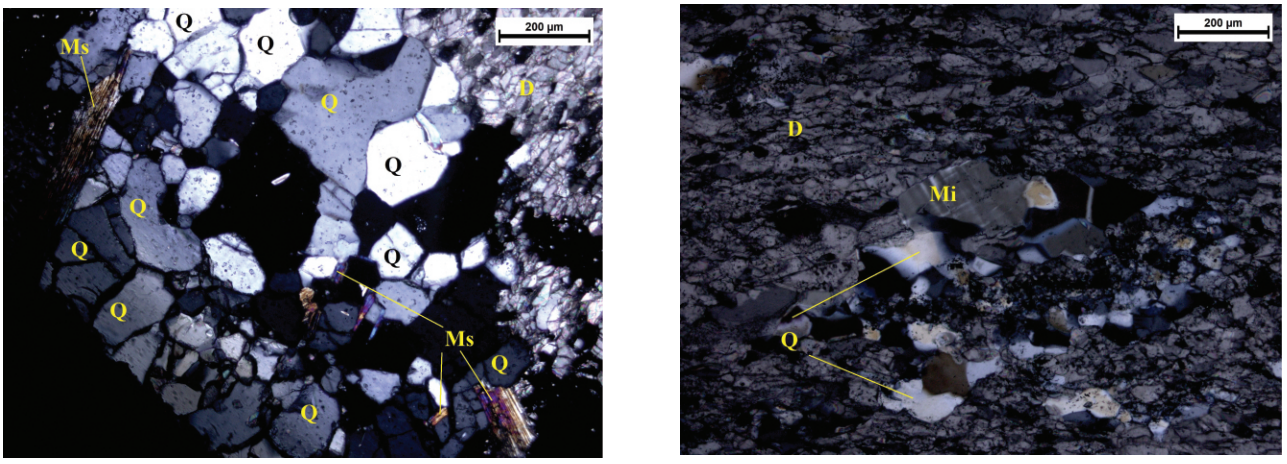


Figure 8 (a & b) : Photomicrograph of dolomite under crossed nicols; [a] grains of quartz (Q), muscovite (Ms) within dolomite (D); [b] microcline (Mi) and quartz (Q) grains in dolomite (D)

CSIR PROJECTS

A Smart Sensing System for Cold Drawn High End Wires

Zinc coating is the most effective and widely used process to prevent corrosion and increase the longevity and performance of steel wire. Zinc coating is generally applied to steel wire by hot dip galvanizing (HDG) process, which is one of the best ways to produce superior and homogenously coated products in a cost-effective manner. In this process the steel wire is passed through a bath of molten liquid zinc or zinc alloy resulting in a protective layer. The final quality of galvanized wire depends on material surface, zinc adhesion, and uniform coating weight. Proper substrate cleaning and temperature control can govern the first two parameters, but the coating weight is often measured too late in the process to correct. In fact, many producers verify hot dip zinc coating weight after the coil exits the mill. At this point, if the results are unacceptable the entire coil is downgraded or scrapped - causing delays, wasted raw materials, and expense. Moreover, premature failures can occur if the thickness is either too thin or too thick. Generally coating is done in two different ways: Nitrogen wiping (for thick coating) and Pad wiping (commercial line, thin coating). Though the Zinc weight control system exists in N_2 wiping line but no such system is available for Commercial line. This makes the producer handicapped to assess the required weight. Hence, automatic coating weight control in the HDG line is essential for uniform production with minimized zinc consumption. CSIR-NML has developed a sensing coil based technology for in-line Zinc coating weight measurement of moving GI wires in the commercial HDG line. The device has been successfully tested in the commercial line at the most renowned wire mill of India at Tarapur, Maharashtra. The developed sensing device was benchmarked with the available sensor in the Nitrogen wiping GI line. The demand for this technology is huge, only in one of the wire mills in india, there are 100 GI lines. This indegeneously developed technology is low cost which can even serve as import substitution of Zinc weight control system available for Nitrogen wiping GI line. The developed device, placement of the sensor in the GI line during plant trial and the result of zinc weight measured in the commercial line are shown in figure below :

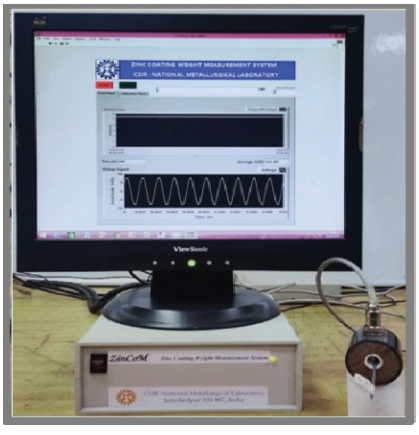


Figure 1: Zincometer, device developed at NML and the sensor

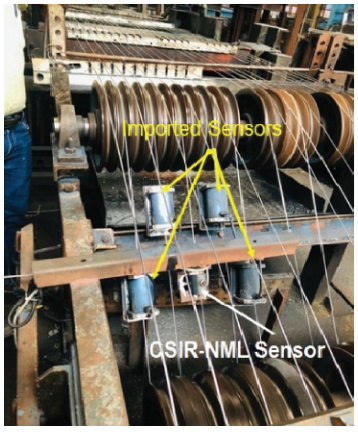


Figure 2: CSIR-NML sensor placed in one GI line

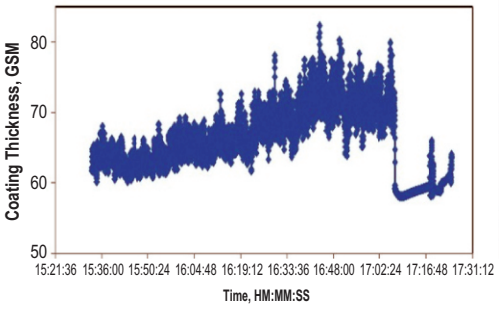


Figure 3: Measured data of Zinc coating weight in the commercial line

Synthesis of new 2D materials other than graphene for energy application

The development of two-dimensional (2D) high-performance electrode materials is the key to new advances in the fields of energy conversion and storage. These new 2D materials with high electron mobility and inherent band gap can be explored for energy storage through super capacitor and clean hydrogen energy generation utilizing solar energy. Under NCP project efforts were made to exfoliate the bulk materials in large quantity. Exfoliation of MoS_2 and MXene (Ti_3C_2) were tried with different solvent followed by ultrasonic treatment. Best results for transition metal dichalcogenide (TMDC) was obtained with 30% aqueous solution of n-methyl pyrrolidone and triethanol amine. Possibly nitrogen containing molecules can easily bind with the surface of these two materials thus helping in reducing the van der Walls force between the layers. After sonication at different time period, the solution was centrifuged at 2000rpm for 20 minutes so as to separate the heavier particles. The exfoliated sheets are produced as stable dispersion having 0.5g of MoS_2 per 100ml of mixture solvent. TEM image as shown in Figure 4a conforms the exfoliation in the form of multilayered MoS_2. Similarly FE-SEM image of MXene (Figure 4b) proves the exfoliation of MXene sheets. Exfoliated sheets are used to prepare the composites like MoS_2-CdS (Figure 5a) & MXene-CdS for H_2 evolution through direct water splitting reaction. Correlation of band gap, heterojunction formation and hydrogen evolution activity was carried out. We have used molecular dynamics simulations to explain the exfoliation mechanism of MoS_2. Electrochemical performances of metal sulphide modified Ti_3C_2 (MXene) was carried out and based on the improved stability and capacitance value (Specific Capacitance: 1900 at 1 mV s^{-1}) above material is filed for patent as electrode materials.

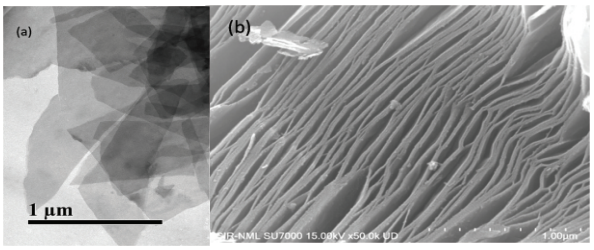


Figure 4 : (a) TEM image of exfoliated MoS_2 and (b) SEM image of exfoliated MXene

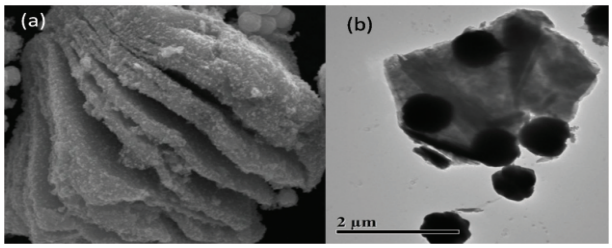


Figure 5 : (a) TEM image of MoS_2-CdS and (b) SEM image of MXene-CdS composite

Self-healing Coating for Corrosion protection of Steel and Aluminium alloys

In selecting a construction material, a compromise is made between the desired properties and price. Mild steel, despite its low corrosion resistance, is extensively used as a construction material in many cases primarily because of its low cost and ease of fabrication. Instead of using a more corrosion resistant expensive material like stainless steel, mild steel surface is often covered with a protective coating. Nowadays, protective coatings have to meet the legal requirements of avoiding use of harmful substances including hexavalent chromium, the main compound employed in such coatings until recently. Consequently, there is a pressing need to develop environment friendly coatings without compromising on the product life cycle. Self-healing coating is most promising to achieve this objective. Compared to normal barrier coatings, self-healing coating present great advantage in that it provides maintenance free corrosion protection for longer durations. This is extremely beneficial for critical components like oil and gas tanks, pipelines, bridges where failure in coatings can result in loss of materials and lives.

CSIR-NML has recently developed a self-healing coating for corrosion protection of mild steel. The coating is a two-component formulation based on epoxy resin and hardener. A mixture of acidic and basic inorganic compounds having inherent corrosion inhibition properties is added to the epoxy resin to impart self-healing functionality to the coating. After breakage of the coating, autonomous self-healing process is triggered when the breached coating area is exposed to moisture or water. Upon contact with moisture or water, the inorganic compounds react with each other to produce a hard, water insoluble material and heal the coating. The self-healing characteristics of the coating have been established by several techniques like electrochemical impedance spectroscopy (EIS), salt spray, Scanning Electron Microscopy (SEM) and Localized Electrochemical Impedance Spectroscopy (LEIS).

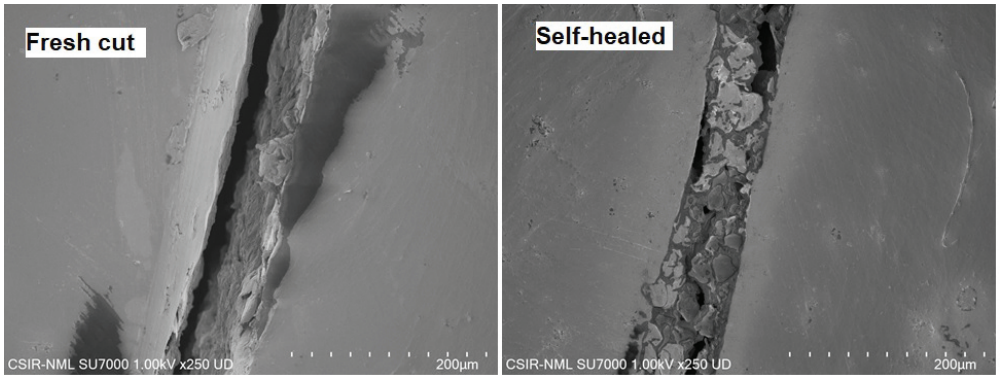


Figure 6 : SEM images of steel samples coated with the self-healing coating. Self healing of the coating was observed after immersion in water for 15 minutes

Annealing simulator integrated with online process control sensors for run out table process simulation

New generation advanced high strength steel development strongly depends on various metallurgical process controls during *Run Out Table* in hot strip mill and in *Continuous Annealing Line* processes. Expensive and time consuming industrial trials are made based on inputs from mathematical simulations or post-process evaluations. Therefore, development of industrial process parameter simulators is desirable for determining critical process parameters to avoid such time consuming expensive industrial trials.

The main goal of the proposed research project is to develop an indigenous simulator for Run Out Table and Continuous Annealing Line process simulation. This will be integrated with indigenous electro-magnetic sensors for online process monitoring and control. Under this research proposal, two key process control components as in the following will be addressed;

i) Indigenously design, develop and fabricate a fully automated Run Out Table simulator for hot rolling mill and continuous annealing line for cold rolled products

ii) Development of high temperature NDT sensor devices with necessary robotics for online data acquisition for monitoring of various metallurgical phenomena occurring during ROT process technology and continuous annealing line process of cold rolled products.

Scale up and Commercialization of indigenously developed Hydrogen Standard in Steel

Hydrogen present in steel product is detrimental to its properties, as it causes hydrogen embrittlement, stress corrosion cracking, flake formation etc. It can be well submitted that enormous amount of care is taken during all the stages of steel manufacturing to keep hydrogen to a bare minimum level (< few ppm). Measurement of this element in steel requires very careful manipulation during the sample preparation and testing. Contamination of hydrogen from any other sources during testing would lead to thus an erroneous value. Standards/reference materials used for calibration and hydrogen detection is costly and time consuming process as the product is presently imported. CSIR-NML had executed a project under Fast Track Translational (FTT) program and successfully developed hydrogen standard in steel, indigenously. In continuation of this activity, to compete well and to offer better service to the Indian customers, the present program aims to scale up (No of bottles: 100 and No of pin/bottle: 100) and commercialize the indigenously developed product hydrogen standard in steel for hydrogen determination. However, certain issues observed during developmental program such as identifying/producing reliable starting material for standard development, improvising the standard deviation of the product, better surface appearance and hydrogen standard in different levels will be exclusively addressed in this project.

The current available hydrogen CRM in Steel has been supplied by foreign vendor at a cost of Rs. 20,000/- to Rs 40, 000/- for 1 pack/bottle (100 nos. of pin sample). At present, the plan for commercialization is as follows:

No of bottles	:	100
No of pins per bottles	:	100 /bottle
Tentative cost	:	Rs 12,000 to 14,000/bottle

The value added (w.r.t uncertainty, surface appearance etc.) hydrogen standard will be certified and listed in the regular CRM list of CSIR-NML for external usage. It is expected that the product will be commercially available to the Indian users from April 2020.



Piloting of the process for Production of Premium Grade Iron Oxide from Waste Ferrous Chloride Solution Generated from Steel Pickling and Ilmenite Processing Units

Iron oxide is a very popular alternative to naturally-occurring pigments due to its high tinting strength, hiding power, color fastness, chemical and heat resistance. CSIR-National Metallurgical Laboratory developed a simple process for production of highly dispersed red iron oxide of uniform size and shape from waste ferrous chloride pickle liquor. The major processing steps consists of oxidation of ferrous iron followed by conversion to desired grade iron oxide. The process does not involve any prior purification steps. The process produce very uniform size iron oxide of different shapes and color. A specific color grade iron oxide could easily be engineered by varying certain processing parameters. The iron oxide gives very high color purity due to highly dispersed and very uniform nature of the particles

produced by the process. The product matches with the color of different standard grade high end iron oxide available in the market. India is a net importer of such grades of iron oxide.

The process was demonstrated and transferred to M/s Rang Sarjan Chemicals for production of high grade iron oxide from waste chloride pickle liquor. Initially, with the guidance of CSIR-NML, they set-up a pilot plant at their proposed plant site and tested the process at a pilot scale. The pilot plant was run for several batches for production of various grades of iron oxide and for confidence building. Simultaneously, they set up a 500 matric ton capacity commercial plant. They have already started commercial production and are able to produce desired grade iron oxide pigment application. Since larger reactor/ autoclaves are not available in India, M/s Rang Sarjan is planning to set-up a few more parallel iron oxide precipitation for further expansion of production capacity.



Figure 7 : 15000 litres capacity reactor installed at M/s Rang SarjanChemicals for precipitation of iron oxide

Pilot scale processes for recycling of metals/ materials from E-waste

Based on the developed and proven know-how at CSIR-NML, scale-up and pilot scale trials for the recovery of marketable metals and materials from e-waste are going on under the aegis of FTT project. The developed pilot scale process and recommended protocol will provide the safe collection of E-waste, proper storage, dismantling and segregation for the recovery of valuable metals and materials along with necessary treatment of solid, liquid effluent and gaseous waste generated during processing of E-waste.

CSIR Madras Centre (MC)

CSIR-National Metallurgical Laboratory Madras Centre had its roots in NML Foundry Station established in 1965 at Guindy Industrial Estate, Chennai. The idea of establishing Foundry Stations across the country was first proposed by Sir Jehangir Ghandy, the then Chairman of the Executive Council of the National Metallurgical Laboratory with the intention of providing technical assistance and testing facilities to the foundry industry. The station had facilities to undertake the analysis of both ferrous and non-ferrous metals and chemical analysis of molding sands. Later on, the idea of setting up of the CSIR Madras Complex, in close proximity to many other technological institutions, was conceived by Dr. S. Husain Zaheer and Dr. Atma Ram, former Directors General of CSIR. The objectives were two-fold, (i) to provide Common Services in the interest of economy and (ii) to allow interplay of scientists working in different disciplines offering a unique opportunity for developing a multi-disciplinary culture. NML Foundry Station was shifted to the present campus of CSIR Madras Centre in 1973 and came to be known as NML Madras Centre. An Ore Dressing laboratory and a Refractory Unit were also added. Over the years, the Centre expanded its activities to include investigations on failure and root-cause analysis of metallurgical components, analysis of metallurgical and ore samples and value addition to metallurgical and mineral wastes. The beneficiaries include M/s Hinduja Foundries, Chennai, M/s Hindustan Zinc Limited, Udaipur, M/s The Ramco Cements Limited, Chennai, M/s Rajshree Sugars & Fertilizers, Tamil Nadu, and M/s Tamil Nadu Electricity Board, Chennai.

The Centre made its mark at a national level for indigenization of 'Column Flotation technology' for processing lean and fine-grained ores. The activities pertaining to it started in the middle of 1980s and have been continuing since then. Laboratory scale (74mm diameter) and Pilot plant scale (500mm diameter) flotation columns were designed, fabricated and field tested at various private and public sector mineral processing plants located across the country. Development of column flotation technology achieved Technology Readiness Level of 9, that is, it was ready for successful deployment at a commercial scale. The USP of the NML Madras Centre is providing One-stop solution for installing commercial scale flotation columns by collaborating and partnering with an EPC company M/s McNally Sayaji Engineering Limited, Bengaluru and Reagents



Figure 1 : Commercial scale flotation columns for barite (1000 tpd) at M/s Oren Hydrocarbons (P) Ltd., Chennai

manufacturers and suppliers M/s Somu Organo-Chem Private Limited, Bengaluru and M/s Xanthate Technologies, Visakhapatnam. So far, 5 laboratory scale, 1 pilot scale and 6 commercial scale flotation columns have been commissioned (Figure 1). Presently, two commercial scale flotation columns are under installation, one at the Coal Preparation Plant of an International Steel giant (200 tpd) and another at the Mineral Separation Plant (MSP) of a Mineral and Metals company. Technology Award for Most Significant CSIR Technology of the Five Year Plan Period - 2014 from CSIR, and the 'National Mineral Award' from the Ministry of Mines, Government of India were received in recognition of the Development of Column Flotation Technology. The Centre also embarked on a programme for developing bio-degradable and eco-friendly flotation reagents for sillimanite, coal, graphite, limestone and iron ore fines in collaboration with CSIR-Central Leather Research Institute, Chennai. The newly developed reagents for sillimanite and coal flotation proved to be more effective than that presently used in the plants. Another flagship programme currently being pursued is on 'Development of graphene-based membranes from graphite ore for desalination' in collaboration with CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvanthapuram, and sponsored by the Ministry of Mines, Government of India.

Commercialization of Column flotation technology for sillimanite recovery at M/s Kerala Minerals and Metals Limited

CSIR - NML Madras Centre had been in the forefront of indigenizing and developing column flotation technology for the mineral industry. In this series, the latest addition is the commercial scale flotation



Figure 2 : Top view of the column - generating sillimanite concentrate

column of 1m diameter and 11m height with a throughput capacity of 5 tonnes per hour for sillimanite recovery at Mineral Separation plant of M/s KMML, Chavara, Kerala. It was commissioned on 27th September, 2019. Sillimanite based refractory bricks are used in the linings of blast furnaces, arc furnaces, soaking pits, reheating furnaces of iron and steel, rotary kilns of cement manufacturing and general kilns of lime production. In beach sands, ilmenite is the most predominant mineral followed by other minerals such as rutile, zircon, monazite, garnet and sillimanite. Generally, specific gravity, magnetic and electrical properties are exploited to separate these minerals. Sillimanite, being a non-conducting and non-magnetic mineral, is separated from other gangue minerals, primarily quartz, by using flotation techniques. Better hydrodynamic conditions and froth washing mechanisms that exist in the flotation column enhance both recovery and grade, compared to conventional cells. Extensive laboratory scale studies were carried out at CSIR-NML Madras Centre on feed to sillimanite flotation circuit to arrive at the required reagents' dosage, optimum grade and recovery of sillimanite and design parameters of the flotation column. M/s McNally Sayaji Engineering Limited, Bengaluru executed the supply of all equipment and

instruments, fabrication, erection and integration of all sub-systems consisting of air compressor, air dehumidifier, column shells and conditioners, etc. By the end of February 2019, 1000 tonnes of sillimanite concentrate of two grades, premium grade (+55% Al_2O_3) and standard grade (52% - 55% Al_2O_3) were produced meeting the requirements of various customers. Incidentally, by January 2019, the value of cumulative concentrate generated was worth more than the investment made (1.17 Cr.), thus crossing the break-even point of the investment made on this project. The flotation column is supposed to generate sillimanite concentrate worth 5 Cr. a year.

Failure Invetsigation of TMT bars of M/s AGNI steels private limited, Tamilnadu

Metallurgical failure Investigation of Thermo-mechanical treated (TMT) bars" was carried out on three varieties namely Type 1, Type 2 and Type 3. A comparative study was carried out for all the three varieties of TMT bars, to find the metallurgical factors that are contributing the failure of one variety of TMT bar namely Type 1. Different metallurgical characterization tools were used to establish the root cause of failure. Based on the results obtained Type 1 -TMT bars failed mainly due to the *presence of oxide scale* on the RIM portion, dominant presence of inclusions and micro slag inclusions on the RIM portion, and subsequent crack opening on the same. Inclusion analysis and rating conforms the maximum and *dense presence of inclusions* in Type 1 bars in comparison to Type 2 and Type 3 bars.

Failure Investigation of Wind mill gear box parts

The main objective of the present investigation is divided into two parts (i) Identification of the root cause of failure of the sun pinion gear, ring gear and planetary gear of planetary stage-II (ii)Identification of the root cause of failure of high speed stage and slow speed stage of helical stage bearings, carrier bearings of planetary stage 1 and stage 2 of the wind mill gear box. Based on the results obtained on gear box failure, the gears failed due to rolling contact surface fatigue. Bearing accessory namely rollers are damaged due to denting of the surface due to hitting of the metal particles. The damage mechanisms on gears (Rolling contact surface fatigue) and bearings accessories (scoring marks on surface) are gradual and simultaneous in nature.

Failure analysis of ESV Steam Strainer, ESV Spring and MS TEE Joint

Based on the results obtained from visual and various experimental evidences, the strainer failed mainly due to operation of *Creep mechanism* in the material line along the point of contact between the curved and flatter surface. The mechanism of material loss is enhanced by the simultaneous operation of different corrosion mechanisms induced by various extraneous elements carried by steam. The material loss at the point of contact, already damaged by creep and corrosion was due to "wear". The fusing of the flat and curved strips surface is possibly due to diffusion of atoms during creep mechanism in the material. The spring failed mainly due to *contact fatigue.* The repeated over loading of the spring at contact surfaces resulted in the failure. The MS TEE Joint failed mainly due to simultaneous action of *corrosion and creep mechanism*.



Team CSIR-NML MC

IMPRESSION

... It is my pleasure to inform you that Materials Engineering Division of CSIR NML has provided unparalleled and valuable technical support in completing critical testing vis-a-vis creep and low cycle fatigue for 5-stages of High Pressure Compressor (HPC) disc forgings for Adour Engine in a time bound manner. We received full co-operation from CSIR NML, Jamshedpur during the period of qualification approval and subsequent testing. I also specially appreciate the dedicated and relentless efforts put in by Dr J. Swaminathan, Mr. K. Guguloth and team members as well as Dr. Sandip Ghosh Chowdhury for timely completion of testing with accurate and seamless reporting of results in line with the stringent aeronautical requirements. With the testing support extended by CSIR NML so far, 2 sets of HPC discs were supplied to HAL. It has been a privilege to work with CSIR NML Jamshedpur in this indigenization project of national importance. These indigenized HPC discs are import substitute for use in engine of Jaguar aircraft catering the Indian Air Force. I also extend thanks to the other staff who were directly or indirectly associated in testing of the HPC discs at CSIR. NML Jamshedpur.I wish and hope your continuous support in carrying out creep and low cycle fatigue testing for this indigenization project of national, importance to propel "Make in India" are import substitute for use in engine of Jaguar aircraft catering the Indian Air Force. I also extend thanks to the other staff who were directly or indirectly associated in testing of the HPC discs at CSIR. NML Jamshedpur.I wish and hope your continuous support in carrying out creep and low cycle fatigue testing for this indigenization project of national, importance to propel "Make in India".

Y. V. Hanumantha Rao, General Manager
QCL, AMTL & Special Products, Midhani, Hyderabad
25th September 2019

...I write this to express my sincere gratitude to you for very kindly sparing your valuable time to address the Business Session II of the Summit of "India Steel Summit 2019" on the topic 'Beneficiation of Low-grade ore for steel sector 'on 25th October 2019 in New Delhi. Your address was highly appreciated by the audience. I am sending few copies of the photographs taken at the venue. We look forward to receiving your continued support in our future endeavour.

Saurabh Sanyal, Deputy Secretary General
ASSOCHAM, New Delhi, India Steel Summit 2019
31st October 2019

SERVICES & FACILITATION

Menander I, Silver tetradrachm (Attic standard)

Weight: 13.03 gm. Helmeted bust of king left, Athena Alkidemos standing left, holding horizontal shield on outstretched left arm, hurling thunderbolt with right hand, monogram at right





Queen Kumaradevi and King Chandragupta I, depicted on a gold coin



An elegant and entirely Greek coin by Antimachos I (r. c.185-170 BCE)



Gold coins of Chandragupta II.



Coin of Samudragupta, with Garuda pillar. British Museum.

Indian Coins : Rich source of history

Our coins are a rich source of Indian history. Large hoards of coins have been found across the country at various sites. Indeed, a large part of Indian history such as that of the Indo-Greeks, the Hunas and Guptas has been reconstructed using information obtained from coins.

Source: http://www.suvarnamohur.com/articles/7-incredible-facts-about-indian-coins.php
http://www.wikipedia.com

Engineering

The division caters and co-ordinates the engineering needs pertaining to both R&D and infrastructural for of the laboratory, large scale testing facilities and residential complexes. The division has two groups: the Works Services and Maintenance (WSM) group, and, the Project Planning and Engineering (PPE) Group. The activities of the division include: Design and Development of prototypes, Project Engineering, Engineering Consultancy, Infrastructure Development, Up-keeping of premises, In-house maintenance, Workshop facilities and support services.

Project Planning and Design Engineering Group

Prototype design and development is the requirements of several projects, the major prototypes designed and developed were: wire stripper for recycling disposed cables, tool post for buffing amorphous melt spinning wheel, pulsated air stratifier prototype for PIV studies, clay mould drier for brass melting furnace, and many others.

Research and consultancy in the area of welding: one collaborative research project sponsored by a steel giant was completed. The division is also developing a state of the art welding research laboratory: The major achievements in the areas of welding are :

- Research project completed on toughness behavior of simulated heat affected zone (HAZ) of SA 508 and P 91 steels
- Conducting a BRNS project on Heat Affected Zone (HAZ) Simulation of SA 508 and 9Cr1Mo steel. This project was awarded by department of atomic energy and is targeted to understand effect of welding parameters on HAZ of the materials used in nuclear plants.
- Consultancy to Metal Industry Development Institute (MIDI), Ethiopia to set up welding research facility.
- Installation of facilities for welding research laboratory, which include Welding Simulator, Twin, wire submerged arc welding (SAW) machine, High Speed imaging system for study of metal transfer phenomena in welding, Stereo Microscope, CMM, Robotic MIG equipment.
- A research scholar from Nigeria has joined our Division for research in the field of welding on a CSIR-TWAS fellowship.

Setting up of critical infrastructure: the following major jobs for critical infrastructure development are in process :

- Facility development for 24×7 controlled atmosphere testing conditions for the Creep Laboratory.
- Setting up of infrastructural requirements for upcoming amorphous electrical steel pilot plant.
- Setting up of 493kwP solar power plant for catering to the electrical load requirement of Laboratory.

Basic Engineering Packages: The group has been involved in preparation of Detailed Project Report (DPR) for technological intervention through Technology Facility Centres (TFC) at five numbers of Bell and Brass metal clusters of West Bengal.

Pilot plant operation and maintenance: In this category of work, the following were carried out:

1. Construction of energy efficient brass melting furnaces in various clusters of Bengal, Jharkhand and Odisha, and their demonstration to artisans.
2. Support in carrying out campaigns in annealing simulator facility.
3. Support in conducting campaign in Magnesium pilot plant facility: Electrical & Instrumentation systems, Signal flow SCADA systems has been revived and brought into operations.
4. Support in revival of rolling mill.
5. Technical support for Design, Development & Commissioning of Pilot Plant for production of sodium at 3000Amps closed cell at the shop floor of the industry.

Maintenance of equipment: The division is actively involved in providing in-house maintenance support to high value equipment of the laboratory, viz., Amorphous melt spinning wheel setup, Rolling Mill in rolling Bay and its upgradation, Magnesium Plant automation system upgradation, 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 and fabrication of prototypes and repairing of miscellaneous jobs. 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 including provision of S&T Services for R&D activities, upkeep of infrastructure, creation of new infrastructure and renovation of facilities in the seven campuses of CSIR-NML. The technical services include air conditioning & refrigeration, civil and electrical engineering, power, lifts and water supply, etc.

New Infrastructure :

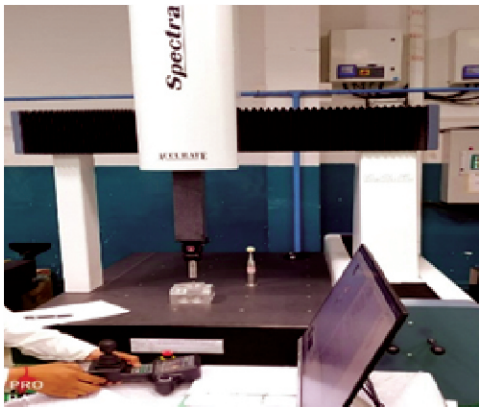
The infrastructure management team has successfully created new facilities as per the requirements of the laboratory. Some of the new facilities developed are as follows :

1. Pilot Scale facility for urban ore (E-Waste)
2. Facilities for New SEM laboratory
3. New facilities for sheet metal forming Laboratory
4. Covered connecting bridge between main building & pilot plant of main laboratory
5. Facilities for Robotic Welding Machine, Welding training center& Coordinating Measuring Machine in workshop

Newly Developed & Refurbished Facility for R&D in Engineering Division :



Robotic MIG Facility



CMM Facility



Particle Image Velocimetry (PIV) Facility



Welding Skill Development Centre



Team Engineering

Knowledge Resources and Information Technology

SCI PUBLICATIONS AND CITATIONS

123 research papers were published in SCI journals from CSIR-NML during April, 2019 to March 2020. Published papers are regularly uploaded in the Laboratory's Institutional Repository. The citation of the cumulative SCI publications (1986 onwards) from CSIR-NML has increased from 5610 (in 2008) to 50782 (as on December 31, 2019) registering an increase of 9.05 fold in the citation growth. The average citation per paper is 18.29. 117 articles of CSIR-NML (all times) have received more than 90 citations/paper (source: Web of science/ Google scholar).

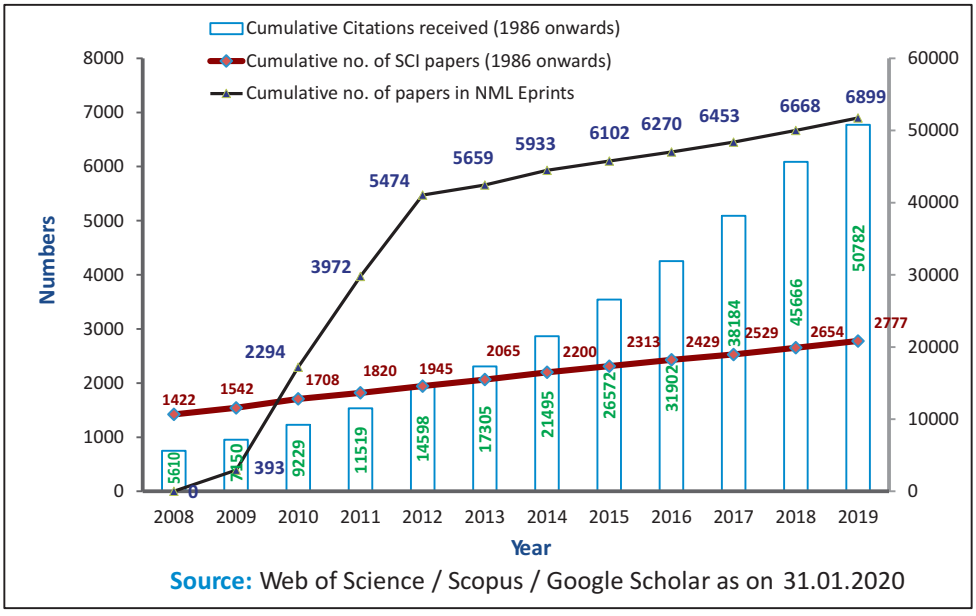


Figure 1 : Growth of Research Publications, Citation and NML IR (Eprints)

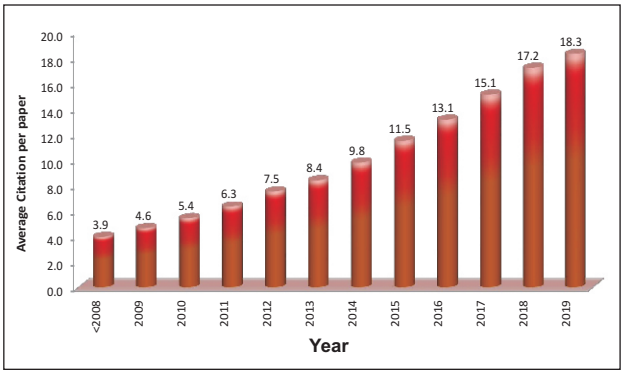


Figure 2 : CSIR-NML H-index

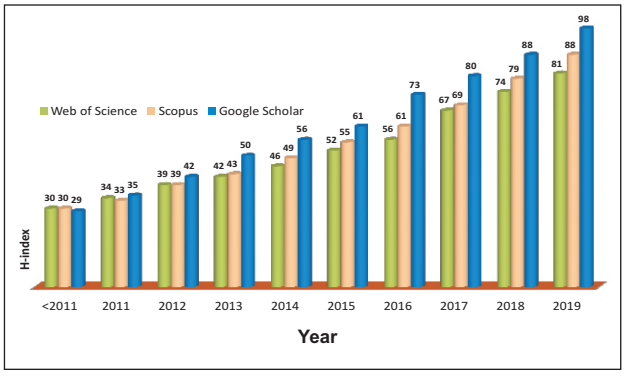


Figure 3 : Average Citation per paper

Institutional Repository

The CSIR-NML Institutional repository (http://eprints.nmlindia.org) has maintained its global visibility and achieved a 19.3 fold increase in popularity with average hits of over 0.306 million per month and a cumulative of over 27.79 million hits since inception (2009). The researchers from 173 countries have accessed NML repository database. Among the global users, the top countries in decreasing order are United States, India, China, Russia, Brazil, France, UK, Germany, Denmark, Japan, Netherlands, and so on.

Transparency Portal

The CSIR-NML Transparency portal (http://library.nmlindia.org/tp/index.htm) launched in May 2012, containing all information pertaining to pay and allowances, foreign and local travel, expenditure pattern, payment to the vendor, local purchase data, works and services, CAG report, etc., has been updated periodically.

Information under Right to Information Act

During the reporting period, CSIR-NML received 65 RTI applications; all of them were responded to within the time framework, as per the RTI guidelines. The 65 RTI applications, emanated from seventeen states of India. So far, no appeal has been referred to Central Information Commissioner (CIC) for review. The subject areas of the RTI queries from applicants were related to the nineteen areas as highlighted below. Since November, 2016, CSIR-NML has switched over to online mode for the transaction of the RTI application through the "RTI Request and Appeal Management Information System" (RTI-MIS) portal. Additionally, a good number of RTI applications are received physically.

Information Technology Group

The Information Technology Group [ITG] caters and co-ordinates the lab wide needs for IT resources and management in terms of creation of IT infrastructure, its services and maintenance. The group is mainly looking after the development and services of IT facilities and infrastructure at CSIR-NML from basic to advanced level.

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, important project meetings around the globe through video conferencing/ Skype, etc.

Following are some of the major milestones achieved while equipping the three campuses of CSIR-NML and two Dispensaries at the residential campuses with the requisite IT infrastructure during the year 2019-2020:

(a) Upgradation of existing server in terms of hardware and Software.

(b) Web based utility application development using open source software for in-house use.

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

(d) IT support to Human Resource Group (HRG) for performing various HR activities.

(e) Resolution of various technical issues related to biometric attendance system and CCTV.

(f) IT support for conduction of seminars, workshops and conferences at NML.

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

Information Products

The following are the important information products of the division

- CSIR-NML Annual Report 2018-2019 (English and Hindi)
- CSIR-NML Brochures / Posters
- Director's Desk - September 2019
- CSIR-NML Record Book 2020
- Hindi Patrika (Samanvaay - 4th ed.)
- Journal of Metallurgy and Materials Science (2019)

Research Planning & Business Development

The Division acts as a connecting link for the laboratory and the collaborators from Industry, Academia and Government. The Division is the first point of contact for the new clients who are seeking solutions for their R&D problems. Further, the Division serves as a gateway to reach the concerned technical area expert and helps the client to find appropriate solutions. The Division then suggests a feasible mode of collaboration and facilitates in completing all required formalities.



Figure 1 : RPBD as a Business Interface

Business Development Activities

The division is primarily engaged in developing and managing business of the laboratory in a variety of ways like tender searches, filling quotations, e-procurement enquiries, and arranging industry meets and conclaves. The responsibilities of the division also include facilitating new and existing customers of the laboratory by preparing and executing Agreements/MoUs, communicating with the customer, providing reports; and gathering Customer Satisfaction Evaluation (CSE) and calculating the satisfaction indices. During 2019-20 the division executed 29 MoUs.







Figure 2 : MoUs executed with various parties

Project Monitoring and Evaluation

An important function of the division is to take care of timely approvals of new project proposals and deviations while complying to the CSIR rules and guidelines. Other related activities include monitoring of the CSIR Plan, Contract and Consultancy Research Programmes. The division also takes care of the GST based Invoicing and External Cash Flow allocation to the projects, for the laboratory. The financial resource management in OneCSIR ERP - CVR entry, resource allocation and utilization, is also performed by the division. On an average 800 invoices and 150 project approvals are handled by the division, every year.

Information Management, Business/Research Intelligence, Analytics and Documentation

A number of web based information systems and related databases are continuously developed and maintained in-house at CSIR-NML for the efficient overall functioning of the laboratory. These information systems and databases provide input for managerial decision-making as well as support numerous key activities of the laboratory, like, Project Information Management and Monitoring, Documents and Reports Management, Employee Profile Management, Human Resource (Competence and Man days Involvement) Management, Enabling Online Recruitment, Online In-house Projects Management and GST based Invoicing. These databases are maintained in the division.

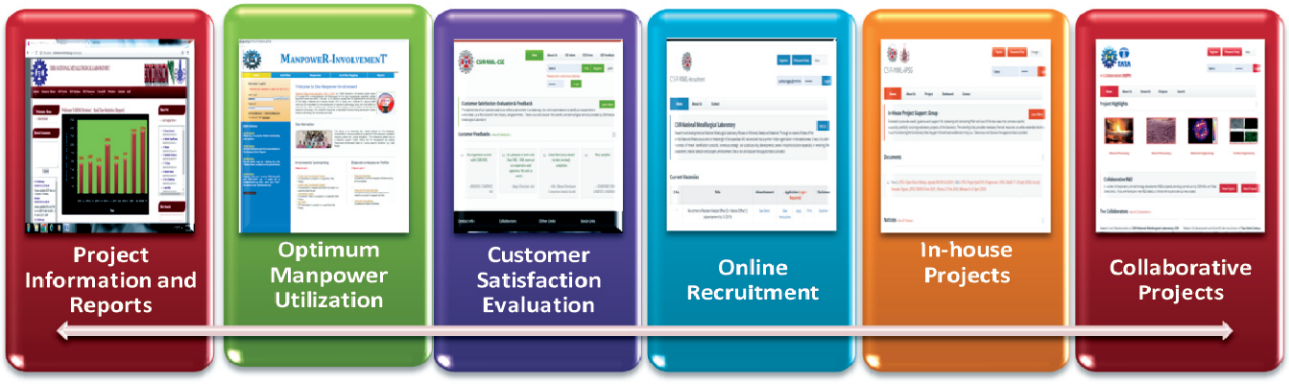


Figure 3 : E-Information Management in key functional areas of laboratory

Development of Web-based Directory of Indian Industries

The directory is a comprehensive listing of Indian industries. The listing is categorized by sectors, like Iron and Steel, Metals and Mining, Oil and Petroleum. The list and the website has been the outcome of an endeavor to build a readily available repository of varied Information, emphasizing the Current and Future S&T needs of the Indian Industry. The information can also be utilized to update the basket of R&D solutions on offer and for R&D planning.

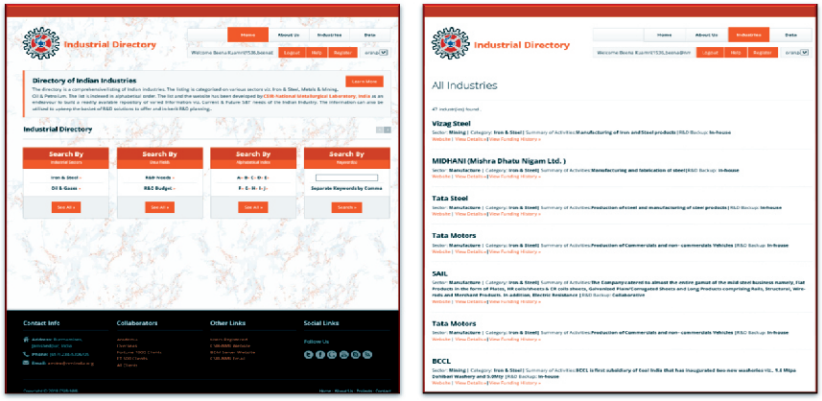


Figure 4 : Snapshot of Industry Directory Website

IP and Technology Management

Business Development group provides IP search and analysis services to its clients as well as in various projects undertaken by the Laboratory. The group comprises a dedicated team, having cutting edge tools and database resources to deliver such jobs to its clients on time. During 2019-20 the business Development group facilitated (i) IP search and Analysis, (ii) Evaluation of FTO Space, (iii) Patent Landscaping, (iv) Patent portfolio Analysis, (v) Patent Mapping, (vi) Patent Citation Analysis, (vi) White Space Mapping, (vii) Competitive Intelligence services in various technological domains in the area of Minerals, Materials and Metals,(viii) Technology Approval and preparation of BEP, (ix) Technology promotion (Preparation of Flyer, Video and Handbook) and (x) Technology Transfer, Demonstration and Maintenance.



Figure 5 : Technology Transfer to M/s. Recycle Karo , Mumbai

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.



Coordination of Institutional Meetings/Events

The division coordinates the Research Council (RC) Meeting twice every year. The research council envisions and provides guidance to the long term R&D plans of the laboratory pertaining to the national level projects and national importance mega projects. The council also provides inputs and monitors the progress of the overall functions of the laboratory. In the financial year 2019-20, the division coordinated the 74th RC meeting on 27th September 2019. The meeting was held to discuss the new and existing R&D initiatives undertaken by the laboratory. The members and chairman of RC suggested various mechanisms to overcome possible difficulties in executing R&D projects of the laboratory.

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 staff as well as providing sustained care right from their recruitments to superannuation, and most of the times even after superannuation i.e. the pensioners. Administration connects all staff from single nerve line and facilitates in fulfilling various vital needs of staff viz. academic, 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 viz. Director, Advisor Management, Head Human Resource Group for decisions on administrative matters .
- Implement instructions of the Director on various matters.

The division is headed by COA, over all In-charge of the activities and supported by, Section Officers, and a group of Assistant Section Officers and other supporting staff. The division also includes a health care centre, security services and Hindi cell. The health care centre is run by three Medical Officers and supported by a group of staff assisting the officers in providing medical facilities for all staff. A number of security services for the laboratory are provided by the security department which is headed by Senior Security Officer.

In recent past, the Administration has undergone major shift in terms of work culture and towards implementing paperless processes. An improved work culture and decentralized leadership at all levels has been introduced to bring the desired changes. A trend of faster service delivery system has been inculcated in the staff to match with the expectations of CSIR-Enterprises Transformation initiative. The initiative was undertaken by CSIR to focus on building electronic workplaces and re-engineering processes for augmented service delivery by implementing the integrated ERP system through Internet Communication Technologies interventions.

Hindi Cell

Official Language Implementation

CSIR-National Metallurgical Laboratory, Jamshedpur has an active Programme for the Implementation of 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 training, workshops, talks and annual competitions and divisional inspections for enhancement of Hindi use in the divisional activities.

Publications In Hindi

The Annual Report, the Hindi Magazine- Samanvay, CSIR-NML Newsletter and Brochures have been published in Hindi and English; these are circulated to CSIR units and various organizations of Government of India. Various 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 were awarded to actively participating Thirteen Employees. Dr. M.K. Jha, Dr. AK Sahu, Shri Amit Prakash, Shri Parmarth Suman, Shri Santosh Kr. Rai, Shri C.R. Chakraborty, Shri Rohit Mudi, Shri Shekhar Sanga, Shri Sudhir Kumar, Shri Ravi Ranjan Kumar, Shri Anil Kumar, Md. Nayeem Ansari and Shri Rachit Ghosh were given awards in this scheme.

Hindi Workshop

Four Table Workshops were conducted in Administration. The objective of the workshop was to address the issues encountered for preparing the Quarterly Hindi Progress Report, Hindi Noting and Drafting and imparting training of Unicode.

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 Government offices located in and around Jamshedpur, with the Director, CSIR-NML as Chairman of this committee.Under the aegis of the Town Official Language Implementation Committee, Jamshedpur, a Literary and Culture Programme was organised on 14th January, 2020 at CSIR-National Metallurgical Laboratory, Jamshedpur. More than three hundred officers with their spouses from different Central Government offices graced the occasion. Along with the staging of a short play "Gharaunda", songs, ghazals by famous artists were also performed. The presence of chief commissioner of Income Tax, Shri Avinash Kishore Sahay infused energy and enthusiasm into the function.



Publications in Hindi

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, CSIR and other stakeholders through the management information system.

Following are the major activities of the Finance & Accounts Division

- Preparation of budget estimate and revised estimate for CSIR-NML and submitting the same to CSIR for allocation of funds.
- To ensure that there are adequate funds available to acquire the resources needed to help the organization to achieve its objectives.
- To ensure cost control while facilitating adequate spending within laid down guidelines and procedures in the matter.
- To ensure adequate cash flow and proper management of funds through transfer of funds from CSIR as well as additional allocation, if any.
- To provide appropriate financial information relating to different heads of accounts and projects to the Director, Project leaders and other decision makers so that informed judgments and decisions are made. Posting of monthly progressive expenditure in NML intranet to keep all employees informed about fund position.
- To prepare financial documents such as Receipts and Payments account and Balance Sheet of the organization on a given date for submission to CSIR and decision makers including submission to CAG (Audit) for certification of accounts.
- Preparation and Submission of utilization certificate to sponsorsof the projects as and when required.
- Pre Audit of all the bills before making final payment to avoid any irregularity or deviation from the financial rules
- 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 New Pension Scheme and Professional tax, income tax, etc., within schedule 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 report returns on monthly expenditure, OB, Bank reconciliation, Audit Paras, etc. to maintain transparency

Performance Highlights for the Financial year 2019-20

1. Utilized Budget Grant allocated by CSIR- Rs.6522.259lakhs + Rs.4738.086 lakhs (pension)
2. Utilization from Laboratory Reserve- Rs.468.004lakhs
3. Generation of interest by investment of surplus funds- Rs.815.713 lakhs
4. Generation of Lab Reserve - Rs.1863.816 lakhs.
5. Bank reconciliation of the Cash Book completed up to 31st March, 2020
6. GPF Account as on 31-03-2020 has been reconciled, finalized and closed.
7. During the year, new cases of 21 pension and 03 family pension have been completed with issuing of PPO and pension papers on time.

Special Achievements

- Shri Deepak Kumar, JSA of this Division was a member of the Runners-up team of National level Cricket tournament for Specially abled (deaf & dumb) persons.
- Shri A. M. Pradhan, FAO, attended 'Festival of Letters' organized by Sahitya Academy, New Delhi and chaired a session on Tribal Language Poetry.

Stores & Purchase

The Stores & Purchase Division is mainly responsible for procurement of capital goods, spares & consumable items and annual maintenance services. Different committees 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 2019-2020 are :

1. 10kN Close Loop Controlled Servo Electric Creep-Fatigue Test Machine
2. Inductively Coupled Plasma Mass Spectrometer
3. Oxygen and Nitrogen Determinator
4. Hydrogen Determinator
5. Thermal Conductivity Measurement System
6. Temperature Modulated Differential Scanning Calorimetry.

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

The division has taken up the challenging task of implementation of the ERP, E-Procurement through CPP portal and procurement through Government E Market (GeM) platform, with an objective of automation of processes leading to a paperless office. It is coordinating with the corresponding CSIR Team and others in ensuring a speedy implementation of ERP, E-Procurement and GeM. The Stores & Purchase Divisionis headed by Stores and Purchase Officer (SPO). The SPO is supported by Section Officers, Assistant Section Officers, Junior Secretariat Assistant, Stenographers and Multi-tasking staff. The Stores and Purchase Division strive to keep the system of R&D and other supporting services running in a smooth condition by taking care of procurement activities related to materials / services in time and within the ambit of public procurement rules / guidelines.

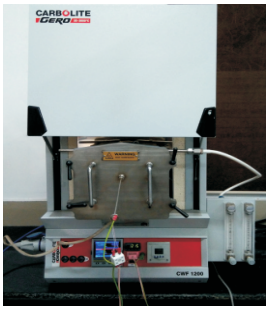
New Facilities

High Resolution Raman Spectroscope with 3D Imaging

Make : Witec, Germany
Features/ Specs.: attached with 532nm and 633nm lasers.

Can directly analyze flat metallic surface, thin film and powder samples without sample preparation. It can be used for characterisation of nanomaterials and composites. Monitors in-situ corrosion product on metallic surfaces after exposure to environments. Raman spectra can be recorded at different locations by selecting the specific particles/ area through confocal microscope which can help to monitor different molecular structure formation and growth.





Muffle Furnace with Additional Retort

Make : Carbolite

Features/Specs. : Capable of continuous operation up to 1100^{0}C. Equipped with a Nanodac advanced Eurotherm controller/ recorder/ programmer for efficient operation and setting of heating ramps and soaking temperatures with multiple segments. It has additional retort to carryout high temperature oxidation studies under controlled environments.

Rotational Viscometer System

Make : Rheosys, USA; *Model :* Merlin VR
Features/Specs. : Viscosity range: 0.001 - 600000 Pa.s,

Accuracy: 0.01 Pa.s, temperature range of 20-120°C. It can be used to measure viscosity of solutions and paste. The instrument is used to measure viscosity of polymer solutions synthesized for coating applications.



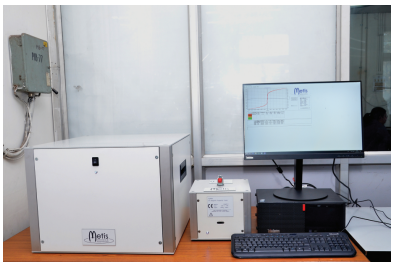


High Performance Computing System (HPC) Cluster

Make : DELL

Features/Specs. : consists of one master node and two compute node. Master node enabled with 24CPUs with total 97 GB memory. Each compute node enabled with 48 CPUs with 97GB memory. Two Graphics processing units (GPU) with 16GB memory used as accelerator for the programming calculations. Open source software like LAMMPS, Quantum Espresso and Open Phase installed for the general purpose simulation.

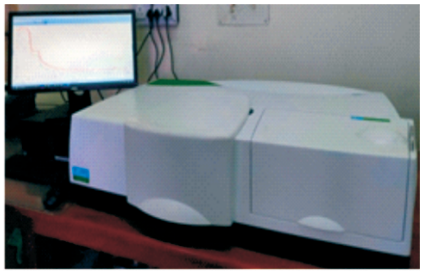
Magnetic Characterisation System for Amorphous Alloys in the form of Ribbons.



Make : Metis Instruments, Belgium, *Model :* HyMAC.

The system can be used for determination of AC magnetic characteristics of soft magnetic materials like soft ferrites and electrical sheets in the frequency range 3 to 2500 Hz. It can also be used for DC measurements. The instrument plots magnetic hysteresis loops and can measure coercive force, permeability, losses. The system can be operated at fixed B and fixed H operations.

High Resolution UV-VIS NIR Spectrometer with Solid-state Facility



Make : Parkin Elmer; *Model* : Lambda 750

Features/Specs. : Double monochromator having solid state facility which can record the spectra in the range of 190-3300nm covering full NIR range. Present equipment having high sensitivity, low noise can give accurate results for even minimum concentration measurement. Availability of diffused reflectance spectra recording attachment can be utilized for recording spectra even in solid state covering the full solar spectrum. Additionally, one can record the diffused, specular reflectance and transmittance of solid sample in the range of 200-2600nm. It can be used for quantitative determination, reaction kinetic study, spectral recording, reflectance and transmittance measurement of solid, liquid and gel samples. Using the equipment one can additionally calculate the band gap of semiconductors, oxidation state and concentration of transition metals.

Titanium Pressure Autoclave



Make : Trident Labortek

Features/Specs.: 30 litre of capacity with working temperature of about 300°C and pressure up to 80 bar. It can carry out high pressure and temperature leaching along with material synthesis.



Gel Permeation Chromatography (GPC) System

Make : Agilent; *Model :* 1260 Infinity II

Features/Specs. : Molecular weight range: 1000-10,000,000 Da. Solvent: both aqueous and organic (THF, toluene, DMF, dichloromethane). Detector: RI detector. GPC system is used to measure molecular weight of polymers. It is used in Molecular weight distribution, number average molecular weight, weight average molecular weight, and, polydispersity index of polymers can be determined using this instrument.

Integrated EDS EBSD



Make : EDAX; *Model :* Team Pegasus Integrated EDS EBSD with Octane Elect Super and Velocity

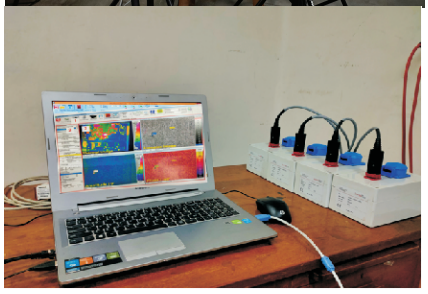
Features/Specs. : Attached with HITACHI SU700 field emission scanning electron microscope. Octane Elect Super EDS system has Silicon Drift Detector and delivers high-quality EDS at high resolution and speeds. Sensor area : 70 mm^2, Throughput up to 850 Kcps and resolution of 127 eV for Mn Kα. Velocity EBSD Camera is a CMOS-based high speed, high sensitivity, and low noise digital camera system for EBSD applications. It has data collection rates greater than 3,000 indexed points per through CMOS sensor. It is used for advanced material characterization for obtaining compositional information, mapping, crystallographic information, etc., down to nanometre scale. Microanalysis users will benefit from both speed and data quality to maximize their materials insight.

Excitation System for Lock-in Thermography

Make : Infratec GmbH, Germany; *Model :* IRBIS3 Active Online

Features/Specs. : The excitation system for lock-in thermography is used for application of periodic heat energy using 4 flash lamps to heat the specimen undertest. The resulting heat flow is influenced by interior material layers and defects. The computer controlled high-precision long range (7.5-14m) infrared camera, the state-of-the-art thermography system, can be employed to capture these inhomogeneities on the object surface. Different evaluation algorithms improves the signal-to-noise-ratio, which allows for detection of the smallest defects. It is used for Non-destructive detection of material defects, such as joint flaws, blowholes, cracks or delamination. Allows contact-free testing with low thermal stress, offers informative images of defects, categorization of defect types.





Automated SEM-EDS with Inclusion Analyser for Steel Cleanliness Assessment



Make : Carl Zeiss U.K; *Model :* EVO18

The automated inclusion analyser is capable of analysing wide range of steel samples like- lollypop, cast, rolled, etc., to detect, measure and analyse the inclusions in the steel and processes the resulting data set to published standard methods namely ASTM E45, ASTM E2142, E2283, ISO 4967, DIN 50602 and EN 10247 for cleanliness assessment of steels. It has an integrated platform (SEM-EDS with suitable automation and software) for dedicated quick analysis of non-metallic inclusions or particles in fully automated principle in terms of chemical composition, size, morphology along with high magnification imaging.ASTM E2142, E2283, ISO 4967, DIN 50602 and EN 10247 for cleanliness assessment of steels. It has an integrated platform (SEM-EDS with suitable automation and software) for dedicated quick analysis of non-metallic inclusions or particles in fully automated principle in terms of chemical composition, size, morphology along with high magnification imaging.

Robot Integrated Pulse Synergic MIG/MAG Welding Equipment- 500A Welding Power Source "TPS 500i (Fronius) and Robot : KRB R1620 arc HW (KUKA)



Make : KUKA robot and Fronius welding power source

Features/Specs.:KUKA robotic welding machine is six axis automatic gas metal arc welding (GMAW) machine with several advanced features like pulse welding, cold metal transfer (CMT) technology, pulse on pulse, penetration control welding. The welding machine can also be used in manual mode and can perform shielded metal arc welding (SMAW) and gas tungsten arc welding (GTAW). The Robot can be programmed to execute complex welding with consistent quality. It can cover area upto 2 m^2 radius. This equipment can be used for additive manufacturing, 3D printing, dissimilar welding/ Brazing of Aluminum and steel, etc. In addition to research, the equipment will also be used for developing welding procedures for automobile component manufacturers, training of robotic welders.

Ultra-High-Resolution Schottky Scanning Electron Microscope



Make : HITACHI; *Model :* Su700

Features/Specs. : Detectors: In-lens SE detector, In-lens BSE detector, In Chamber SE detector, In chamber PD-BSE detector, Integrated EDS-EBSD detector (EDS: EDAX Octane Elect Super, EBSD: EDAX Velocity). Simultaneous acquisition of multiple secondary electron and back-scattered electron signals. Resolution @ optimum WD (high vacuum): 0.8 nm at 15 KV, 0.9 nm at 1 kV Versatile ultrahigh resolution, very low kV imaging and analytical capabilities to meet most demanding nanoscale characterization requirements. It will be used for advanced characterisation of materials.

CNC 3Axes Coordinate Measuring Machine



Model : Spectra 685

Features/Specs. : Max. work-piece weight: 250kg; Measuring Range: X axis: 600mm, Y axis : 800mm, Z axis : 500mm. Resolution : 0.1 µm or better. CMM facilitate features such as free-form surface comparison with 3-D CAD model, sheet metal surface comparison with 3D model and program generation through 3-D model.

It is used for Inspection & quality control, Reverse Engineering, Residual stress measurement. Measure and provide all GD&T parameters e.g. point, line, plane, circle, cylinder, step cylinder, cone, sphere, different types of slots, position tolerance of point, line, plane, straightness, circularity, flatness, parallelism, concentricity, co-axiality, perpendicularity, angularity, run-out, tolerance to the variables, etc. CMM supports scanning of known/unknown profile, reverse engineering, export of point cloud data in machine code like DXF and IGS format.



Creep Crack Growth Test Machine

Make : Zwick-Roell, Austria; *Model :* Kappa 100 SS-CF,

Features/Specs. : 100kN load capacity, max. operating temperature 1000°C.

Ion milling equipment for TEM sample preparation



Make : Gatan Inc; *Model :* PIPS II 695

Features/Specs. : Two ion guns each with independently adjustable gas flow controller. Ion beam energy adjustable in the range of 100eV-8KeV or above for both the ion guns. *Milling angle :* -10° or lower to maximum +10° and fully adjustable during operation. Equipped with cold stage which is capable of maintaining temperature up to -165°C. *In-situ viewing :* It is possible to view the sample any time without shutting down the milling operation. It can be used for TEM specimen preparation with large electron transparent areas from a wide variety of materials.

RECOGNITIONS & ACHIEVEMENTS



Gold Mohur with Zodiac Sign - Muhammad Nuruddin Salim Jahangirs - AD 1605 to 1627 - AH 1031 - Mughal Empire - Sagittarius Sign - 15



Portrait Coin of Emperor Jahangir Sold





Jahangir, the Mughal Emperor minted gigantic gold coins with a diameter of 21 cm. These coins weighed about 12 kg and were gifted to visiting foreign dignitaries.



A remarkable feature of Jahangir coinage is the association of the name of Nurjahan. He was the first Mughal Emperor in India who minted coins with his wife Nurjahan's name inscribed on them.

Jehangir, The Mughal Emperor : Gigantic gold coils

A remarkable feature of Jahangir coinage is the association of the name of Nurjahan. He was the first Mughal Emperor in India who minted coins with his wife Nurjahan's name inscribed on them.

Source: http://www.suvarnamohur.com/articles/7-incredible-facts-about-indian-coins.php

International and National Awards & Recognitions

Metallurgist of the Year Award

Awarded during the 57th NMD-ATM 2019



Dr. S. Sivaprasad
Sr. Principal Scientist

Prestigious Fellowship

Fellow of Indian Chemical Society, 2019



Dr. Arvind Sinha
Chief Scientist



Dr. Sanjay Kumar
Sr. Principal Scientist

High Citations Achieved

Has got 602 citations for his publications in calendar year 2019 making total 3270 citations on google scholar citations. Two of his papers have more than 300 citations; four papers have more than 200 citations and three papers more than 100 citations.

Reviewer of Reputed Journals

International Reviewer of Russian Science Foundation

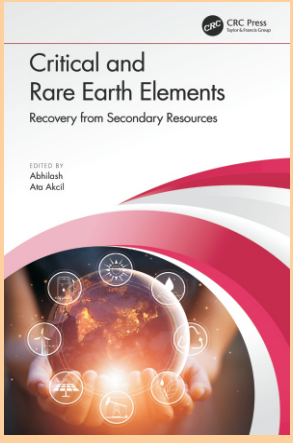
National/International Committee Memberships

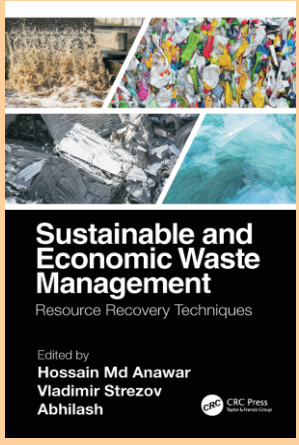
- Member of Scientific Committee of 3rd International Bauxite Residue Valorisation and Best Practices Conference to be held during 11-15 MAY, 2020, CONSTANTA, ROMANIA
- Expert Advisory Committee Member of Waste Management Technology Committee of DST, India

Editor of Book(s)



Dr. Abhilash
Principal Scientist





- Editor of the book titled "Critical and Rare Earth Elements: Recovery from Secondary Resources", CRC Press (ISBN: 978-0367086473, Nov 2019)
- Editor of the book titled "Sustainable and Economic Waste Management: Resource Recovery Techniques", CRC Press (ISBN- 9780429279072, Nov 2019)

Editorial Board Membership



Dr. Sanjay Kumar
Sr. Principal Scientist

Editorial Board Member of the "Transactions of Indian Ceramic Society" a Taylor & Francis Journal for the year 2019-21



Dr. S. Ghosh Chowdhury
Chief Scientist

Editor of Transaction of Indian Institute of Metals



Dr. Manis Kumar Jha
Sr. Principal Scientist

Chief Editor of an International journal of Scientific Research and innovation, "MANTHAN"

SKOCH Order of Merit, 2019

CSIR-NML team received SKOCH ORDER of MERIT (Top 150 ICT Projects in India) for the implementation of Manpower Involvement Website in the category of e-Governance.





Dr. Beena Kumari
Sr. Scientist



Dr. Sital Kr. Pal
Sr. Principal Scientist



Mr. A.K. Upadhyay
Sr. Technical Officer



Dr. Amitava Mitra
Sr. Principal Scientist



Mr. Uday Bhaskara Rao
Scientist

Certified Energy Manager

Certified as energy manager for Bureau of Energy Efficiency, Ministry of Power, Government of India.



Mrs. Yenni Usha
Scientist

Master Trainer

Qualified as a master trainer conforming to national skill qualification framework level-6.

CSIR Foundation Day Awards (26th September 2019)

Essay Competition Awards

Winners (Hindi)



1st
Mr. Naveen Kr. Sharma
Section Officer



2nd
Mr. Shashikant Choudhary
Sr. Technical Officer



3rd
Mr. Amit Prakash
Sr. Technical Officer

Winners (English)



1st
Ms. Swetha Ghosh
Project Assistant



2nd
Dr. Abhilash
Principal Scientist



3rd
Mr. Hrishikesh Shastri
Project Assistant

Meritorious Children Awards to the Wards of Staff for Academic Excellence



Mr. Shubhraneel Pal
(S/o. Dr. Jagannat Pal)



Mr. Rik Bhattacharya
(S/o. Dr. M. Bhattacharya)



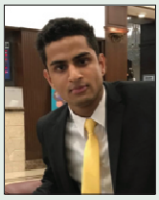
Mr. Sayan Maity
(S/o. Dr. S. K. Maity)

One time lump sum cash award of for securing 90% marks or above in each of minimum three science subjects in the Senior Secondary Examination (12th class) held in 2019.



Mr. Shubhraneel Pal
(S/o. Dr. Jagannat Pal)

One time lump sum cash award for securing 100% marks in any science subject in the Senior Secondary Examination (12th class) held in year 2019.



Mr. Varun Nayar
(S/o. Dr. Suprabha Nayar)

One time lump sum cash award for securing admission in premium education institute of the country i.e. Indian Institute of Management Bangalore (2-year Post Graduate Program (2019-21) in Management)

CSIR-NML Foundation Day Awards (26th November 2019)

P. Ramachandra Rao Award for Best Employee (Technical)



Mr. Sanjay Kumar
Technical Officer



Mr. Ramashrya Ram
Sr. Technician

P. Ramachandra Rao Award for Best Employee (Non-Technical)



Mr. Robert Barla
Section Officer (F&A)



Mr. Sitaram Paswan
Bearer

Altekar Award for Best Technology

For developing a process for "*The production of DRI from Mill scale and low grade non-coking Coal in Tunnel kiln*".



Dr. D. Paswan
Senior Scientist



Dr. M. Malathi
Senior Scientist



Dr. D. Banopadhyay
Chief Scientist



Mr. S. Thatoi
Technical Assistant

Nijhawan Award for the Best Technical Paper Published from NML in the Calendar Year 2018

For the paper entitled, "*Aqueous process intensification through enhanced oxygen vector: An application to cleaner leaching*" in the Journal of Cleaner Production.



Mr. Shivendra Sinha
Scientist



Dr. Devbrata Mishra
Principal Scientist



Dr. Archana Agarwal
Chief Scientist



Dr. Kamala Kant Sahu
Sr. Principal Scientist

SP Mehrotra Award

For the best speaker in Colloquium series held at CSIR-NML during 2018-19



Mr. Mahesh Walunj
Scientist



Mr. Snehashish Tripathy
Scientist

Special Appreciation Award for 2019



Mr. Premjeet Singh
ASO S&P (MACP)



Mr. S. Sankar
Senior Steno

Meritorius Student Awards 2019

(for securing 85% or above marks in ICSE/CBSE in Class 10th and 12th Examination held during the year 2019)



Mr. A. Kumar
(S/o Mr. M. Kumar)



Mr. S. P. Ruchir
(S/o Dr. S. Sivaprasad)



Ms. D. Ghosh
(D/o Dr. S. G. Chowdury)



Mr. Shubhraneel Pal
(S/o. Dr. Jagannat Pal)



Mr. Rik Bhattacharya
(S/o. Dr. M. Bhattacharya)



Mr. Sayan Maity
(S/o. Dr. S. K. Maity)

(for securing 100% marks in any subject in the 9th/10th/11th/12th Class Examination held during the year 2019)



Mr. Shubhraneel Pal
(S/o. Dr. Jagannat Pal)



Mr. Rik Bhattacharya
(S/o. Dr. M. Bhattacharya)

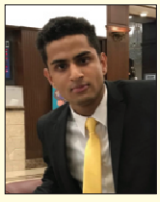
(for securing admission in institutions of national repute through competitive examination held during 2019)



Mr. Shubhraneel Pal
(S/o. Dr. Jagannat Pal)



Mr. Sayan Maity
(S/o. Dr. S. K. Maity)



Mr. Varun Nayar
(S/o. Dr. Suprabha Nayar)

Awsar Award 2019



Ms. Aarti Kumari
Scientist

Received AWSAR AWARD 2019 (Consolation) on National Science Day from Department of Science & Technology.





Mr. G. Bansal
Scientist

Received AWSAR Award 2019 for the paper "*Overcoming the Strength-Ductility Trade-off in Low Alloy Steel for Superior Performance*"

***AWSAR** (Augmenting Writing Skills for Articulating Research) is an initiative of Department of Science and Technology (DST), Government of India. It attempts to disseminate Indian research in Science, Technology & Innovation being pursued by Phd Scholars and Post Doctoral Fellows in popular science writing format.

Misra Award for Best Paper Published

Indian Institute of Minerals Engineers (IIME)



Dr. Pratima Meshram
Senior Scientist



INDIAN INSTITUTE OF MINERAL ENGINEERS

MISRA AWARD
(IIME BEST PAPER AWARD ON HYDRO-ELECTRO-BIO PROCESSING)

is presented to
Pratima Meshram, Hemant Somani, Banshi Dhar Pandey, Tilak Raj Mankhand, Haci Deveci and Abhilash
For the Best Paper titled
"Two stage leaching process for selective metal extraction from nickel metal hydride batteries"

Published in the
Journal of Cleaner Production, V-157 (2017) pp. 322-332.

Hyderabad
16-18 December, 2019

Dr. N. K. Nanda
President



Dr. Abhilash
Principal Scientist

Received the Mishra Award-2019 for the best paper published in the category of Hydro-Electro-Bioprocessing for the year 2017-18 for their work entitled "Two-Stage Leaching Process For Selective Metal Extraction From Nickel-Metal Hydride Batteries".

Misra Award for Oral Presentation

MPT-2019, Hyderabad



Mr. Shivendra Sinha
Scientist



Mr. S. Shekhar
Scientist



Dr. Devbrata Mishra
Principal Scientist

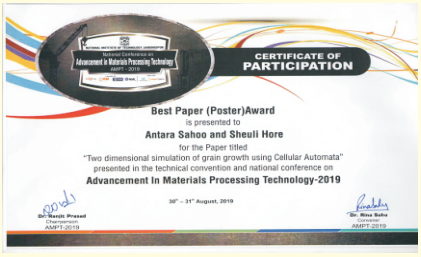
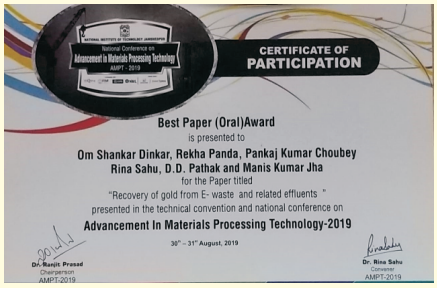


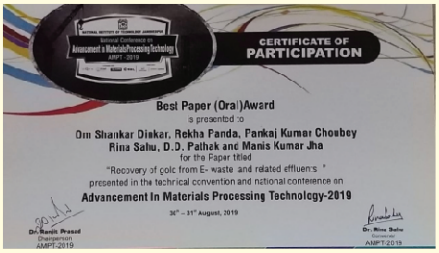
Dr. Kamala Kant Sahu
Principal Scientist

Received the Mishra Award-2019 for the paper, entitled "Selective dissolution of Manganese via salt roasting-leaching techniques from Low grade manganese ore".

Best Paper/Poster Presentation Awards

Authors	Details	
 **Mr. K Ashok** Scientist  **Mr. Nimai Halder** Sr. Technical Officer  **Mr. Prem Kumar M** Scientist	Secured best paper award for the presentation entitled "Hot model simulation of mold phenomenon during the continuous casting process".	

Authors	Details	Conferred During or By
 **Dr. N. S. Randhawa** Sr. Tech. Officer  **Ms. Soni Jha** Project Assistant  **Mr. J. N. Patel** Technical Officer  **Dr. Jhumki Hait** Principal Scientist	Received third prize in Poster Presentation	International Conference ICNFMM-2019
 **Ms. Antara Sahoo** (D/o Dr. K.L. Sahoo)  **Dr. Sheuli Hore** Sr. Principal Scientist	Received best paper (Poster) award for Poster entitled "Two dimensional simulation of grain growth using Cellular Automata". 	National Conference on Advancement in Materials Processing Technology (AMPT-2019 held at NIT, Jamshedpur during 30-31 August 2019
 **Mr. Om S. Dinkar** Project Assistant  **Ms. Rekha Panda** Sr. Research Fellow  **Dr. P. K. Choubey** Research Associate  **Dr. Manis Kr. Jha** Sr. Principal Scientist	Received Best Paper (Oral) award for paper entitled " Recovery of gold from E-waste and related effluents" 	National Conference on Advancement in Materials Processing Technology (AMPT-2019 held at NIT, Jamshedpur during 30-31 August 2019

Authors	Details	Conferred During or By
 **Ms. Sweta Verma** Project Assistant  **Ms. Archana Kumari** Sr. Research Fellow  **Dr. Jhumki Hait** Principal Scientist  **Dr. M. K. Jha** Sr. Principal Scientist	Received Best Paper (Oral) Award for paper entitled “Recovery of Stratetic Metal Germanium using Metallurgical Techniques” 	National Conference on Advancement in Materials Processing Technology (AMPT-2019 held at NIT, Jamshedpur during 30-31st August 2019
 **Ms. Jayati Priya** Project Assistant  **Dr. N. S. Randhawa** Sr. Technical Officer	Awarded a cash prize as First Prize for the Poster Presentation in the Seminar on "Green Initiatives on title Recovery of copper from flash smelter dust by sulfation roasting - water leaching - electrorefining method". 	Metallurgical Industries in India. (GIMII-2019)" held on September 2019 in the Department of Metallurgical and Materials Engineering, IIEST (Shibpur)
 **Dr. P. K. Choubey** Research Associate	Received first prize in Oral Presentation for his paper entitled "Overview on recycling of energy storage element Lithium Ion Batteries (LIBs)", authored by P.K. Choubey, D. D. Pathak and M.K. Jha. 	National Conference on "Trend in Minerals & Materials Technology (MMT-2019)" held at SIKSHA "O" ANUSANDHAN UNIVERSITY, Bhubaneswar on 30th October 2019.5

Authors	Details	Conferred During or By
 **Mr. Chandan Dutta** Project Assistant  **Dr. T. K. Das** Principal Scientist  **Mr. Alok Kumar** Project Assistant  **Mr. J. Kumar** Project Assistant  **Dr. S. Palit Sagar** Sr. Principal Scientist	Received cash prize for their e-poster entitled "High-Temperature Eddy Current Sensor for Real-Time Structural Health Monitoring of Critical Engineering Components" by well-known global publisher company Springer in Non-Destructive Evaluation (NDE)-2019 conference. 	Non-Destructive Evaluation (NDE)-2019 conference.
 **Mr. Shivendra Sinha** Scientist	First Prize in oral presentation in the category of Bio-hydro-electro-metallurgy category	MPT-2019, Hyderabad
	First Prize in oral presentation in Forum of Revolution in Renewable Energy	FOREN-2019, Italy
	Facilitation award by IIM Jamshedpur Chapter for the Best Oral Presentation in nonferrous category	NMD-ATM
	Third e-poster prize in e-poster competition	IIM, Jamshedpur Chapter
 **Ms. N. Vasumathi** Principal Scientist	Tamotia Award for the Best Paper 	During the technical session of environment for her oral presentation on "Development of biodegradable collector for low grade graphite flotation" in XVIII Mineral Processing Technology Conference (MPT - 2019) held at Hyderabad between 16-18th December 2019.

Authors	Details	Conferred During or By
 **Mr. Shivendra Sinha** Scientist  **Mr. R. Choudhari** Technical Officer  **Dr. Devendra Mishra** Principal Scientist  **Mr. S. Shekhar** Scientist  **Dr. K. K. Sahu** Sr. Principal Scientist	Best Oral Presentation award for the technical paper "Recovery of Zinc from the metallurgical waste of Hot Dip galvanizing plant" presented in METWASTE-2020 in Varanasi	Organized by IIT-BHU and University of Edinburgh during 22-23rd February 2020 at Varanasi

Horticulture Awards

Received various prizes for in different categories at the 31st Annual Flower Show organized by Horticultural Society, TATA Steel & JUSCO, Jamshedpur during 22-25th December 2019 in Jamshedpur. Mr. Shailendra Kumar received the awards on behalf of CSIR-NML.



Media Appearance of CSIR-NML Scientist

Radio Talk on Scientific Temperament

In order to promote the culture of scientific temperament among the masses of Jharkhand, Chairman of the chapter, Dr Arvind Sinha was invited to Jamshedpur Center of Aakashvani for an interview on the subject during November 2019. Through a question & answer session, Dr Sinha explained the meaning of scientific temperament in common men's language and its importance in every walk of our life of every citizen irrespective of his or her profession. It was clearly spelled out that by following a scientific temperament, how one can reduce the possibility of making wrong decisions effecting one's life.



An interview on “Scientific Temperament & its importance” at All India Radio, Jamshedpur .

Invited Lecture Delivered



Dr. Indranil Chattoraj
Director-NML

- Invited as Guest of Honor and a Speaker at International conference on "Steelmaking and Casting-Sustainable Technology and Practices" organised by IIM, Jamshedpur Chapter in association with Tata Steel and CSIR-NML during 6-7th February 2020 at Alcor Hotel, Jamshedpur.





Dr. Sandeep Ghosh Chowdhury
Chief Scientist

- Delivered an invited talk 12th Asia-Pacific Microscopy Conference (APMC-2020) Hyderabad International Convention Centre, 3-7th February 2020, Hyderabad.



Dr. Suman Kumari Mishra
Chief Scientist

- Delivered an invited talk on "Nanocomposite Coatings" at BITs Pilani Hyderabad campus February 2020.
- Delivered an invited talk on "Microstructure and mechanical behaviour correlation of nanocomposite coatings" at International conference, 12th Asia pacific Electron Microscopy Conference at Hyderabad, India, February 2020, APMC 2020.
- Delivered an invited talk on "Innovation in Science Education" NASI seminar at Jharkhand women's college.
- Delivered an invited talk on "Synthesis and sintering of borides and composite by innovative processes" at ADMAT-2019, International Conference on "Materials for Defence" held at Hyderabad by DMRL.
- Delivered an invited talk on "Thermal Barrier coatings" at TEQIP workshop on "Surface Engineering & Composite Materials", May 2019.

- Delivered an invited talk on "Hard nanocomposite coatings" at TEQIP workshop on "Materials, Manufacturing and Modeling: Advances and Constraints", NIT Jamshedpur, May 2019.
- Delivered an invited talk on "Surface Engineering" at TEQIP Workshop on "Surface engineering & Composite Materials", May 2019.



Dr. S. Palit Sagar
Sr. Principal Scientist

- Keynote Speaker & Chief-Guest : National Workshop on "Applications of NI LabVIEW in Electronics & Communication Engineering (ANECE-2019); NIT Jamshedpur, 07th June, 2019.
- Invited speaker at the National Seminar on Non-destructive evaluation (NDE 2019), Bengaluru, 04-06th December, 2019.
- Invited speaker. Recent Advances in Materials for Sensor Design & Microwave Application, (RMSM-2019), 8- 13th July, 2019, NIT, Jamshedpur.
- Invited to participate as an expert in the brainstorming session on more reliable and fast NDT detection technique for chevron cracks at Bharat Forge, Pune on 14th September, 2019 (on the eve of Engineers' Day).



Dr. Trilochan Mishra
Sr. Principal Scientist

- Invited talk at International Conference on "Nanomaterials for energy, environment and sustainability" at Siksha 'O' Anusandhan University, Bhubaneswar during 20th -22nd December 2019



Dr. Sanjay Kumar
Sr. Principal Scientist

- Invited as the Chief Guest in Training Course on Sustainable Manufacturing at NIT, Jamshedpur on 16th December 2019. Delivered the keynote address on ' Innovation, Sustainability and Circular Economy".
- Delivered an invited talk on "Processing & Utilisation of Iron & Steelmaking Slag" in the Professional Training Program on "Experimental Techniques in Iron and Steelmaking (ETIS 2019)", 10 -13th December 2019.
- Delivered an invited talk on "Waste Utilisation Strategies & Avenues for Ferrous and Non-ferrous Metal Sector" in the Professional Training Program on "Recycling of Metallurgical Wastes (4RWASTE-2019)", 27th November 2019.



Dr. Amitava Mitra
Chief Scientist

- Delivered an invited talk on "Application of Rapidly Solidified Magnetic Materials for Structural Health Monitoring of Engineering Components" (Invited Talk), 26th International Symposium on Metastable, Amorphous and Nanostructured Materials (ISMANAM-2019), 8-12th July, 2019, Chennai, India.



Dr. Ratnakar Singh
Chief Scientist

- Delivered an invited lecture on "Beneficiation of Low Grade Iron Ores for Steel Sector - Recent trends" at "India Steel Submit 2019 - Role of Steel in Achieving $ 5 Trillion Economy", organized by The Associated Chambers of Commerce and Industry of India in New Delhi on 25th October 2019.





Dr. Rajneesh Kumar
Principal Scientist

- Delivered two invited lectures on the topics "Mechanical properties of Materials and their evaluation" & "Welding metallurgy and weldability of materials" in GLA University, Mathura in a five days short term course in advanced materials, processing & their future prospects" during 17 -21st April, 2019.





Dr. Navneet Singh Randhawa
Sr. Technical Officer

- Delivered an invited talk on "Endeavor to develop environmental-friendly processes for manganese ferroalloys production" presented at Indian Institute of Engineering, Science & Technology (IIEST), Shibpur in "National Seminar On Green Initiatives for Metallurgical Industries in India (GIMII 2019)", organized by Department of Metallurgy and Materials Engineering, IIEST Shibpur & Corporate Monitor on 11th September 2019.
- Delivered an invited talk on "Endeavors to improve energy efficiency towards environmental-friendly production of manganese ferroalloys by CSIR-NML, Jamshedpur" presented at The Lalit, New Delhi in "Steel Technology Festival 2020", organized by Metalogic on 21st January 2020.



Dr. Sandeep Ghosh Chowdhury
Chief Scientist

- Delivered an invited talk in 12th Asia-Pacific Microscopy Conference (APMC-2020), Hyderabad International Convention Centre.



Dr. Vikas Chandra Srivastava
Principal Scientist

- Delivered an invited talk on "Advanced Manufacturing of metals and Alloys" during a seminar on 'Sustainable Growth of MSMEs' held at Engineering Export Promotion Council (EEPC) Kolkata on 24th June 2019.
- Delivered an invited talk on "Bulk materials using layer-by-layer deposition of liquid droplets' during International Symposium of Metastable, Amorphous and Nanostructured Materials (ISMANAM 2019) held at Chennai during 08-12th July 2019.
- Delivered an invited talk on "Steel development activities at CSIR-NML: An overview" and chaired a session during Gleeble Users' Workshop in India (GUWI 2019) held at Coimbatore during 26 -27th September 2019 aired a session.
- Delivered an invited talk on "Additive Manufacturing" during TEQIP-III short Term Course on 'Machines and Machanism' held during 17-22nd June 2019 at NIT Jamshedpur.
- Delivered an invited talk on "Additive Manufacturing: Role in Product Development" and chaired a session in two day IIF sponsored seminar on "Challenges and Opportunities in Foundry Industries" held at Jamshedpur during 10-11th January 2020.



Dr. Jagannath Pal
Sr. Principal Scientist

- Delivered invited lectures in course work on, "Indian Iron & Steel Technologies : Challenges and Remedies" at National Institute of technology, Durgapur, 9-13th December, 2019.

  Topics :

  (i) Sintering of iron ore fines, (ii) Some recent development in agglomeration, (iii) Pelletization of iron ore fines, (iv) Mechanism and kinetics of Iron ore reduction
- Delivered invited lecture in Workshop on "Advances In Agglomeration Of Industrial Wastes and Sludge: Present Prospects and Future Trends'' Tata Steel, Jamshedpur, 12 -14th August 2019.

  Topic : Novel agglomeration technique for utilization of waste iron oxide fines in BOF steel making.



Dr. Sital Kumar Pal
Sr. Principal Scientist

- "Setting up Intellectual Property Facilitation Centre at CSIR-NML - Opportunities for MSME in the Workshop on Technopreneurship and Skilling: Opportunities and Challenge for Metal Sectors organized by IIM, Jamshedpur at Centre for Excellence, XLRI, Jamshedpur on 10th February 2020.
- "Export Marketing of Metal Crafts -Role of Intellectual Property Rights" in the workshop on Management Development Programme on Export Marketing of Metal Crafts Organized by CSIR-NML & MSME Development Institute, Ranchi on 16-20th December 2019.
- "Importance of IPRs and challenges faced in Academia / Research Institution" in the workshop on IPR Awareness, Practice and Challenges in Academia at IIEST-Shibpur on 6-7th November 2019.



Dr. Abhilash
Principal Scientist

- Invited Speaker at "23rd International Conference on Nonferrous Minerals and Metals (ICNFMM 2019), Kolkata (5-7th July 2019) (Topic: Nonferrous Wastes for addressing critical elements).





- Invited Speaker at "National Conference on Science and Technology for Rare Earth Applications (STAR 2019), BARC, Mumbai (5-7th Dec 2019) (Topic: Interdisciplinary methods for extraction of REEs from secondaries).
- Invited Speaker at "International Seminar on Mineral Processing Technology (MPT 2019), Hyderabad (16-18th Dec 2019) (Topic: Microbial beneficiation of mineral and metallurgical wastes).



Dr. Raghuvir Singh
Sr. Principal Scientist

- Delivered lecture on "Metallurgical Corrosion" during One day seminar on 'Corrosion prevention control program (CPCP)' organized by 11 BRD, Nasik, Indian Air Force held on 3rd May 2019 at Nasik.
- Delivered lecture on "Flow assisted corrosion and its implications on water injection pipe line in oil and gas industries" during short term course on "Protection of On-Shore and Off-Shore Facilities against Corrosion in the Coastal Region" organized by IIMT Bhubaneswar and IOC held during 20-24th January 2020 at Bhubaneswar.
- Delivered lecture on "Development of surface pre-treatments to increase corrosion resistance of AZ91 magnesium alloy" Sixth Asian Conference & Expo on Heat Treatment and Surface Engineering (6ACHTSE 2020) organized by ASM International Chennai Chapter in association with International Federation of Heat Treatment and Surface Engineering (IFHTSE) held during 5-7th March 2020 at Chennai Trade Centre, Chennai.



Dr. T. V. Vijay Kumar
Sr. Principal Scientist

- Delivered keynote address on "Indigenization and development of column flotation technology at CSIR - NML Madras Centre" on 18th December 2019 in XVIII Mineral Processing Technology Conference held at Hyderabad between 16 - 18th December 2019.



Dr. Manis Kumar Jha
Sr. Principal Scientist

- Delivered a Keynote Lecture on the topic " E-waste: Status, Prospects and Contribution of CSIR-NML, India" during 12 to 14th December 2019 at BCSIR Congress 2019, Bangladesh [Sponsored by Bangladesh Govt.].
- Delivered an invited lecture on the topic " Developed processes for the recovery of rare earth metals (REMs) from primary and secondary resources at CSIR-NML, India" at National Conference on Science, Technology and Applications of Rare Earths held during 5 to 7th December 2019 at DAE Convention Centre, BARC, Mumbai.



Dr. Pankaj Kumar Choubey
Research Associate

- Delivered an invited Lecture on the topic E-waste at LBSM College, Jamshedpur on 5th March 2020.

HUMAN RESOURCES



1486, Indian States Gold Fanams (2) Cochin - Hoysala 14th Century Vira Raya type, 0.39 grammes NVF, Mysore Haider-'Alli 1761-1782 Mitchener 971a 0.29 grammes VF



One Fanam (Gold) 0.39 grammar



India Gold Fanam Hoysalas, Karnataka, Malabar Coast (14th to 18th Century) 0.38 grammes

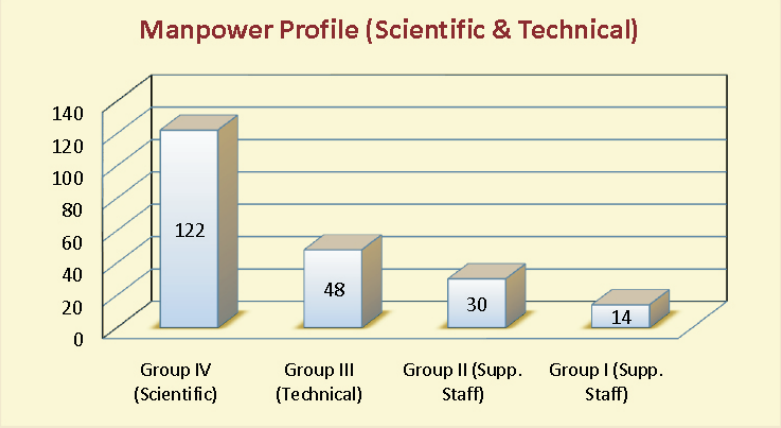
Fanam : Lightest & Smallest Coins

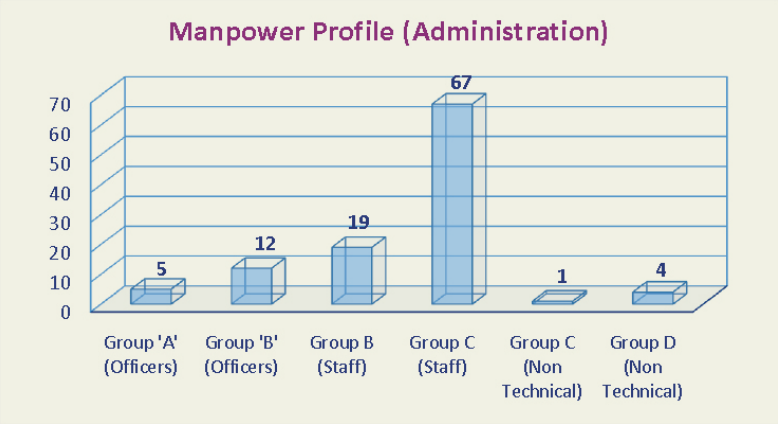
The 'fanam' was a small coin used in south India between the 9th and 19th centuries. These small gold coins weighed as little as 0.3 grams and had a diameter of less than a centimetre. India was thus home to some of the largest and smallest gold coins in the world !

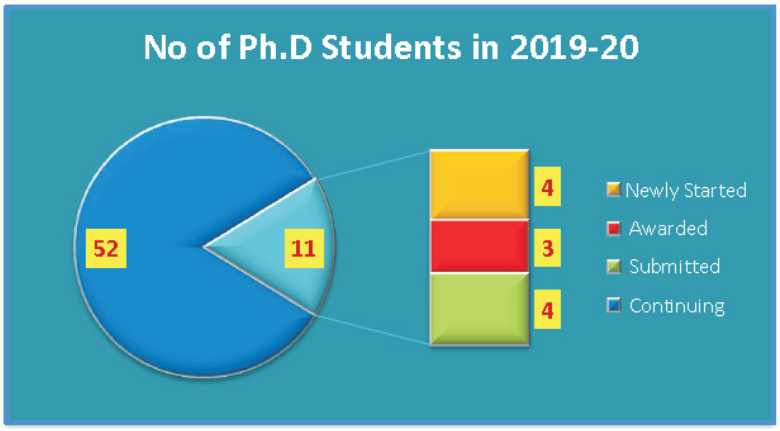
Source: https://coins.lakdiva.org/medievalindian/hoysalas_fanam_au.html

Human Resources

Current Staff Profile :







Employee(s) Superannuated

We are thankful for their inspirational services provided to the laboratory in their own capacities



Mr. Kali Ram
Multi Tasking Staff
30th April 2019



Mr. Arvindan
Multi Tasking Staff
31st May 2019



Dr. Suchandan K. Das
Chief Scientist
31st May 2019



Mr. Rajesh K. Jha
Multi Tasking Staff
31st May 2019



Mr. Ganesh Sharma
Lab Assistant
31st July 2019



Dr. D. Bandyopadhyay
Chief Scientist
31st July 2019



Mr. P. K. Sharma
Multi Tasking Staff
31st August 2019



Mr. I. Raja Rao
Multi Tasking Staff
31st August 2019



Dr. Amitava Mitra
Chief Scientist
30th September 2019



Mr. R. K. Minj
Chief Scientist
30th September 2019



Mr. Eshwar Rao
Multi Tasking Staff
30th September 2019



Mr. Narayan
Multi Tasking Staff
30th October 2019



Mr. S. A.Akhatar Ali
Lab Assistant
31st December 2019



Mr. Asish Kumar Datta
Chief Scientist
31st December 2019



Dr. S. K. Mandal
Chief Scientist
31st January 2020



Ms. Fromcy Jacob
Principal Technical Officer
31st January 2020



Mr. Y. C. Machua
Multi Tasking Staff
31st January 2020



Mr. S. K. Bhattacharjee
Lab Assistant
31st January 2020



Mrs. Shahnaz Begum
Multi Tasking Staff
31st January 2020



Dr. Swapan Kumar Das
Senior Principal Scientist
29th February 2020

Staff Transferred

Our best wishes for your new endeavours in the new work place...



Mr. Sanatan Naiya
Senior Technician
CSIR-CGCRI, Kolkata in 2019



Mr. A. K. Nigam
Assistant Section Officer
IITR, Lucknow in 2019

New Entrants

We are looking forward to have a mutually rewarding and long-lasting association with the new entrants in 2019-20...



Shri Gaurav Bansal
Scientist
20th June 2019



Ms. Rashmi Singla
Scientist
9th July 2019



Dr. S. K. Pradhan
Scientist
8th August 2019



Ms. Kumari Ruby
Scientist
19th August 2019



Dr. Priyanka Singh
Res. Medical Officer
19th August 2019



Ms. Ajita Kumari
Scientist
27th August 2019



Mr. Roshan Kumar
Scientist
10th December 2019



Dr. Naveena
Senior Scientist
7th January 2020



Dr. Pallab Bhattacharya
Senior Scientist
7th January 2020



Dr. Atanu Das
Senior Scientist
9th January 2020

Sad Demise of Staff



Mr. Amber Tirkey
Section Officer
17th October 1994 to
3rd June 2019



Mr. Manish Sharma
Senior Technical Officer
9th April 2001 to
25th August 2019



Mr. G. Shailendra Kumar
Senior Technician
28th September 1984 to
23rd September 2019



Dr. (Mrs.) Suprabha Nayar
Senior Principal Scientist
1st June 2004 to
23rd November 2019

Professional Training Organized

4R waste 2019 (25th to 27th November 2019)

A three-day training program on recycling and reuse of wastes was organized by CSIR-NML. The 4R waste 2019 focused on imparting tutorial and hands-on training in the matters of waste utilization and recycling of tailings, scrap, mud, electronic wastes, etc. Dr. Lakshmi Raghupathy, Ex-Director MoEF elaborated on the need for the waste management. 32 delegates, from different premier institutes and industries, took part in the event.



















Experimental Techniques in Iron and Steel making (ETIS 2019) (10th -13th December 2019)

CSIR-NML organized a 4-day training program in the field of Iron and steel making. The objective of the training program was to impart knowledge to the participants to enhance their skills. The training program included classroom lectures followed by hands-on training with sophisticated instruments.









Metallurgical Failure of Engineering Components: Diagnosis & Remedies (21st - 24th January 2020)

A 4 days training program on metallurgical failure analysis of engineering components was conducted. The prime objective of the training was to impart knowledge to the participants so as to enable them to understand the failure mechanism of engineering components and preventive methods. Delegates from different organizations participated in this program.









THE AVENUE MAIL

JAMSHEDPUR • WEDNESDAY, JANUARY 22, 2020 • VOL : 27 NO : 210 • www.av

Training programme on Metallurgical Failure kicks off at NML

Mail News Service

Jamshedpur, Jan. 21: The Professional Training Programme on Metallurgical Failure of Engineering Components: Diagnosis & Remedy (MFEC 2020) organised by CSIR-National Metallurgical Laboratory was inaugurated by SoumitraTarafder, acting director & advisor management, CSIR-NML, Jamshedpur.

Dr. Tarafder welcomed the participants and appreciated delegates for coming to CSIR-NML to attend this four-day professional training programme. He mentioned that it's a good opportunity for the delegates to interact with the scientists and carry out collaboration programme for R&D activities in future. He went on to say that the importance of failure analysis in engineering domain and also emphasized having basic knowledge in different areas like chemistry and mechanical helps to understand the failure mechanism.

MitaTarafder, Head of RPBD (Research Planning & Business Development) division of CSIR-NML was delivering on the importance of training programme which was not only for enhancing knowledge but for developing interactions between R & D laboratory, industry & academics. She presented briefly about CSIR and different training programs offered by CSIR-NML which are society and industry oriented. She also talked about the state of the art facilities and services, CSIR-NML is providing and encouraged the delegates to explore the laboratory.



Mainak Ghosh, Principal Scientist of MTE (Materials Engineering) division of CSIR-NML and coordinator of this training programme named various technical sessions of this programme which includes lectures and hands-on sessions followed by laboratory visit. The Inaugural programme was concluded after the introduction of participants. Each participant expressed their interest and expectations from this training program. Delegates from different organizations such as Tata Steel Ltd., Jamshedpur; Siddhartha Spectro, New Delhi; Indian Oil Corporation Ltd., Panipat and BPCL, Kochi participated in the programme.

The valedictory programme of Metallurgical Failure of Engineering Components: Diagnosis & Remedy (MFEC 2020) will be conducted on January 24. The participants will be given the certificates of participation and each participant will give presentation, summarizing their learning.

Deputation

Person	Place	From	To	Purpose
 Dr. Indranil Chattoraj, Director	Germany	4th March 2019	7th March 2019	As a part of a delegation led by DG, CSIR to a few Fraunhofer institutes, to discuss mutual interests and collaborations in research.
	Adis Ababa, Ethiopia	14th Sept. 2019	18th Sept. 2019	For attending APEX meeting related to Twinning Program with MIDI, Ethiopia.
 Dr. Abhilash, Principal Scientist	Hanover, Germany	1st March 2019	2nd July 2019	To avail Raman Research Fellowship.
 Dr. Ashis Kr. Panda, Principal Scientist	Moscow, Russia	8th June 2019	15th June 2019	Visit under Bilateral Research project (DST-RFBR).
 Dr. Amitava Mitra, Chief Scientist	Moscow, Russia	8th June 2019	15th June 2019	Visit under Bilateral Research project (DST-RFBR).
 Dr. V. C. Srivastava, Sr. Principal Scientist	MIDI, Adis Ababa, Ethiopia	2nd August 2019	31st August 2019	To work on their respective assignments with respect to the Twinning Program between MIDI and CSIR-NML.

 Dr. Gopi Kishor Mandal, Principal Scientist	MIDI, Adis Ababa, Ethiopia	2nd August 2019	31st August 2019	To work on their respective assignments with respect to the Twinning Program between MIDI and CSIR-NML.
 Mr. A. K. Chandan, Scientist	Borlange, Sweden & Budapest Hungary	23rd August 2019	12th Sept. 2019	To attend Summer Colloquium & Departmental Seminar.
 Dr. Pratima Meshram, Senior Scientist	Lappeenranta, Finland	3rd August 2019	5th October 2019	As a part of in Indo-Finland Bilateral mobility program
 Mr. Abhishek Kumar, Scientist	Johannesberg, South Africa	9th August 2019	3rd Nov. 2019	To attend 5th NAM S&T Centre-DST (South Africa) training.
 Ms. Aarti Kumari, Scientist	Bagnol-sur-Ceze, France	13th Sept. 2019	30th Sept. 2019	For activities related to Indo-French Project.

 Dr. Swapan Kumar Das, Sr. Principal Scientist	Adis Ababa, Ethiopia	14th Sept. 2019	18th Sept. 2019	For attending meeting related to Twinning Program with MIDI, Ethiopia.
 Ms. Rekha Panda, SRF	San Diego, California, USA	21st February 2020	28th February 2020	TMS 149th Annual Meeting.

Person	Place	From	To	Purpose
Dr. B. Ravi Kumar, Senior Principal Scientist Sarmistha Palit Sagar, Senior Principal Scientist	DRDO, Kanpur	4th March 2019	4th June 2019	To participate in National Seminar on "Advanced Materials and Materials Technology for Prototypes & Systems".
Mr. AP Murugesan, Senior Scientist Dr. Tipu Kumar, Senior Technical Officer	IIM & RINL, Vizag	4th April 2019	4th May 2019	To participate in National Seminar on "Technological Advancements and Developments of New Grades in Long Products (Prolong 2019)".
Dr. Rajneesh Kr. Gupta, Principal Scientist	GLA University, Mathura	17th April 2019	21st April 2019	To deliver a lecture on "Advanced Materials, Processing & their Future Prospects"
Dr. Paras Nath Mishra, Principal Scientist	CSIR-HRDG, Ghaziabad	29th April 2019	30th April 2019	To attend training programme on "Effective Implementation of RTI Act and Record Management".
Mr. R. R. Srivastava, Senior Technical Officer	CSIR-HRDC, Ghaziabad	29th May 2019	31st May 2019	To participate in training program on managerial effectiveness for technical officers
Mr. L. K. Meena, Scientist	IIT-Kharagpur	20th May 2019	22nd May 2019	To attend a course on Non-destructive testing of failure analysis and prevention.
Dr. Rajat Kumar Roy, Principal Scientist	Ranchi, Jharkhand	20th June 2019	21st June 2019	To participate in Conference and Exhibition in "Advancement of Welding & NDT"

Ms. Rima Dey, Research Associate	Bordeaux, France	21st June 2019	27th June 2019	To participate in Conference.
Dr. Sanjay Prasad, Principal Scientist Dr. Pratima Meshram, Senior Scientist Mr. Saurabh Shekhar, Scientist Dr. N. S. Randhawa, Senior Technical Officer	Kolkata	12th July 2019	13th July 2019	To attend an International Conference on "Non-Ferrous Minerals & Metals - ICNFMM 2019)" jointly organized by Corporate Monitor & CGCRI, Kolkata.
Mr. Premkumar M., Scientist Dr. V. C. Srivastava, Senior Principal Scientist Dr. Ashish Kumar Panda, Principal Scientist	Madras	8th July 2019	12th July 2019	To attend an International Symposium on "Metastable, Amorphous and Nanostructured Materials (ISMANAM 2019)" organized by Department of Metallurgical and Materials Engineering, IIT Madras.
Dr. Rajendra Kumar Rath, Senior Principal Scientist Dr. Sanjay Prasad, Principal Scientist Mr. Shivendra Sinha, Scientist Mr. Saurabh Shekhar, Scientist	Bangalore	4th July 2019	5th July 2019	To participate in the Conference on the "Advances in Process Metallurgy (APM 2019)" jointly organized by Indian Institute of Science, Bangalore, IIM & IIME Bangalore Chapter.
Dr. Ganesh Chailavadi, Scientist Dr. N. S. Randhawa, Senior Technical Officer Mr. Ashok K, Scientist	Bangalore	4th July 2019	5th July 2019	To participate in the Conference on the "Advances in Process Metallurgy (APM 2019)" jointly organized by Indian Institute of Science, Bangalore, IIM & IIME Bangalore Chapter.
Mr. Shivam Kumar, Senior Research Fellow	Hyderabad	8th July 2019	13th July 2019	To attend GIAN course on "Integrated Computational Materials Engineering for Metals" organized by IIT Hyderabad

Dr. Sushanta Kumar Nath, Senior Scientist Mr. K. Sudhakara Rao, Technical Officer	Ghaziabad	8th July 2019	10th July 2019	To attend a training on "New Paradigm in Technology Transfer and Commercialization" organized by CSIR-HRDC, Ghaziabad.
Dr. N. S. Randhawa, Senior Technical Officer	Kolkata	11-07-2019 2019	11-07-2019 2019	To attend special session on "Refractories & Raw Materials for the Non-Ferrous Industry" connected To 23rd ICNFMM 2019.
Ms. Soni, Project Assistant	Jaipur	1st July 2019	5th July 2019	To attend GIAN course on "Protective coatings: low friction, wear and corrosion" organized by MHRD, Govt. of India at Materials Research Centre, Malviya National Institute of Technology, Jaipur
Dr. Vinod Kumar, Principal Technical Officer Dr. Sanchita Chakravarty, Senior Principal Scientist	Jamshedpur	15th July 2019	20th July 2019	To deliver a lecture and to attend National Workshop on "Advancement in Minerals Processing Techniques with Special Reference To Iron and coal (AMPTIC-2019)" organized by NIT Jamshedpur
Mr. Kumar Rahul, Section Officer Mr. Amod Kumar, Assistant Section Officer	New Delhi	15th July 2019	19th July 2019	To attend training on "Establishment Rule -1 " organized by The Institute of Secretariat Training & Management, New Delhi.
Mr. Anuj Mohan Pradhan, FAO	Bhubaneshwar	12th July 2019	14th July 2019	To participate in National Conference on "Revitalization of Indigenous Languages" at Kalinga Institute of Social Sciences, Bhubaneshwar
Mr. Shivendra Sinha, Scientist Mr. Rajnikant Choudhary, Technical Assistant Dr. Abhilash, Principal Scientist	Kolkata	12th July 2019	13th July 2019	To attend an International Conference on "Non-Ferrous Minerals & Metals - ICNFMM 2019)" jointly organized by Corporate Monitor & CGCRI, Kolkata
Mr. Nalin Kumar Singh, Stores & Purchase Officer Dr. Sital Kumar Pal, Senior Principal Scientist Dr. Raghuvir Singh, Senior Principal Scientist	CSIR-CDRI, Lucknow	19th August 2019	23rd August 2019	To take part in a training program on "New CSIR Manual Procurement of Goods, 2019"

Dr. Thomas C Alex, Senior Principal Scientist	FICCI Federation house, New Delhi	27th August 2019	27th August 2019	To speak and promote awareness and usage of Iron & Steel Slag.
Mrs. Aarti Kumari, Scientist	NIFFT, Ranchi	28th August 2019	29th August 2019	To deliver a lecture on "Entrepreneurship development on E-waste Collection & Deconstruction".
Dr. Krishnendu Mukherjee, Principal Scientist Dr. Sheuli Hore, Principal Scientist Mr. Biraj Kumar Sahoo, Scientist Mr. Om Shankar Dhinkar, Project Assistant Dr. Pankaj Kumar Choubey, Research Associate	NIT-Jamshedpur	30th August 2019	31st August 2019	To take part in National conference on "Advancement in Materials Processing Techniques (AMPT-2019)"
Mr. Shiva Dandiya, Project Assistant Ms. Sweta Verma, Project Assistant	NIT-Jamshedpur	30th August 2019	31st August 2019	To participate in National conference on "Advancement in Materials Processing Techniques (AMPT-2019)".
Dr. Trilochan Mishra, Principal Scientist Mr. Anuj Mohan Pradhan, Finance & Account Officer Mr. Laxmi Narayan Singh, Section Officer	CSIR-CDRI, Lucknow	19th August 2019	23rd August 2019	To take part in a training program on "New CSIR Manual Procurement of Goods 2019".
Mr. Anand Bharti, Section Officer Mr. Amarendra Kumar, Section Officer Mr. Paul Deepak Lakra, Section Officer	CSIR-CDRI, Lucknow	19th August 2019	23rd August 2019	To take part in a training program on "New CSIR Manual Procurement of Goods 2019".

Mr. Ramana Raju, Assistant Section Officer Mr. D. A. Srivastava, Assistant Section Officer Mr. Ved Prakash, Assistant Section Officer	CSIR-CDRI, Lucknow	19th August 2019	23rd August 2019	To take part in a training program on "New CSIR Manual on Procurement of Goods, 2019".
Mr. Neeraj Mehta, Jr. Steno Mr. Sital Ram Murmu, Jr. Secretariat Assistant	CGRCI, Kolkata	29th August 2019	30th August 2019	To attend ERP Zonal Workshop.
Dr. Suman Kumari Mishra, Chief Scientist Dr. Ashok Kr. Mohanty, Principal Scientist Mr. Surla Ramesh, Scientist Dr. S. Sivaprasad, Senior Principal Scientist	Hyderabad	23rd Sept. 2019	25th Sept. 2019	For attending International Conference on "Advance Materials for Defense Technology (ADMAT 2019), Hyderabad".
Mr. Arun Kumar, Project Assistant Mr. S Ranga Pandu, Project Assistant Mr. Somnath Das, Project Assistant Mr. Manish Kumar, Project Assistant	CSIR-NML, Jamshedpur	5th Sept. 2019	6th Sept. 2019	For attending Students Seminar “Behind the Teachers Desk (BTTD 2019)” .
Ms. Soni Jha, Project Assistant Ms. Priti Sharma, Project Assistant Ms. Kumari Richa Rao, Project Assistant Ms. Bhawna, Project Assistant Ms. Sneha Kumari, Project Assistant	Bhopal	19th Sept. 2019	21st Sept. 2019	For attending brainstorming session on Water by NASI-Bhopal Chapter.

Mr. Raj Kr. Vishwakarma, Project Assistant Mr. Somnath Das, Project Assistant Ms. Siuli Dutta, CSIR-Sr. Research Fellow Mr. Alok Kumar, Project Assistant Mr. Abhinav Raj, Project Assistant Ms. Minati K. Sahu, Senior Research Fellow	CSIR-NML, Jamshedpur	20th Sept. 2019	20th Sept. 2019	For attending Symposium on "Non-Destructive evaluation & Magnetic materials (NDEMM)".
Mr. Ashok K, Scientist	Kolkata	19th Sept. 2019	19th Sept. 2019	For delivering a talk on "Innovative Technology for Production and Processing of Iron & Steel To Remain Competitive & Sustainable"
Dr. Gopi Kishor Mandal, Principal Scientist Mr. Mahesh Gulab Walunj, Scientist Dr. Lokesh Ch. Pathak, Chief Scientist	New Delhi	18th Sept. 2019	21st Sept. 2019	For attending 3rd International Galvanizing Conference.
Mr. P. S. Manoranjan Jena, GATE-JRF Mr. Rupendra Singh Mr. Rajpurohit, Nehru Doctoral Research Fellow	IIT, Kharagpur	20th Sept. 2019	20th Sept. 2019	For attending one day Workshop on "Metallography".
Mr. Tipu Kumar, Senior Technical Officer Mr. V Rajnikant, Principal Scientist	Coimbatore	26th Sept. 2019	27th Sept. 2019	For attending Gleeble User Workshop of India, and National Conference on "Physical Simulation of Thermo-Mechanical Processing of Materials".
Dr. N. S. Randhawa, Senior Technical Officer	IIEST, Shibpur, Howrah	11th Sept. 2019	11th Sept. 2019	For attending National Seminar on "Green Initiative for Metallurgical Industries in India (GIMI 2019)".

Ms. Swapna Dey, Principal Investigator	Bikaner, Rajasthan	14th October 2019	15th October 2019	To participate in 3rd International Conference on "Condensed Matter and Applied Physics (ICC 2019)".
Mr. AP Murugesan, Senior Scientist Mr. Gaurav Kumar Bansal, Scientist	Tata steel, Jamshedpur	17th October 2019	18th October 2019	To take part in a Workshop on “Special Steels: Physical Metallurgy, Processing and Applications”.
Mr. Krishna Kumar, Scientist	DMRL, Hyderabad	17th October 2019	19th October 2019	To deliver a lecture during one day National Workshop on “Magnesium Indigenous Technologies for Metal Production”.
Dr. Pankaj Kumar Choubey, Research Associate Mr. Rahul Kumar, Project Assistant Ms. Sweta Verma, Junior Research Fellow	ITER, Bhubaneshwar	30th October 2019	30th October 2019	To participate in the National Conference on "Trends in Mineral & Materials Technology".
Dr. Sharma Paswan, Senior Scientist	Hyderabad	30th October 2019	30th October 2019	To deliver a talk in the National Conference on "Advanced Ultra Super Critical Technology".
Dr. Sanghita Mridha, Research Associate	CSIR-CMERI, Durgapur	7th Nov. 2019	7th Nov. 2019	To participate in a Workshop on "Artificial Intelligence in Industry 4.0".
Dr. B. Ravi Kumar, Senior Principal Scientist	Thiruvantha-puram	11th Nov. 2019	18th Nov. 2019	To deliver a lecture at National Metallurgist Day (NMD)-Annual Technical Meeting (ATM) 2019.
Dr. Ratnakar Singh, Chief Scientist Dr. Shobana Dey, Senior Principal Scientist Mr. Abhishek Kumar, Scientist	India Habitat Centre, New Delhi	13th Nov. 2019	15th Nov. 2019	As a speaker at XIXth International Coal Preparation Congress & Expo 2019.
Dr. Sabita Ghosh, Principal Investigator Mr. Ashok K, Scientist Mr. Saurabh Shekhar, Scientist Mr. Ammasi A, Scientist	Thiruvantha-puram	13th Nov. 2019	16th Nov. 2019	To deliver a lecture at NMD-ATM 2019.

Dr. S. Sivaprasad, Senior Principal Scientist Dr. R. S. Rajpurohit, Nehru PDF	Thiruvantha-puram	14th Nov. 2019	16th Nov. 2019	To take part in NMD-ATM 2019.
Dr. K. Gopala Krishna, Senior Principal Scientist Dr. Md. Murtuja Hussain, Senior Scientist	IIW, Jamshedpur	29th Nov. 2019	29th Nov. 2019	To speak at Annual Welding Seminar 2019 on "Maintenance, Repair and Reclamation of Components by Welding".
Ms. Soni Jha, Project Assitant	Banaras Hindu University, Varanasi	29th Nov. 2019	30th Nov. 2019	To participate in the National Symposium on "Contemporary Trends and Future Prospects of Functional Materials".
Mr. Uttam Kumar Jha, Section Officer (G)	CSIR-HRDC, Ghaziabad	2nd Dec. 2019	7th Dec. 2019	To attend training program on taxation laws: "Direct and Indirect Taxes".
Dr. Sarmistha Palit Sagar, Senior Principal Scientist Dr. Tarun Kumar Das, Principal Scientist Dr. Arpita Ghosh, Principal Scientist Mr. Avijit Kumar Metya, Senior Scientist Mr. Alok Kumar, Project Assistant Dr. Abhilash, Principal Scientist Dr. Pratima Meshram, Senior Scientist	Bengaluru	5th Dec. 2019	7th Dec. 2019	To take part in the Conference & Exhibition on Non-Destructive Evaluation: NDE-2019.
Mrs. Aarti Kumari, Scientist	DAE, BARC-Mumbai	5th Dec. 2019	7th Dec. 2019	To participate as speakers in the National Conference on "Science, Technology & Applications of Rare Earths (STAR) 2019".
Ms. Archana Kumari, Senior Research Fellow Ms. Rukshana Parween, Project Assistant	DAE, BARC-Mumbai	5th Dec. 2019	7th Dec. 2019	To participate as speakers in the National Conference on "Science, Technology & Applications of Rare Earths (STAR) 2019".
Dr. Jagannath Pal, Senior Principal Scientist	NIT-Durgapur	9th Dec. 2019	13th Dec. 2019	To participate as a speaker in a short term course on "Indian Iron & Steel Technologies: Challenges and Remedies (IISTCR)-2019".

Mr. Bhupendra Kumhare, Project Assistant	CSIR-NML, Jamshedpur	10th Dec. 2019	13th Dec. 2019	To participate in Experimental Techniques in Iron & Steel making (ETIS 2019).
Dr. Manoj Kr. Mohanta, Senior Principal Scientist Dr. A. Vidyadhar, Principal Scientist Dr. Abhilash, Principal Scientist Dr. Pratima Meshram, Senior Scientist Mr. Ranjeet Kumar Singh, Senior Scientist	IIME Hyderabad	16th Dec. 2019	18th Dec. 2019	To take part in the XVIII Conference on "Mineral Processing Technology".
Mr. Shivendra Sinha, Scientist Dr. Ganesh Chalavadi, Scientist Mr. Abhishek Mohapatra, Project Assistant	IIME Hyderabad	16th Dec. 2019	18th Dec. 2019	To take part in the XVIII Conference on "Mineral Processing Technology".
Dr. Sanjay Agarwal, Principal Scientist	Visakhapatnam	19th Dec. 2019	20th Dec. 2019	To participate as a speaker in a Summit on "Manganese and Chrome ores and Ferro-alloys 2019".
Mr. Avanish Kr. Chandan, Scientist Mr. P.S. Manoranjan Jena, GATE-JRF	IIT-Delhi	23rd Dec. 2019	27th Dec. 2019	To attend GIAN course on "Atomistic Simulations of Materials".
Mr. Ashok Kumar K, Scientist	NIT-Tiruchirappalli	27th Dec. 2019	28th Dec. 2019	As a speaker in the International Conference on "Recent Trends in Metallurgy, Materials Science and Manufacturing (IMME 2019)".
Dr. Pankaj Kumar Choubey, Research Associate	College of Engineering, Pune	3rd January 2020	4th January 2020	To take part in the conference entitled "Opportunities and Challenges in Materials for Energy Generation and Storage for Electric Vehicles".
Dr. Mita Tarafder, Chief Scientist Dr. K Gopala Krishna, Senior Principal Scientist Dr. Sanghita Mridha, Research Associate	Indian Science Congress, Bangalore	3rd January 2020	7th January 2020	To participate in the 107th Indian Science Congress 2020.

Dr. A. K. Mohanty, Principal Scientist	Jamshedpur	15th January 2020	18th January 2020	To participate in the NABL Internal Auditor Training.
Dr. N. S. Randhawa, Senior Technical Officer	New Delhi	21st January 2020	21st January 2020	To speak in the "Steel Technology Festival-2020".
Dr. N. S. Randhawa, Senior Technical Officer	BARC, Mumbai	28th January 2020	1st February 2020	To particiapte in the 22nd DAE-BRNS Workshop & Symposium on thermal analysis (THERMANS-2020).
Dr. S. K. Mishra, Chief Scientist Mr. Premkumar M, Scientist Mr. P. S. Manoranjan, Research Fellow	Hyderabad	3rd February 2020	7th February 2020	To take part in the Asia-Pacific Microscopy Conference (APMC-2020).
Dr. Ashok K, Scientist Mr. A Ammasi, Scientist	Jamshedpur	6th February 202	7th February 2020	To talk about their work at International conference on Steel Making and Casting Sustainable Technology and Practices.
Dr. Rajneesh Kr. Gupta, Principal Scientist Mr. Uday Bhaskara Rao, Senior Scientist	Navi Mumbai	6th February 2020	8th February 2020	To participate in International Congress (IC 2020) on "Advanced Welding Technology & Quality Systems for Developing Economies".
Dr. Mita Tarafder, Chief Scientist Dr. Ashok K, Scientist Dr. Sangita Mridha, Research Associate	Jamshedpur	10th February 2020	10th February 2020	To attend one day Workshop by Indian Institute of Metals, Jamshedpur Chapter on Technopreneurship and Skilling: Opportunities and challenges for metal sector".
Mr. Ajoy Puran, Senior Technician Mr. Binod Kalindi, Technician	New Delhi	10th February 2020	21st February 2020	To participate in 14th capacity building program for technical personnel.

Mr. Roshan Kumar, Scientist Dr. Nimai Halder, Senior Technical Officer Mr. Manoj Kumar, Senior Technician Mr. Dilip Kumar Sumbrui, Senior Technician	CSIR-CMERI, Durgapur	12th February 2020	14th February 2020	To take part in Transfer of Technology on Metrology.
Mr. Avijit Kumar Metya, Senior Scienist, Mr. Amit Beung, Project Assistant Mr. Rahul Chauhan, Project Assistant	CSIR-SERC, Chennai	19th February 2020	21st February 2020	To participate in advanced course on fatigue and fracture behaviour of structures and structural components.
Mr. Shivendra Sinha, Scientist Mr. Saurabh Shekhar, Scientist	IIT-BHU, Varanasi	22nd February 2020	23rd February 2020	To take part in International Conference on "Management and Recycling of Metallurgical Wastes (MetWaste-2020)".
Dr. A. M. Pradhan, Finance & Accounts Officer	Sahitya Academy, New Delhi	24th February 2020	26th February 2020	To talk about his work at the Tribal Writers Meet.
Mr. K. Sudhakara Rao, Technical Officer	RGNIIPM, Nagpur	2rd March 2020	6th March 2020	To avail training in the area of Intellectual Property Rights (IPR).
Dr. Raghuvir Singh, Senior Principal Scientist	Chennai Trade Centre, Chennai	5th March 2020	7th March 2020	To attend Heat Treatment and Surface Engineering -Expo 2020 organized by ASM International Chennai Chapter.

INTERACTIONS & CELEBRATIONS

One and Two Mohur Coins of British India



1862 One Mohur



1835 Two Mohur[nb 1]















India's Coinage : Remarkable Diversity

Mohurs, Rupees, Koris, Hons, Pagodas, Fanams, Kasu, Larins, Jitals, Cruzados, Pounds Sterling are a few of the myriad denominations prevalent in various parts of the country.

Source: https://en.wikipedia.org/wiki/Mohur

Distinguished Visitors

Speaker	Date	Topic	
Dr. Madhumanti Bhattacharyya, *PhD, McMaster University*	23rd April 2019	*"Grain Growth in High Manganese Steels"*	
Mr. Sanjay Choudhary, Administrator, *properties Jamshedpur Blood Bank of blood and blood donation".*	16th May 2019	*"Generic information about*	
Dr. Priti Singhania, MBBS, MD (Internal Medicine), DM (Cardiology), Consultant, Brahmananda Narayana Hrudyalaya, Jamshedpur	7th July 2019	"*Cardiac related issue*".	
Mr. Hitesh Mamgain, Director, India & Middle East, WITec GmbH, Germany	24th July 2019	*"Optimisation of instrumentation for a highly efficient RAMAN Imaging & spectroscopic techniques such as RAMAN and Photoluminescence with surface techniques such as AFM & SNOM".*	
Dr. BVA Patnaik, Scientist G, GTRE-Bangalore	2nd August 2019	*"Life estimation and Monitoring of Gas Turbine Components".*	
Prof. B. K. Gandhi, Head, Dept. of Mechanical and Industrial Engineering, IIT-Roorkee	5th August 2019	*"Slurry Transportation : Centrifugal Pump Performance and Erosion".*	
Dr. Tapabrata Maity, Postdoc Scientist, Arizona State University, Past-Erich Schimd Institute of Materials Science, Austria	8th August 2019	*"Deformation behavior and the Origin of strain accommodation in eutectic high entropy composites (HECs)".*	

Prof. Partha Protim Chattopadhyay, Director, NIFFT-Ranchi	23rd August 2019	*"Pursuit of Need".*	
Prof. Karabi Das, IIT, Kharagpur	24th September 2019	*"Functionally Gradient Composite Coating by Electrochemical Route."*	
Dr. R. K. Satpathy, Scientist, DMRL-Hyderabad	12th October 2019	*"Failure Analysis- A System Approach to Life Revision of Aero engines".*	
Dr. Biswajit Saha, Principal Researcher, Raw Materials Research Group, R & D Tata Steel Limited	6th January 2020	*"Formation and Properties of Carbon Nanostructures : Molecular Modeling Studies".*	
Prof. Surajit Paul, IIT Patna	24th January 2020	*"Failure criteria in sheet metal forming: Flow Limit Diagram (FLD) and Hole Expansion Ration (HER)".*	
Dr. Kinnor Chattopadhyay, Associate Professor & Dean's Catalyst Professor, AIST Foundation Steel Professor, Department of Materials Science & Engineering, University of Toronto, Canada	11th February 2020	*"The Metallurgical Entrepreneur - How Ironmaking Inspired a Battery Recycling Process and a Start Up Venture".*	
Prof. Gour Gopal Roy, Professor & Associate Dean, Indian Institute of Technology, Kharagpur	14th February 2020	*"Inclusion control by Cored Wire Injection in Steel melt".*	

SPECIAL EVENTS

A Vist of DG, CSIR at CSIR-NML (20th -21st of April 2019)

Dr. Shekar C Mande,Director General of CSIR and the Secretary of the Department of Scientific and Industrial Research (DSIR), visited CSIR-NML, Jamshedpur. He interacted with scientific and technical staff of the laboratory and witnessed state of the art technologies at the laboratory. In an inspiring lecture he talked about the CSIR contributions to Indian Science and Society and also laid out the path and milestones for each constituent institute. He congratulated the researchers and encouraged them to do more meaningful work for the social welfare. He also inaugurated the urban ore recycling center in the laboratory.















In-House Fire Safety Training (16th of April 2019)

The training was organized to impart knowledge on basic fire fighting, use of fire extinguishers, prevention of fire at an incipient stage, treatment of burn injuries and usage of fire devices.




44th Meeting of Town Official Language Implementation Committee (TOLIC) Jamshedpur at CSIR-NML (22nd of April 2019)

Government officials from in and around Jamshedpur participated in the meeting and deliberated on promoting the use of official language "Hindi" in government organizations.



Technology Transfer to M/s. Recycle Karo , Mumbai (19th April, 2019)

"Extraction of Precious Metals (Gold, Palladium and Platinum) from metallic concentration of e-waste"



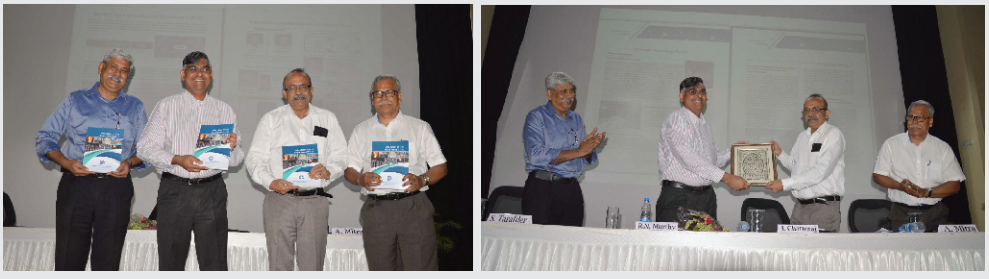
Swachhta Pakhwada (1st - 15th May, 2019)

CSIR-NML observed swachhta pakhwada through different activities to promote cleanliness & sanitation.



National Technology Day Celebration (13th May 2019)

Dr. RN Murthy, Managing Director of Tinplate Company of India, Jamshedpur, graced the function as the Chief guest. During the function, the Annual Report of 2018-19 of CSIR-NML was also released by the dignitaries.



Blood donation camp (17th May 2019)

A blood donation camp was organized at CSIR-NML. The staff of CSIR-NML voluntarily came forward and donated more than 113 units of blood.





MoU Signed with Engineering Export Promotion Council of India, Kolkata on General R&D Collaboration (June 2019)



3-Months' Female Literacy Drive Programme-2019

A 3-months program was organized by CSIR-NML in association with the Central Board for Workers Education (Ministry of Labour & Employment, Govt. of India). The objective of the program was to provide basic education to the female workers of CSIR-NML to enable them to carry out formal procedures efficiently and independently. Around 30 ladies from CSIR-NML took part in this program.





Inauguration on 03rd June 2019





THE AVENUE MAIL
Jamshedpur, Tuesday, June 04, 2019

Educating young women for a better future

Mail News Service

Jamshedpur, June 3 :

दैनिक जागरण
जमशेदपुर जागरण

इन महिलाओं की जिंदगी में अक्षरों ने भरा नया उजाला



Conduction of the Female Literacy Drive





Valedictory Programme – Literacy Drive

MoU signing with Aircraft Accident Investigation Bureau (AAIB), New Delhi (12th July 2019)

Agreement was reached with AAIB for utilising the technical infrastructure, laboratory facilities, technical expertise and availing consultancy services of CSIR-NML.



The MoU was signed by Dr. Indranil Chattoraj, Director, CSIR-NML and Arvindo Handa, Director General, AAIB

hindustantimes

CSIR-NML now to probe civil aircraft failures

THE AVENUE MAIL

NML signs MoU with Aircraft Accident Investigation Bureau

Mail News Service

Jamshedpur, July 12 :

दैनिक जागरण

मान दुर्घटनाओं की जांच में करेंगे सहयोग

दैनिक भास्कर

एनएमएल में विमानन संबंधी समस्याओं पर अब होगा रिसर्च

Independence Day Celebrations 2019

Independence Day was celebrated at CSIR-NML and its residential complexes. Director-NML hoisted the national flag. A number of events were organized to mark the occasion including Sit & Draw, Hindi Poem Competition, Essay Competion, Quiz, and Cultural Programs.








Football Tournament (24th August 2019)





Prof. S N Sinha Memorial Materials and Metallurgy Quiz 2019 (29th August 2019)

CSIR-NML and IIM-Jamshedpur organized the Prof. S N Sinha Memorial Materials and Metallurgy Quiz 2019. Students from different schools across the city participated in this event.



CSIR-NML signed an MoU for Technology Transfer on e-Waste Recycling with M/s. SBCON Recycling, Ahmedabad (28th August 2019)





हिन्दुस्तान

मोबाइल की बैट्री फिर बनेगी इस्तेमाल के लायक

एनएमएल

In-house Fire Safety Training (03rd September 2019)





Workshop on Interpretation of Instrumental Methods (WIIM 2020) (6th -10th January 2020) at Chennai.

The workshop was organized by CSIR-NML, Madras Centre, and the Sathyabhama Institute of Science and Technology.



Stendents' Seminar on Metallurgical Engineering "Behind The Teacher's Desk (BTTD-2019)" (5th-6th September 2019)

The seminar was organised by Indian Institute of Metals (IIM) Jamshedpur Chapter in association with CSIR-National Metallurgical Laboratory (NML), and Tata Steel. The seminar was inaugurated with the release of seminar souvenir by the Chief Guest Dr. Tridibesh Mukherjee, Chairman, Techno Plus Consultants, Jamshedpur. The aim of the seminar was to provide a common platform for promising and aspiring metallurgists to interact with the pool of experts from industries and R&D.



Hindi Week Celebrations(6th-13th September 2019)

A number of events and competitions were organized to mark the occasion, like, Essay writing, Dictation and Poetry recitation. The awards were presented to the winners during the valedictory function.









MoU Signing (13th September 2019)

MoU on Know-How Transfer to M/s Recycle Karo, Mumbai for "Extraction of cobalt metal/salt from the black powder of Li-cobalt batteries"





Hindi Town Official Language Implementation Committee (TOLIC) Meeting (24th September 2019)







CSIR Foundation Day-2019 (26th September 2019)

The foundation day lecture was delivered by Director-NML Dr. I. Chattoraj on "Science & Technology in Ancient India". The employees who completed 25 years of service in the council and the retirees of the last fiscal were honored with a memento. The meritorious children of NML staff, who had secured high marks in their Xth or XIIth examinations and/or secured admissions in reputed educational institutions in the country were awarded with cash prizes. The winners of "Foundation Day Essay Competition" were also awarded on this occasion.



74th Research Council (RC) Meeting (27th September 2019)

The meeting was held to discuss the new & existing R&D initiatives undertaken by the laboratory. The members and the chairman, RC, suggested mechanisms to overcome any possible hurdles in executing R&D projects of the laboratory.



Outreach program of Indian International Science Festival (IISF-2019) (30th October 2019)

Coinciding with the 5th IISF (2019) celebrations, CSIR-NML organized an outreach program. The theme of the exhibition was "Technologies, Products and Technological Services". The chief guest, Mr. CK Asnani, Chairman & Managing Director of UCIL, Jaduguda, shared his valuable thoughts about the value of education and discipline for the students. Dr. Arvind Sinha, Chairman, NASI Jamshedpur Chapter talked about the "Ethics in Science". More than 350 students in and around the city participated in the event.





National Skill Competition for Best of the Best Welders - 2019 (Branch level), (05th November 2019)

The Indian Institute of Welding in association with CSIR-NML organized this branch level competition at CSIR-NML. The competition featured various welding processes to assess welders qualification in different welding positions.






Vigilance Awareness Week at CSIR-NML (28th October - 2nd November 2019)

Various events were organized to mark the occasion. A lecture was also organized on the topic "Vigilance Awareness" which was delivered by Dr. K.K. Shukla, Director, NIT, Jamshedpur.




MoU Signing (14th November 2019)

General R&D Collaborative MoU was signed with NIIFT, Ranchi.




Technology Transferred to M/s. SBCON Recycling Pvt. Ltd., Ahmedabad on e-waste Recycling (18th November 2019)



Startup Conclave-2019 (CII) (22nd November 2019)









CSIR-NML Foundation Day Celebrations (26th November 2019)

The 70th foundation day function was graced by Prof. Ganapati Dadasaheb Yadav, Vice-Chancellor, Institute of Chemical Technology, Mumbai. The chief guest, Prof. Yadav, delivered the Nijhawan memorial lecture on the "Global Energy Scenario and Hydrogen Economy". The dignitaries also awarded the staff in various technical and non-technical categories, and the meritorious children of NML staff who had demonstrated academic excellence in the past year.













In-House Safety Training (19th December 2019)



MoU Signing with CCL, SAIL & RINL for the work of sampling, preparation & analysis of washed coking coal from various loading points of CCL for supply to SAIL and RINL Steel plants (9th January 2020).







TOLIC Program (15th January 2020)

Narakas Jamshedpur & CSIR-NML organised a cultural program at CSIR-NML for the TOLIC members and the guests.



Republic Day Celebrations (26th January 2020)





CSIR-NML Picnic 2020

CSIR-NML organized picnic for the entire staff and their families in a resort in the city.





CSIR-NML Tennis Ball Cricket Tournament 2020 (02nd February 2020)





MoU signing with M/s. Tata International, Kolkata (4th March 2020)





MoU signing with M/s. FSNL (4th March 2020)




MoU signing with M/s. Walle Infotech, Ranchi on e-waste recycling (5th March 2020)




MoU signing with M/s. UNQ IND, Firozabad for the extraction of cobalt by e-waste recycling (10th February 2020)




MoU signing with M/s. JSW Steel Limited, Vijaynagar (10th February 2020)




National Science Day (28th February 2020)

CSIR-NML in association with NASI, Jamshedpur Chapter celebrated the occasion. Prof. Satya Deo, NASI Senior Scientist, Harish Chandra Research Institute, Allahabad & General Secretary, The NASI Academy of Sciences, India, Allahabad graced the occasion as the chief guest. Two teachers from Jamshedpur were awarded the Best Teachers 2019 Awards. They were Ms. Shipra of Tata Workers Union High School, Kadma and Mr. Vikash Kumar Dash of NML Kerala Public School, Agrico. More than 350 students and teachers from schools and colleges in and around Jamshedpur participated in the event.







International Women's Day (12th-13th March 2020)

The event was celebrated at the laboratory for two days. On the first day , a preventive medical checkup camp was organized for the female employees of the organization and on the second day, an inspirational lecture was delivered by Padmshree Mrs. Premlata Agrawal, renowned mountaineer. This was followed by a Fun Fair.





हिन्दुस्तान

जमशेदपुर • रविवार • 14 मार्च 2020 06

महिला-पुरुष बराबर सम्मान के हकदार : प्रेमलता

जमशेदपुर | वरीय संवाददाता

महिला और पुरुष दोनों के अपने विशेष गुण हैं। इसलिए दोनों का ही बराबर सम्मान करना चाहिए। कोई भी ऐसा मुकाम नहीं जो महिलाएं नहीं हासिल कर सकतीं, बशर्ते दृढ़ निश्चय हो।

ये बातें पर्वतारोही पद्मश्री प्रेमलता अग्रवाल ने शुक्रवार को बर्मामाइंस स्थित सीएसआईआर-एनएमएल के प्रेक्षागृह में कहीं। वे यहां

कार्यक्रम को संबोधित करती प्रेमलता।

सीएसआईआर-एनएमएल की ओर से आयोजित महिला दिवस कार्यक्रम को बतौर मुख्य अतिथि संबोधित कर रही थीं। इससे पूर्व कार्यक्रम का शुभारंभ प्रेमलता अग्रवाल, एनएमएल के निदेशक डॉ. इंद्रनील चट्टोराज व उनकी पत्नी डी चट्टोराज और प्रिंसिपल साइंटिस्ट डॉ. एस पालित सागर ने संयुक्त रूप से किया।

डॉ. इंद्रनील ने समाज में महिलाओं की अहम भूमिका के बारे में बताया। डॉ. एस पालित ने एनएमएल की ओर से वंचित वर्ग की महिलाओं के उत्थान के लिए एनएमएल द्वारा किए जा रहे प्रयासों की जानकारी दी।

डी चट्टोराज ने धन्यवाद ज्ञापन किया। इस दौरान स्वास्थ्य शिविर में 80 महिलाओं की स्वास्थ्य जांच की गई। मौके पर महिला कर्मचारियों के लिए कई प्रतियोगिताएं आयोजित की गईं। विजेताओं को पुरस्कृत भी किया गया। फुड जोन में सयातिका सिंह और पेंटिंग में संगीता किशोर ने प्रथम स्थान प्राप्त किया।



जागरण सिटी जमशेदपुर

तय करें लक्ष्य, कुछ भी असंभव नहीं



the pioneer

Premlata: Nothing is impossible in this world



THE AVENUE MAIL

JAMSHEDPUR • SATURDAY, MARCH 14, 2020 • VOL : 27 NO : 259 • www.avenuemail.in • RS 2/- • PAGE-12

Nothing is impossible in this world, if your goal is fixed: Premlata

Mail News Service

NML celebrates International Women's Day



लाइफ जमशेदपुर

जमशेदपुर, रविवार 14.03.2020 17

prabhatkhabar.com

एनएमएल में वीमेंस डे : महिलाओं के स्वास्थ्य की हुई जांच, महिला उत्थान पर हुआ व्याख्यान

महिलाओं से है धरती पर मानव जीवन : प्रेमलता


THE AVENUE MAIL
Jamshedpur, Saturday, April 20, 2019
State and Neighbour
Director general of CSIR to visit NML today, to inaugurate pilot plant
Mail News Service
Jamshedpur, April 19: Shekhar C. Mande, director general of the Council of Scientific and Industrial Research (CSIR) and the Secretary of the Department of Scientific and Industrial Research (DSIR), Government of India will be
Earlier he was the Director, National Centre for Cell Science (NCCS), Pune has been involved research on the struc characterization Mycobacteri tuberculosis proteins the computational ana of genome-wide pro protein interactions.

BusinessLine
e-waste recycling with zero waste concept
Huge generation of mobile phone batteries, its rudimentary disposal, improper collection system as well as the lack of cost-effective processing technology have resulted in loss of

दैनिक भास्कर
27-Nov-2019
जमशेदपुर Page 9
एनएमएल का 70वां स्थापना दिवस समारोह, प्रयोगशाला के वैज्ञानिक, कर्मचारियों को मिला पुरस्कार
पानी से बनेगी हाइड्रोजन, ऊर्जा का वैकल्पिक स्रोत बनेगा, प्रदूषण कम होगा: प्रो. गणपति
किसे कौन पुरस्कार मिला

जागरण सिटी
जमशेदपुर
स्वदेशी तकनीक विकसित करने की जरूरत

दैनिक भास्कर
06-Jun-2019
सीटी स्टार जमशेदपुर Page 2
सिटी ACTIVITY
विश्व पर्यावरण दिवस पर विशेष: पर्यावरण सुरक्षा के लिए एनएमएल ने कई ग्रीन टेक्नोलॉजी को किया विकसि
औद्योगिक कचरे से सीमेंट, ईंट, बिल्डिंग मेटेरियल किए जा रहे तैया और इलेक्ट्रॉनिक कचरे से सोना-चांदी, निकेल जैसे निकल रहे पदा

THE AVENUE MAIL
Jamshedpur, Sunday, March 01, 2020
Shipra, Vikash bag Best Science Teacher Award
Mail News Service

उदित वाणी
एनएमएल में प्रोफेशनल ट्रेनिंग प्रोग्राम का समापन

दैनिक जागरण
चीन-फ्रांस पर नहीं रहेगी निर्भरता, भारत में बनेगा सोडियम मेटल

NML signs MoU with Aircraft Accident Investigation Bureau
Mail News Service
Jamshedpur, July 12 : Council of Scientific and Industrial Research (CSIR) NML signed an MoU with Aircraft Accident Investigation Bureau (AAIB) MoU on Thursday. The MoU was signed in presence of Pradeep Singh Kharola, secretary, Ministry of Civil Aviation, at Rajiv Gandhi Bhawan New Delhi
gations and gave information to the investigations established by the Court of Inquiry and the Committee Inquiry. A separate investigative agency was established to comply with the Standards And Recommended Practices (SARPs) of the International Civil Aviation Organisation (ICAO). The National Metallurgical Laboratory

शाबाश! एनएमएल के 26 निरक्षर कर्मचारी बनाये गये साक्षर

राष्ट्रीय विज्ञान दिवस पर शिक्षा और विकास कुमार दास को मिला बेस्ट साइंस टीचर अवॉर्ड
गणित को मोरपंख और कोबरा का मणि माना जाता है : सत्यदेव त्रिपाठी

The Telegraph
TWO-DAY SEMINAR AT CSIR LAB TO ENCOURAGE NEW IDEAS IN METALLURGY
Industry-student dialogue at NML

लाइफ जमशेदपुर
22.04.2019
19
सीएसआईआर महानिदेशक ने क्रीप टेस्टिंग व एनएमएल का काम देखा-कहा
एनएमएल भावी पीढ़ी को रिसर्च से जोड़ने की दिशा में कार्य करे

हिन्दुस्तान
02
जोड़-घटाव और सब्जी वाले से मोलभाव करना भी सीख गई रायकुमारी

NML celebrates 77th CSIR Foundation Day, students
Mail News Service
Jamshedpur, Sept. 26 : The Council of Scientific and Industrial Research (CSIR) National Metallurgical Laboratory on Thursday celebrated 77th CSIR Foundation Day at NML Auditorium.
Dr. Indranil Chattoraj, director, NML highlighted the achievement of CSIR and he delivered a lecture

दैनिक जागरण

TUESDAY, 14 MAY, 2019
The Telegraph
Technology day
JAMSHEDPUR: CSIR-National Metallurgical Laboratory on Monday celebrated National Technology Day. MD of Tinplate Company of India R.N.

लाइफ जमशेदपुर
14.03.2020
17
एनएमएल में वीमेंस डे : महिलाओं के स्वास्थ्य की हुई जांच, महिला उत्थान पर हुआ व्याख्यान
महिलाओं से है धरती पर मानव जीवन : प्रेमलता

जमशेदपुर जागरण
आधी हुई थर्मल पावर प्लांट में कोयले की खपत, लागत कम
प्रदूषण पर वैश्विक चिंता के बीच जमशेदपुर के राष्ट्रीय धातुकर्म प्रयोगशाला ने विकसित की तकनीक

Symposium on "Non-Destructive Evaluation and Magnetic Materials (NDEMM)

A symposium on "Non-Destructive Evaluation and Magnetic Materials (NDEMM)" was organized on 20th September 2019 at the CSIR-National Metallurgical Laboratory, Jamshedpur. The Jamshedpur Chapters of Material Research Society of India (MRSI) and Indian Society for Non-destructive Testing (ISNT) hosted the event jointly, in association with the CSIR-NML. The symposium was attended by several research scholars and scientists and experts working in the area of non-destructive evaluation and magnetic materials. The chief guest of the symposium was Prof. O. N. Mohanty, Director, Technology & Academic Initiative, RSB Metal Tech and former Vice-Chancellor, BPUT. Prof. Mohanty in his inaugural address, mentioned about material challenges in Oil and Gas, Automotive, Power plant and Construction industries. He also stressed the need of indigenous technology development in the area of non-destructive evaluation and advanced materials. After the inaugural address, there were technical lectures by renowned researchers from across India who spoke on Non-destructive evaluation methodologies and potential magnetic materials along with their applications. Prof. Krishnan Balasubramaniam, IIT Madras, delivered the keynote lecture. Dr. Amitava Mitra, Chief Scientist, CSIR-NML, was felicitated for his excellent contributions to Magnetic Materials and NDE research.



Figure 1 : Inaugural address by Prof. O.N. Mohanty



Figure 2 : Release of Souvenir



Figure 3 : Keynote lecture by Prof. Krishnan Balasubramaniam, IIT Madras

Professor Krishnan Balasubramaniam delivered his lecture on the electro-magnetic based ultrasonic techniques and technology developed for Industries at IIT Madras. Five other eminent speakers delivered invited lectures. Mr. S. Balamurugan, Tata Steel spoke about Industry 4.0 and need of advanced sensing systems for reliable measurement for reducing steel plant downtime. Dr. S T Arasu, elaborated the electromagnetic NDE techniques developed at IGCAR-Kalpakkam for nuclear industry, Prof. Subodh De of IACS, Kolkata, explained the magnetic concepts for future memory storage devices. Prof. Amitava Basu Mallick , IIEST Shibpur, presented developments of MnBi magnets for electric vehicles and energy sector. Finally, Dr. Arvind Sinha presented electromagnetic NDE techniques, Magnetic materials and nanomaterials developed at CSIR-NML for the last 25 years for the Industries.



Figure 4 : First prize in poster presentation



Figure 5 : Second prize in poster presentation



Figure 6 : Vote of thanks by Convener

The symposium also included poster presentations in the areas of non-destructive techniques and also on magnetic materials. Awards for the best and second best posters were bagged by Dr. Partha Sarkar, Department of Mechanical Engineering, National Taipei University of Technology, Taipei and Dr. Lubna Sheikh, R&D Centre, Tata Steel, respectively.



लाइफ जमशेदपुर
prabhatkhabar.com
21.09.2019
19

एनएमएल : चुंबकीय मटेरियल पर कार्यशाला

जमशेदपुर. एनएमएल में शुक्रवार को मटेरियल रिसर्च सोसाइटी ऑफ इंडिया की ओर से आयोजित कार्यशाला में टाटा स्टील, आरएसबी समेत विभिन्न कंपनियों के कुल 20 प्रतिनिधियों ने हिस्सा लिया. मुख्य अतिथि एनएमएल के डायरेक्टर डॉ इंद्रनील चट्टोराज ने दीप प्रज्वलित कर कार्यक्रम की शुरुआत की. उन्होंने अपने अभिभाषण में बताया कि टेक्नोलॉजी में बदलाव आने से कैसे विभिन्न मटेरियल का उपयोग आसानी से किया जा सकता है. इस दौरान पोस्टर मेकिंग कंपटीशन का आयोजन किया गया. विजेता पार्थ सरकार व अमिताभ मित्रा तथा उपविजेता लुबना शेख व सुप्रभा नायर को सम्मानित किया गया.

epaper
हिन्दुस्तान
जमशेदपुर • मंगलवार • 21 सितंबर 2019 • 06

निर्माण उद्योग में बढ़ी चुनौती : मोहंती

जमशेदपुर। सीएसआईआर एनएमएल तथा आईएसएनटी जमशेदपुर के सहयोग से शुक्रवार को एनएमएल में संगोष्ठी हुई। इसमें पावर प्लांट, एयरोस्पेस, रेलवे तथा संरचनात्मक इंजीनियरिंग के लिए एनडीई, हाइब्रिड चुंबकीय सामग्री आदि विषयों पर चर्चा की गई। बतौर मुख्य अतिथि आरएसबी ग्रुप पुणे के निदेशक ओएन मोहंती ने अपने तकनीकी अनुभवों को साझा किया। उन्होंने बताया कि स्टील्स सामग्री की तेल, गैस, ऑटोमोटिव, पावर प्लांट तथा निर्माण उद्योगों में चुनौतियां बढ़ी है। आईआईटी मद्रास के प्रो. कृष्णन बालासुब्रह्मण्यम ने इलेक्ट्रो-मैग्नेटिक पर आधारित अल्ट्रासोनिक तकनीक पर प्रकाश डाला।



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स्वदेशी तकनीक विकसित करने की जरूरत

JHARKHAND'S OWN ENGLISH DAILY
THE AVENUE MAIL

Symposium on non-destructive evaluation and magnetic materials at NML

Mail News Service

Jamshedpur, Sept. 21 : The Symposium on "Non-destructive evaluation and magnetic materials (NDEMM)", organised by Material Research Society of India (MRSI) Jamshedpur Chapter in association with CSIR-National Metallurgical Laboratory and ISNT Jamshedpur Chapter kicked off today at CSIR-NML Lecture Hall.

The Symposium on Non-Destructive Evaluation and Magnetic Materials (NDEMM) focused on some of the recent developments in potential areas of Non-destructive evaluation (NDE) for structural health monitoring and advanced magnetic materials. The topics of the symposium includes: (a) Conventional & advanced NDE techniques for material evaluation, (b) NDE for Power plants, Aerospace, Railways, and structural engineering, (c) Soft & Hard Magnetic Materials & their applications, (d) Hybrid magnetic materials, (e) Magnetic materials for bio-medical applications, and (f) Other research areas related to subject of interest.

The Director, CSIR NML Dr. Indranil Chattoraj welcomes the Chief Guest, invited speakers, students, participants, members of MRSI and ISNT Jamshedpur Chapter. He introduces the Chief Guest of the symposium; Prof O.N. Mohanty Director, (Technology & Academic Initiative), RSB Metal Tech., RSB Group, Pune. Prof O.N. Mohanty recalls his technical experience at CSIR-NML and TATA Steel. Further, he explained the material challenges especially steels in Oil and Gas, Automotive, Power plant and construction industries. He elaborated the technical and economic aspect of slowdown in the economy both by domestic and international events. Also the need of indigenous technology development in the area of non-destructive evaluation and advanced materials.



Technical lectures by renowned researchers across India started after the Inaugural address. Prof. Krishnan Balasubramanian, IIT Madras detailed on the electro-magnetic based ultrasonic techniques and technology developed for Industries at IIT Madras. Mr. S Balamurugan, TATA Steel spoken about Industry 4.0 and need of advanced sensing systems for reliable measurement and reducing steel plant downtime. Dr. S.T. Arasu explained electromagnetic NDE techniques developed at of IGCAR-Kalpakkam for nuclear industry, Prof. Subodh De of IACS, Kolkata explained the magnetic concepts for future memory storage devices. Prof. Amitava Basu Mallick, IIEST Shibpur presented development of MnBi magnets for electric vehicles and energy sector. Finally, Dr. Arvind Sinha presented electromagnetic NDE techniques, Magnetic materials and nanomaterials developed at CSIR-NML for the last 25 years for the Industries.

The poster session is also organized for the students and industrial delegates in the area of sensors, NDE techniques, magnetic alloys and nanomaterials. Dr A.K. Panda, Convener of the Symposium NDEMM gave vote of thanks to the Chief Guest, Invited speakers, Participants, Press/Media persons and industrial Sponsors. The symposium is organize also to appreciate the three decades of research work done by Dr. Amitava Mitra in the area of electromagnetic NDE techniques and Advanced Magnetic materials. The symposium makes way for future collaborations and joint activities in the sensors and advanced materials.

To mark the occasion, a Souvenir of Symposium was also released. Besides oral presentations from these invited speakers, posters were also presented by the authors.

Around 20 delegates are from different parts of India participated and seven invited speakers deliberated in the two technical sessions today. The delegates are from IIT Madras, IGCAR, Kalpakkam, Tata Steel, IIEST, Shibpur, IACS, Kolkata, and many more engineering colleges.

CSIR-NML-NASI Activities

In keeping with the vision of the National Academy of Sciences, India, Jamshedpur Chapter, namely "To empower the pupils of Jharkhand by promoting them to develop scientific temper and approach towards life at the young age", CSIR-NML and NASI jointly organized a number of events to spread scientific awareness amongst the students and teachers of the educational institutions in and around Jamshedpur.

World Conservation Day

In collaboration with team Anveshan and CSIR NML, Jharkhand chapter of NASI organized World conservation day on 26th July 2019 at Kerala Public School, Kadma. More than 100 students from different schools and colleges along with 28 science teachers participated in the program. Dr S K Mishra, Chief Scientist, CSIR-NML, and a fellow of the academy, interacted with the students and teachers and delivered a talk entitled "Lesson from past to future: impact of population on environment and climate change".



Figure 1 : Dr. S. K. Mishra delivering her talk on World Conservation day at Kerla Public School

Seminar on Green Energy

A One-day seminar on Green Energy was organized at ABM College Jamshedpur on 06th August 2019. More than 75 delegates participated in the seminar. In the seminar young researchers, namely Ms Shweta Sharma, Ms Chandrani Sarkar and Ms Meenu Pandey presented their recent research work on the topic. This event was organized in collaboration with team Anveshan and CSIR NML.



Figure 2 : One day seminar on Green Energy at ABM College

Science Teachers Interaction Program

Jharkhand Chapter of NASI in collaboration with CSIR NML organized one-day workshop at Rungta College, Chaibasa, for science teachers from the state government run schools. More than 150 teachers of East and West Singhbhum districts, along with officials of state education department, participated in the workshop. Dr Arvind Sinha and Dr Abhilash from CSIR-NML and Members of NASI, had a close interaction with the teachers and motivated them to make science an interesting subject to learn as well as to teach. They emphasized that artificial walls should not be created among the different facets of science and it should be presented to students as a unified skill for solving our social and technological problems.





Figure 3 : Science Teachers workshop at Runguta College, Chaibasa

Conference on Innovation in Science Education

Recognizing that the teachers play the most important role in the growth of S&T in every nation, the chapter realized that to continue and sustain with the global pace of S&T growth, it is mandatory that mentors must be encouraged to adopt innovative and new tools for providing students' centric science education. Hence a two- day conference entitled "Innovation in Science Education" was organized at Graduate College, Jamshedpur in collaboration with CSIR NML and team Anveshan during Jan 21st and 22nd, 2020. More than 120 delegates from different universities / institutions namely NIT Jamshedpur, Amity University Jharkhand, Kolhan University, Ranchi University, O P Jindal University, BA College of Engineering and other affiliated colleges from Kolhan University participated in the workshop. The Workshop was inaugurated by Prof Shukla Mohanty, honorable Vice Chancellor of Kolhan University. From NASI Jharkhand Dr Arvind Sinha, Dr S K Mishra and Dr Abhilash were among the key note speakers. Besides the five key note addresses, 25 papers were presented by the faculty members and researchers from different institutes.

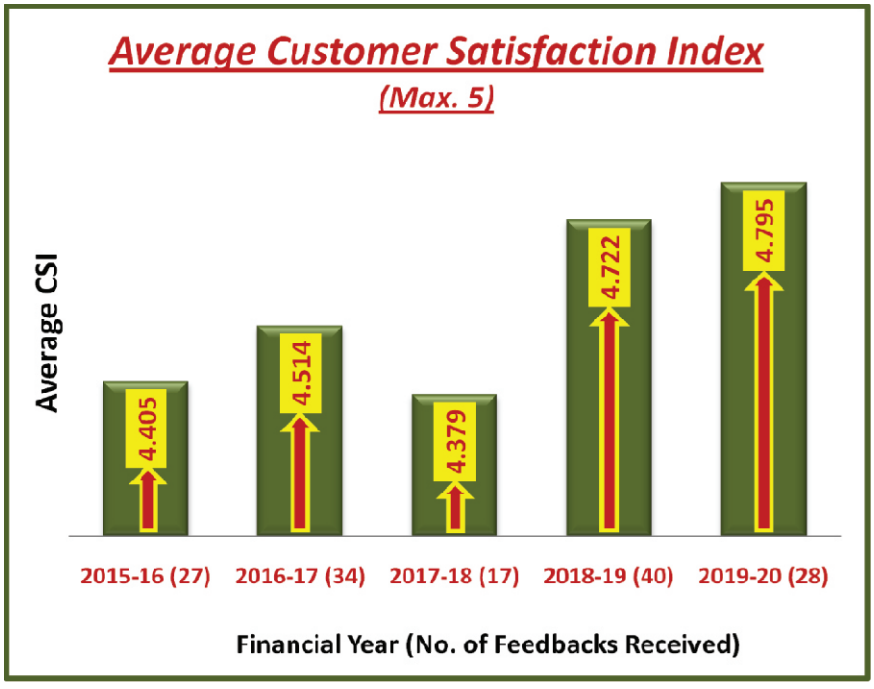




Figure 4 : Inauguration of two days coanference "Innovation in Science Education"

Customer Satisfaction Evaluation Index and Feedback

100% of our customers recommended us for providing R&D Services



"The project gave guidance to develop a full continuous casting simulator for future project work. Fundamental work for expertise development, so financial benefit may be excluded".

– Tata Steel Limited (CLP 0201)

"Good team work".

– Tata Steel Limited (CLP 0196)

"Excellent response and facility. Will do further work in the relevant area".

– Tata Steel Limited (SSP 1187)

"Concluding outcome and got direction on coal dry Beneficiation".

– Tata Steel Limited (CLP 0198)

"It was an excellent work done by the team of scientists under the leadership of Dr. S Palit Sagar".

– Tata Steel Limited (CLP 0203)

"This project was very well executed by the Project Leader. Had great experience to work with NML".

– Tata Steel Limited (SSP 1151)

"Good! The work is just using the facility for grinding, which of course no doubt a good one and support provided there in."

– Tata Steel Limited (SSP 1161)

"Satisfied with project output".

– Tata steel Limited (CLP 0188)

“Excellent!".

– Tata Steel Limited (CLP 0170)

"Dr. Jha is a very experienced scientist. He provided all his learnings from the industry which made us more confident in running this on a production level".

– Evergreen Recyclekaro (India) Pvt. Ltd. Mumbai (SSP 1154)

"Very Good work. Developed an innovative technology for Vanadium recovery".

– Hindustan Zinc Limited (SSP 1109)

"It was nice working with NML, satisfied with the report and observation and its implementation fetch benefits to us. Involve in other projects of HZL".

– Hindustan Zinc Limited, Udaipur (SSP 1152)

"Overwhelm to be associated with your reputed Institute and looking forward to working with you".

– SBCON Recycling Private Limited, Ahmadabad (SSP 1214)

"Satisfactory Completed job in time frame".

– Ferro Scrap Nigam Ltd. (SSP 1158)

"Could not estimate since feasibility on commercial scale has to be worked out still overall very good job has been done".

– Wonder Cement Limited (SSP 1175)

"Satisfied with the support extended".

– McNally Sayaji Engineering Ltd.(CNP 0133)

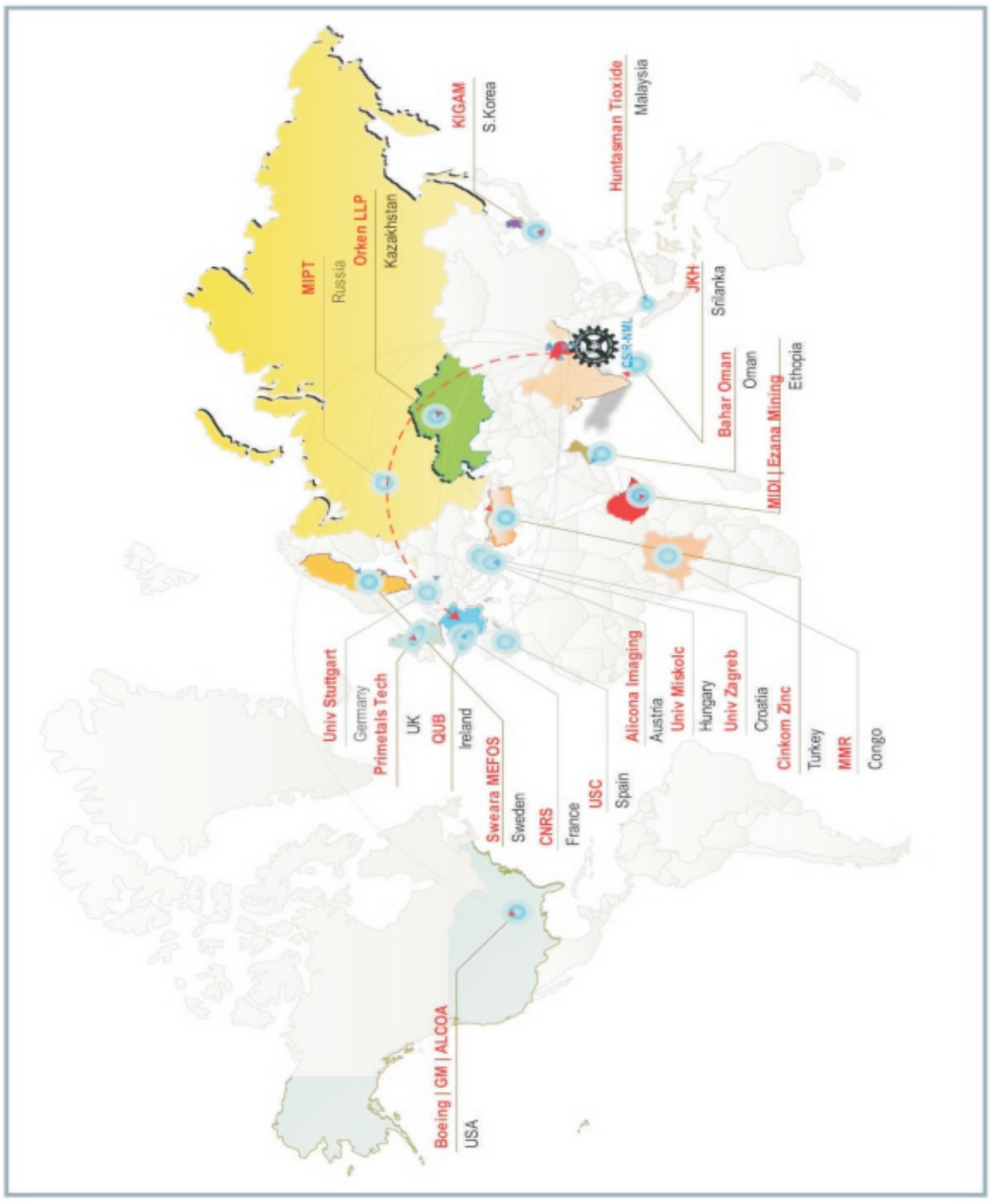
"Precise Results and Satisfactory overall experience with NML Jamshedpur".

– Eastern Coalfield Ltd, Burdwan (SSP 1132)

"Had good experience working with NML. Paper publication may be given more thrust on every stage of the project".

– NTPC, Greater Noida (SSP 1080)

International Collaborations



ET 500 Clients



Fortune 500 Clients



Intellectual Property

Patent Application Filed

Patent Ref No.	Title	Inventor
NML/PAT-0558/2019/IN	A closed loop extraction-cum-separation process for recovery of ammonium metavanadate, vanadium pentaoxide, and derivatives from spent contact process catalysts	Pratima Meshram, Abhilash, Rohit Buddham Meshram, Jai Narayan Patel
NML/PAT-0559/2019/IN	A system for analyzing health of a pipe carrying hot fluid via fiber bragg grating (FBG) sensors	Tarun Kumar Das, Chandan Dutta, Alok Kumar and Sarmishtha Palit Sagar
NML/PAT-0560/2019/IN	A process of preparation of medium Carbon high hardness Nanobainitic Steel	Minal Shah, Swapan Kumar Das and Sandip Ghosh Chowdhury
NML/PAT-0561/2019/IN	An improved process for preparation of briquettes for recycling of iron oxides wastes in steel making	Jagannath Pal, A. Ammasi, K. D. Mehta, D. Paswan, Manoj Kumar and D. Bandyopadhyay
NML/PAT-0562/2019/IN	Hot rolled and direct quenched low alloy steel with ultra-high-strength and good ductility	Gaurav Bansal, V. Rajinikanth, V. C. Srivastava, S. Ghosh Chowdhury
NML/PAT-0563/2019/IN	A process to alter reactivity of over-burden shale for its use as pozzolanic material in blended cement	S. K. Nath, Sanjay Kumar, T. C. Alex, D. P. Sahoo
NML/PAT-0564/2019/IN	An improved process for selective recovery of rare earths from waste Nd-Fe-B magnet	Aarti Kumari, N. S. Randhawa, S. K. Sahu
NML/PAT-0565/2019/IN	A process to prepare coke from non-coking coal using natural gums as additives	Sanchita Chakravarty, Ashok Kumar Mohanty, Saswati Chakladar, Subhajit Mallick, Rupa Das Biswas and Mamta Sharma
NML/PAT-0566/2019/IN	A novel electrochemical method for the recovery of metal values from spent NdFeB magnet	Aarti Kumari, Dipali, N. S. Randhawa, S. K. Sahu
NML/PAT-0567/2019/IN	A gate valve mechanism to connect or disconnect two adjacent but isolated chambers using a single push-pull motion	B. Ravi Kumar and Nimai Haldar

Patent Ref No.	Title	Inventor
NML/PAT-0568/2019/IN	Improvement of edge formability of DP 590 through modified annealing strategy	B. Ravi Kumar
NML/PAT-0569/2019/IN	Design of an auto dip mould simulator for simulation of initial solidification behavior during continuous casting process	Ashok K, Ammasi A, Madan M, Nimai Haldar, Uday Bhaskar Rao, Rajneesh Kr Gupta
NML/PAT-0570/2019/IN	A hypereutectoid bulk nano-pearlitic steel with ultra-high strength and hardness and the process of producing the same	Snehashish Tripathy, P. S. Manoranjan Jena, Soumitra Tarafder, Sandip Ghosh Chowdhury
NML/PAT-0571/2019/IN	A LPG based reduction process for recovery of manganses from pyrolusite ore	Shivendra Sinha, D. Mishra, Saurabh Shekhar, S. Agarwal, A. Agrawal, K. K. Sahu
NML/PAT-0572/2019/IN	A process for improved manganese recovery from reduced manganese ore and production of high pure electrolytic manganese dioxide	K. K. Sahu, D. Mishra, Saurabh Shekhar, Shivendra Sinha, S. Agarwal, A. Agrawal
NML/PAT-0573/2019/IN	Duplex nano-structured low-density steel sheet with strength ductility product exceeding 50 GPa% and preparation method thereof	Biraj Kumar Sahoo, Sandip Ghosh Chowdhury and Vikas Chandra Srivastava
NML/PAT-0574/2019/IN	A Process for the Enhancement in Transduction Efficiency of a Magnetostrictive Sensing Device for Evaluation of Pipeline Defects	Ashis Kumar Panda, Somnath Das, Tarun kumar Das, Avijit Kumar Metya, Premkumar Murugaiyan, Rajat Kumar Roy, Amitava Mitra
NML/PAT-0575/2020/IN	A medium Manganese (< 4wt.%) steel sheet produced through novel Quenching and Partitioning route having strength-ductility product of 30 Gpa%	Biraj Kumar Sahoo, Avanish Kumar Chandan, Gaurav Bansal, B Ravikumar, Sandip Ghosh Chowdhury
NML/PAT-0576/2020/IN	Transition metal carbides/nitrides/ carbonitrides and bimetallic chalcogenides based composite electrode preparation for energy storage application	Pallab Bhattacharya, Manish Kumar Nayak, Trilochan Mishra, Ranjan Kumar Sahu, Arvind Sinha

Patent Ref No.	Title	Inventor
NML/PAT-0577/2020/IN	A hydrogen gas based roasting process for the recovery of potassium from glauconitic rock	S. Shekhar, S. Sinha, D. Mishra, A. Agrawal and K. K. Sahu
NML/PAT-0579/2020/IN	Magnetically enhanced dry gravity separator	Ganesh Chalavadi, Ranjeet Kumar Singh, Abhishek Kumar, Ajit Kumar Swain, R.K.Rath
NML/PAT-0580/2020/IN	A non-invasive system for finding binder metal percentage of tungsten-carbide cobalt components	Avijit Kumar Metya, Arpita Ghosh and Sarmishtha Palit Sagar
NML/PAT 0552/2018/IN	A Novel air generating system for improved performance of column flotation cell	Shobhana Dey, Prasanta Baskey and Ratnakar Singh
NML/PAT-0581/2020/IN	Real time condition monitoring of tuyere using selective temperature input	Tarun Kumar Das, Chandan Dutta, Alok Kumar and Sarmishtha Palit Sagar
NML/PAT-0582/2020/IN	An Improved Water-Cooled Rotating Wheel to Produce Thin Alloy Strips	Usha Y, Nimai Haldar, PremKumar M, Rajat Kr. Roy, Udaya Bhaskara Rao M, Rajneesh Kumar, A K Panda
NML/PAT-0583/2020/IN	A Novel Cable Sheath Stripping Machine with Integral Grip and Adjustable Guide ways	Usha Y, Nimai Haldar, Manis Kumar Jha, Rajneesh Kumar Gupta, Jhumki Hait
NML/PAT-0584/2020/IN	A process for production of high grade Fe-Mo-Ni/Co alloy and alumina slag from spent hydro-desulfurization catalyst	S. Agarwal, S. Sinha, D. Mishra, S. Shekhar, K. K. Sahu

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C109	Development of Methodology for Identification of Secondary (Used) CRGO Strips Using Electromagnetic Sensor	Rajat K Roy, Premkumar M, Ashis K Panda, Rajinikanth V, Parikshit Munda, Amitava Mitra
C110	A Web-based Directory of Industries	Beena Kumari, Ashish Upadhyay, A. Mitra, M. Tarafder, K. Sudhakara Rao, Santosh Tiwary, Priya Nag and S. K. Pal
C111	A Web-based information system for managing GST based Invoicing and Billing System	Ashish Upadhyay, Beena Kumari, Amitava Mitra, M.Tarafder, Santosh Tiwary and S. K. Pal

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Patent Ref No.	Title	Inventor	IPU Ref No.	Patent Application No.	Patent No.
NML/PAT-0381/2010/IN	An Improved extraction process for the selective recovery of cadmium from spent nickel cadmium battery	Archana Agrawal, K. K. Sahu	0062NF2010	1687DEL2010	332438
NML/PAT-0382/2010/IN	A Process for the synthesis of injectable Biomimetic Hydroxy-apatite as Bone Graft Material	Arvind Sinha, Suprabha Nayar, Ashit Kr. Pramanick, Satish K. Sinha	087NF2010	1710DEL2011	318068
NML/PAT-0406/2012/IN	A process for production of various shapes and size of high purity monodispersed iron oxide from waste chloride pickle liquor	K K Sahu, Archana Agrawal, Devabrata Mishra	0228NF2012	0251DEL2013	321463
NML/PAT-0430/2014/IN	A Process for Recovery of potash from fledspar with simultaneous Recovery of ferro-Silicon	Kamal Kant Sahu, Devabrata Mishra, Archana Agarwal	0091NF2014	3006DEL2014	329197
NML/PAT-0439/2014/IN	A process for composi-tional analysis of iron ores	A. K. Mukherjee, R. Mukherjee, T. K. Ghosh, B. Mohanty, S.P. Sagar, A. Ghosh, T. K. Das, B. R. Nayak	0206NF2014	0854KOL2014	322661
NML/PAT-0404/2012/IN	A Method To Determine Corrosive Resistivity Performance Of Various Coating On Reinforce-ment Bars	L. C. Pathak, Shravan Kumar, S. K. Tiwari, S. K. Mishra, D. D. N. Singh	0150NF2019	0278KOL2013	323420

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IMPRESSION

…This is to update you regarding commercialization status of the CSIR-NML's pigment Grade Iron oxide technology where using spent acid containing acidic waste pickling liquor. At the outset, we congratulate you and your team for your efforts towards developing technology for production of high quality Pigment Grade Red Iron oxide from steel pickle liquors' After demonstration and transfer of the technology at CSIR-NML," we set-up a pilot plant at our works and successfully conducted several pilot trials to produce different color grade iron oxide' Gathering confidence from your continuous inputs and trial runs we set up a commercial production plant of 500 MT per annum capacity on commercial scale also we are able to produce desired grade iron oxide for pigment application. We appreciate your timely advises, corrections and efforts for making this possible. We would set-up few more parallel precipitation reactors for further expansion of our production capacity. Once again thank you, your team and Director for transferring the technology and for all the help and guidance provided to us for making the plant ready for commercial production. We look forward for such help and support through continuous interaction for future also.

Rajesh Narielwala, *Rang Sarjan Chemicals, Gujarat*
16th January 2020

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