वार्षिक प्रतिवेदन 2014-15

Annual Report 2014-15

Marrying Science with Industry

for the Progress of Both

CSIR-National Metallurgical Laboratory

Jamshedpur - 831007, India

Overview of CSIR-NML

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. CSIR-NML continues to play a vital role in the quest of the country for scientific and technological leadership and providing scientific solutions to the industries in the areas of minerals, metals and materials.

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. 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 64 glorious years of existence and endeavors to move ahead to meet the challenges of the global economy and reach greater heights.

Vision

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 by 2022

Goals/Targets for 2016

- 50 % budget from Industrial sources
- 80% direct utilization of man-power & major equipments
- Commercialization of 5 technologies with lasting impact
- 5% of operational budget from IP licensing & technology transfer
- Paperless CSIR-NML
- One major national mission project
- Create leadership chain for tomorrow
- 150 SCI papers/Yr with Av C/P of 10
- 20 PhD's/year under AcSIR

The Inspiration

"...What is needed is pursuit of excellence with single-minded determination and dedication-not just individual excellence but institutional excellence-and making it a sustainable hallmark of the entire S&T establishment. Therefore, the Nation expects you to aim higher, be ambitious and achieve big things..."

"...Of the many forces that will shape human history in the new millennium, science and technology will perhaps be the most potent. We know how science and technology have changed the complexion of the world in the last couple of centuries of the last millennium. But this is just the beginning of a long and exciting voyage. All the discoveries of science and all the inventions of technology so far amount to the arrival of just a couple of stars in a sky of countless stars that are yet to appear..."

"...The sky of science belongs to the entire mankind. No part of it can be a monopoly of any single nation. That is how it should be. If science has the power to benefit man, then that power should be accessible to men all over the world. Nevertheless, every nation on this planet and certainly a big and ancient nation like ours is required to ask itself: How many stars in the sky of science have we cause to appear? How much have we contributed to the advance of scientific knowledge and to the betterment of life? And what plans have we drawn up for its progress in the future?..."

Shri Atal Bihari Vajpayee

Organisational structure

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Research Council Members

Shri. HM Nerurkar
Chairman Research Council,
Former Managing Director,
Tata Steel Limited,
Jamshedpur

Shri. Bhaskar Roy
Former Director,
M.N.Dastur &
Company Limited,
Kolkata

Shri. Kamal Dasgupta
Acting Director,
CSIR-Central Glass and
Ceramic Research Institute,
Kolkata

Dr. Pradip
Group Leader,
Materials and Minerals
Processing Technology
Tata Research Development
& Design Centre
(A Division of Tata Consultancy Services Ltd.)

Dr. Om Prakash
Director, Materials & Processes
Boeing Research
Technology- India Centre
Boeing International Corpn,
India Pvt. Ltd., Bengaluru

Director of the Laboratory
Dr. S Srikanth
Director
CSIR-NML,
Jamshedpur

Prof. SN Ojha
Professor,
Dept. of Metallurgical Engg
Institute of Technology,
Banaras Hindu University,
Varanasi

Dr. Amol A Gokhale
Director,
Defense Metallurgical
Research Laboratory
Hyderabad

Permanent Invitee
Dr. Sudeep Kumar
Head, Planning &
Performance Division
Council of Scientific &
Industrial Research,
New Delhi

Dr. Biswajit Basu
Joint Executive President
Aditya Birla Science &
Technology Centre,
Taluka Panvel, Maharashtra

Shri .SS Mohanty
Director, Technical
Steel Authority of India Ltd.
ISPAT Bhawan, New Delhi

Impression

...It is with great pleasure, we here at our organization are congratulating and thanking you, for a fruitful meeting and a very Informative conversation that we had on the 29th of this month. We have full faith and confidence in your being able to share the knowledge and knowhow, we definitely look forward for the demonstration date of your pilot project, we believe to the best of our judgment that your product process shall be one of the best techniques that have been developed till date. .....

Mr. Hitesh Patel,
Maruti tea & Industies (p) ltd & Wolfram metchem (p) ltd
31/01/15

...We have already received the report about the sample pilot plant and we would like to say thank very much for the invaluable effort you and your colleagues have made from the beginning to the end towards the possible better outcome of the ore beneficiation test. We have no words strong enough to explain the dedication and commitment you have shown in this work and we believed this will remain as a strong binding of our relationship in the future.

Thank so much again

Yibra Abera, Ethiopia
15/10/14

Foreword

As I reflect on what we have been able to achieve in the year gone by, there is a sense of fulfilment as well as a sense of anxiety. Fulfilment over the fact that on almost all fronts (financial, technology transfers, patents filed and scientometrics), we have surpassed the targets set for the year and anxiety over whether we will be able to sustain this performance in the present ecosystem and under the constraints that we face today and more importantly whether we would be able to achieve our vision for a "self sustained technology centre" by 2022. We have been able to generate an External Cash Flow (ECF) in excess of Rs 30 Crores of which the industry & international projects component was Rs 20 Crores against a CSIR budget of Rs 35.5 crores. This marks an increase in ECF of 72% and an increase in industrial ECF of 29% compared to last year, which is quite impressive. We have also been able to restrict our public expenditure (other than salary & allowances) to Rs 15.1 Crores this year compared to Rs 17.23 Crores last financial year which is significant. In terms of technologies developed and transferred and patents filed, we have done better than expected. Personally for me, it is very satisfying to see that our thrust on financial self sustenance and technology development has not compromised our pursuit of high science. We have crossed three scientific milestones this year: higher than one publication /scientist, more than 10 citations/paper (based on google scholar analysis) and an H-index of more than 50. The pinnacle of this year's achievement was the conferring of CSIR Technology Award for the most significant technology of the 11th plan to Column Flotation Technology.

Many of our products have been doing well in the marketplace. The anti-tarnishing lacquer for copper, brass and silver hit the market in Aug 2014 and has more than 30 clients in this short time including TITAN Hosur, Ordnance Factory Ambarnath and Saboo Coatings Baroda. The bio-products transferred to M/S Eucare Pharmaceuticals, Surgiwear Ltd. and IFGL refractories have also captured a significant market share. The portable ball indentation machine marketed through M/S Ducom Instruments Pvt. Ltd. and the portable Magnetic Hysterisis & Barkhaussen Noise Measurement device Magstar are becoming popular and have been procured by reputed companies such as NTPC, BARC, JSW, IOCL and BHEL. The 6th commercial installation of the Column Flotation plant for barite beneficiation is coming up at Oren Hydrocarbon close to Chennai. This year, we have been able to transfer our technologies on anti-tarnishing lacquer, production of Ferrite and Pigment Grade Nano Iron Oxide from waste chloride pickle liquor, production of tungsten from a variety of secondary resources, annealing simulator, energy efficient brass and bell metal melting furnace and synthesis of titanium and zirconium di-boride powders to the industries. I have no doubt that these other products will also be in the commercial market soon. Another milestone achieved was the spinning off of two new companies this year, M/S Krisjan Pvt. Ltd. and M/S. Mahashraya Chemicals for the production, manufacturing and marketing of the lacquer and annealing simulator respectively. Having overcome the initial mindset barrier, I am hopeful that we will be able to spin off several start-up companies to market our technologies over the next five years as also create jobs thereby.

We have given high priority to our 12th plan flagship projects on development of an energy efficient technology for Magnesium, development of a dry beneficiation technology for coal and development of technology for Cold Rolled Grain Oriented (CRGO) Steel. In the Magnesium project, we have completed ten pilot scale campaigns over the past two years after the commissioning of the pilot reactor. However, we have faced several engineering issues such as air leakage, re-oxidation of magnesium, choking of charging chutes, damage of lining and gas phase condensation of Mg leading to fire, the resolution of which has delayed our schedule. However, each of these failures have taught us at least one technical lesson and we are sure of perfecting this technology at this scale and produce 500 kgs of Mg in this reactor before we venture into a 1 ton pilot plant which will enable the preparation of a Detailed Project Report (DPR). Despite the hiccups faced, we hope to achieve our target of demonstrating this new technology for Mg at 1 ton scale on schedule so long as financial support would be available. In the project on development of dry beneficiation technology for coal, we have developed a flow sheet at lab scale (150 kg batch) for the dry beneficiation of fine coal (<2 mm) from three coal blocks namely Dakra, Gare Block and Rajmahal and CIMFR Dhanbad has developed a process for the sorting of the coarse coals using an X-ray based sorter. We are working on development of flow sheet for medium size coals using fluidization technology. Geo-polymerisation technologies have also been developed for the combustion products and are most likely to be commercialised by M/S Tata Power who are financial partners in this project. The CRGO project has also kicked off. An engineering consultant, M/S MECON Ltd has been engaged for the preparation of the Detailed Project Report (DPR) for a 3-5 ton CRGO pilot plant. We have also initiated several internal projects towards creating our own intellectual property on new

compositions, novel inhibitors, new thermo-mechanical processing schedule, solidification under magnetic field & on coatings and we have got some very exciting results including the desired microstructure & Goss texture. Another major initiative in the 12th plan has been a joint project taken up with Tata Steel & Ministry of Steel on the development of galvannealing technology for advanced high strength steels under which a high value Hot Dip Galvanizing Simulator will be commissioned at CSIR-NML. The establishment of laboratory scale simulators for annealing (annealing simulator), thermo-mechanical processing (Gleeble Simulator) and for galvanizing (HDPS) combined with the establishment of a 3-5 ton integrated pilot plant for CRGO will provide a unique platform at CSIR-NML for the development of advanced steel flat and long products for the automobile, power, oil and gas and nuclear industries for the country.

It is heartening to see that our engagement with industries has increased considerably. Prestigious international companies such as GE, BOEING and several of the fortune 500 companies from India have savoured the relationship and collaboration with us. The collaboration with Tata Steel over the past five years has been extremely fruitful and beneficial for both. Over the past four years, we have undertaken 120 sponsored collaborative projects (40 sponsored projects were taken last year alone) accruing more than Rs 25 Crores of revenue for CSIR-NML. This has also resulted in 30 joint patents and 39 joint SCI publications. Many of the project results have been commercially exploited and one technology developed jointly on production of tiles from LD slag has been commercialized. At least three more joint technologies are likely to be commercialized in the course of time. The IR-thermography based iron ore sorting device has been commercially implemented and in a short period of a year has already yielded an economic benefit of Rs 3.23 Crores and is likely to yield an annual benefit of Rs 6.3 crores. Another collaborative project on graphene coated steel has won the prestigious Tata Innovista award for 2015. I was told that this is the first time a collaborative project involving a non-Tata company as partner has ever won the INNOVISTA award.

As a public funded laboratory, our focus has always been to benefit the people of the country not only through technological interventions mediated by the industry but also through implementation of societal technologies, science dissemination, employment creation through training and skill building and preservation of traditional artisanal practices. Over the past two years, we have trained more than 250 artisans from the brass clusters of Moradabad and Balasore, 500 entrepreneurs on material characterisation and evaluation techniques, a large No. of JRF's and SRF's and more than 600 engineering students through providing internship.

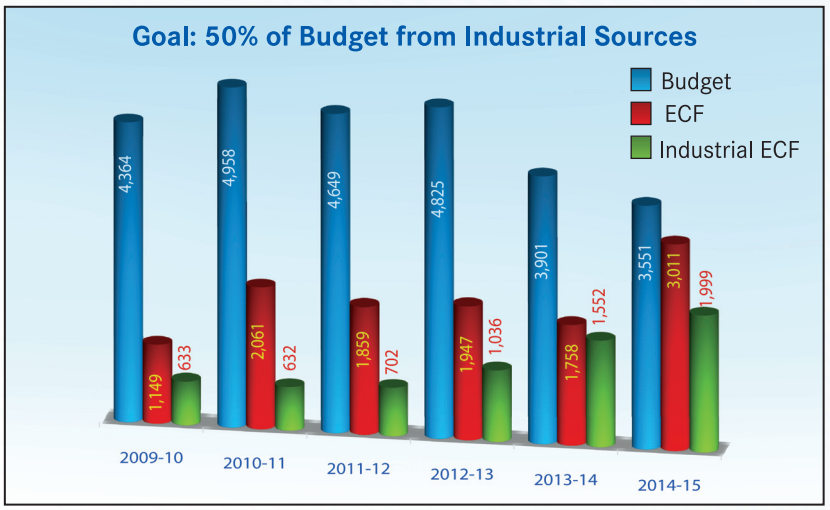
When one looks at the beautiful landscape of Jharkhand laden with natural resources and a rich culture, what is also striking is the poverty around. It keeps bothering me as to whether we are doing enough for this region and we are trying to place special emphasis on contributing in all ways that we can towards the development of this region. We initiated a school-NML interaction program with the purpose of motivating students and teachers to science through which more than 18000 school students and school teachers were taken around laboratory visits and shown laboratory demonstrations. Under the auspices of National Academy of Sciences we conducted a workshop on Women's Empowerment in Science & Technology for the women students, research scholars, faculties and researchers of various universities and colleges in Jharkhand which was presided by Dr Kasturirangan. In addition, we have provided employment to more than 350 local people last year through project assistantships, labour and job contracts and since most of them are paid either from sponsored projects or from lab reserve which accrues from industry projects, the burden on the public exchequer is to the minimum.

However, despite the many silver linings in the sky, there are shades of dark clouds that we cannot afford to overlook. Last financial year, we had to spend Rs 9.61 Crores from our Lab reserve Fund (LRF) for routine and regular expenditure including Rs 5 crores for salary. This is Rs 1.3 Crores more than the lab reserves that we could generate last year. This year also we may have to bear close to Rs 10 Crores from the LRF for regular expenditure. This requires that we not only increase our External Cash Flow from industries but also be able to save sufficiently to the Lab Reserve Fund. If translational or industrial research has to flourish, which are very specific on deliverables and timelines, our ecosystem should provide sufficient autonomy and flexibility. Another serious cause of concern is the depleting human resources position with respect to Scientists and Technical Officers. Our Scientific strength is presently at 121 against a sanctioned strength of 170 and that of Technical Officers is 43 against a sanctioned strength of 61. For various reasons, we have not been able to make any recruitment for more than a year and half. The Enterprise Resource Planning (ERP) system development and implementation at CSIR appears to be facing the last mile problem. If full online implementation of all modules of ERP is not achieved now, it will put us back by 3-5 years in our quest for an electronic paperless workplace.

Despite our successes, we have a long way to go. I appeal to my colleagues to adopt the Olympic Motto of Citius, Altius, Fortius in taking CSIR-NML to a position of international leadership Faster, Higher and Stronger.

(S. Srikanth)

R&D Outputs


Goal: 50% of Budget from Industrial Sources
Budget
ECF
Industrial ECF
4,364
1,149
633
4,958
2,061
632
4,649
1,859
702
4,825
1,947
1,036
3,901
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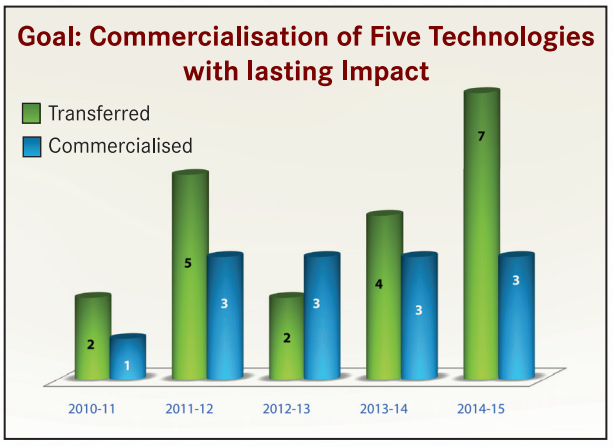
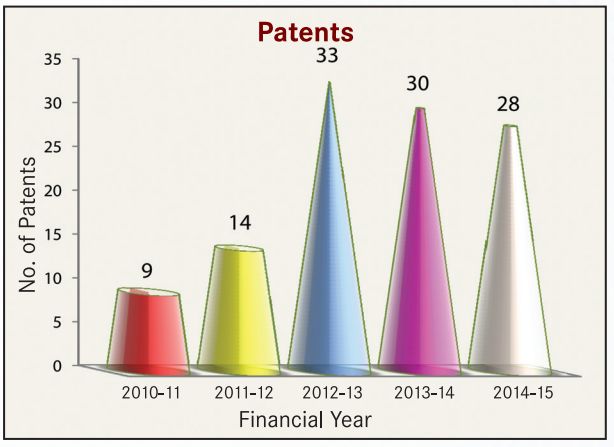
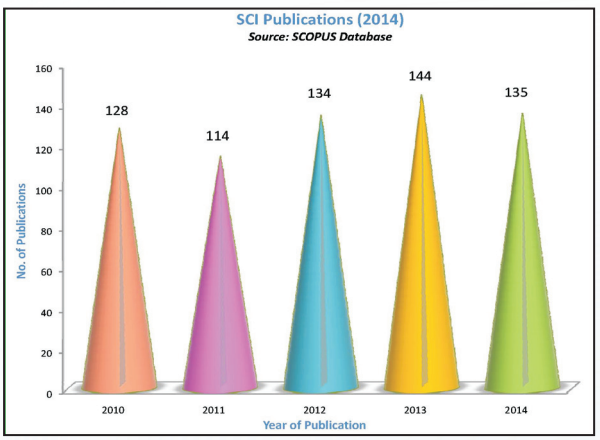
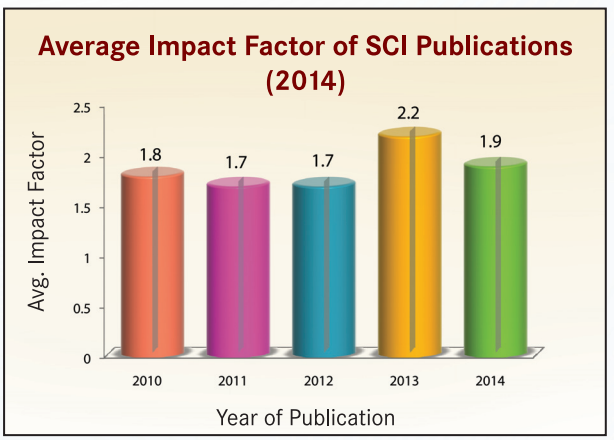
3,551
3,011
1,999
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15


Goal: Commercialisation of Five Technologies with lasting Impact
Transferred
Commercialised
2
1
5
3
2
3
4
3
7
3
2010-11
2011-12
2012-13
2013-14
2014-15


Patents
No. of Patents
Financial Year
9
14
33
30
28
2010-11
2011-12
2012-13
2013-14
2014-15


SCI Publications (2014)
Source: SCOPUS Database
No. of Publications
Year of Publication
128
114
134
144
135
2010
2011
2012
2013
2014


Average Impact Factor of SCI Publications (2014)
Avg. Impact Factor
Year of Publication
1.8
1.7
1.7
2.2
1.9
2010
2011
2012
2013
2014

New Products in Market (2014-15)

MagStar

A Portable Magnetic Sensing Device based on magnetic Hysteresis loop and Barkhausen emissions for Non-destructive Evaluation of Steel Structures/Components. The technology was licenced to M/S. Technofour, Pune. Two units were sold by Technofour, Pune in 2014-15 : one unit to JSW Steel, Bellary and one unit to NTPC under a collaborative project with CSIR-NML which is presently with CSIR-NML and will be handed over to NTPC at the end of the project with the data generated in this project for evaluation of creep damage in P22 and P91 steel.

Certified Reference Materials

1	IRON ORE (161.4)	11 Unit	11 Unit
2	IRON ORE (161.5)	2 Unit	8 Unit
3	IRON ORE (161.6)	1 Unit	17 Unit
4	FERRO-SLICON (31.3)	16 Unit	15 Unit
5	LOW ALLOY STEEL (223.6)	7Unit	19 Unit
6	BLAST FURNACE SLAG (435.1)	4 Unit	3 Unit
7	PLAIN CARBON STEEL (PC - 1)	7 nos.	29 nos.
8	PLAIN CARBON STEEL (PC - 4)	1 no.	18 nos.
9	PLAIN CARBON STEEL (PC - 5)	3 nos	12 nos.

Anti-tarnishing Lacquer for Silver and Copper-based Alloys

Salient Features

Anti-tarnishing lacquer developed at CSIR-NML is a one component fast drying interior lacquer for use on brass, copper, bronze and silver surfaces.

- It prevents tarnishing (blackening) and provides a durable finish resistant to water, acid, and alkali environments.
- The formula contains active corrosion inhibitors chemically bonded to acrylic polymer backbone, hence prevents tarnishing of copper, brass, bronze and items for long durations of several years.
- This one component acrylic resin lacquer is non toxic (Lead and Cadmium free) when dry.
- The lacquer can be applied by spraying, brushing, or dipping and takes 10 minutes to dry. Post treatment like baking not required.
- The coating passes 500 hours of salt spray test (ASTM B 117) and 72 hours of flower of sulfur test (ASTM B 809).

Appearance : Transparent	Gloss @20° : 65-70	Hardness : 2H
Film Thickness : 2-5 micron	Coverage : 15-20 m2/litre	Dry : 10 min.
VOC : 750-800 g/L	Acid resistance : Pass	Lead < 1 ppm
Alkali resistance : Pass	Salt Spray Test : 500 hrs	Cd < 1 ppm

Impact

Rabindranath Tagore (1861 –1941),
Literature, 1913

He made India proud by receiving the Nobel prize in Literature in 1913. He was a Bengali polymath who reshaped Bengali literature and music, as well as Indian art with Contextual Modernism in the late 19th and early 20th centuries. Author of Gitanjali and its "profoundly sensitive, fresh and beautiful verse", he became the first Asian and non-European to win the Nobel Prize in Literature. He was highly influential in introducing the best of Indian culture to the West and vice versa, and he is generally regarded as the outstanding creative artist of the modern Indian subcontinent, being highly commemorated in India and Bangladesh, as well as in Sri Lanka, Nepal and Pakistan. Tagore modernized Bengali art by spurning rigid classical forms and resisting linguistic strictures. His novels, stories, songs, dance-dramas, and essays spoke to topics political and personal. Gitanjali (Song Offerings), Gora (Fair-Faced) and Ghare-Baire (The Home and the World) are his best-known works, and his verse, short stories, and novels were acclaimed—or panned—for their lyricism, colloquialism, naturalism, and unnatural contemplation. His compositions were chosen by two nations as national anthems: India's Jana Gana Mana and Bangladesh's Amar Shonar Bangla. The original song of Sri Lanka's National Anthem was also written and tuned by Tagore.

Impact Making Technologies

Technology : Preparation of Anti-tarnishing lacquer for Copper based Alloys

Technology transferred to : M/S. Multicoat Surfaces Private Limited, Kolkata

The widely accepted inhibition mechanism of organic inhibitors is that the hetero atoms (N, S, and P) form coordinative bonds with copper, resulting in chemisorption of these organic molecules forming a protective layer. Use of these organic inhibitors is successful in preventing corrosion in solution but very few of them provide efficient inhibition for long durations when used as a coating as required for corrosion protection of copper and its alloys in outdoor or marine environments.

A new organic polymer was developed at CSIR-National Metallurgical Laboratory (CSIR-NML), which can be used as a coating to provide protection of copper and its alloys in severe corroding environments like in sea water. The polymer binds strongly with copper through chemical interactions and provides efficient protection in saline and sulphide environments. The polymer preparation technology was transferred to a company M/S. Multicoat Surface Private Limited, Kolkata for commercial production of the polymer. The company intends to use the polymer as the first coat on brass that is used in marine environments.

Technology : Production of High Pure W-Powder from Supplied WC-Hard Metal Scraps

Technology transferred to : M/S. MetChem Wolfram Ltd., Kolkata

Tungsten (W) is a rare and strategic metal which has several remarkable properties. The metal & its alloys find numerous critical applications in defense, energy, mining and other sectors. Global tungsten market is dominated by Chinese supply (~84%), and therefore this metal has a high supply risk index. Indian tungsten reserves are negligibly small and the country fully depends on exports. Efficient recovery of this metal from various available secondary sources has tremendous national relevance, not only in terms of foreign exchange savings but also in making our country partly self reliant for our critical domestic requirements.

At CSIR-NML, an innovative process flow-sheet has been developed for recovering tungsten & other valuable metals such as Ni & Co from a variety of WC-hard metal scraps. The highlight of the developed process includes high tungsten & other metals recovery (>95%) and high product purity. The process can cater to desired product specifications with the generation of little or no solid nor liquid effluents. The developed process know-how has been transferred to two MSMEs in the past and recently it was transferred to M/S. MetChem Wolfram Ltd., Kolkata, who is setting up of a 5- 8 MT/month capacity W-powder production plant near Nagpur.

WC-inserts & produced YTO

High Pure (>99.9%) W-Powder

Technology : Energy efficient Coke based Brass and Bell Metal Melting Furnace

Technology transferred to : M/S. Technical Training Institute, Balasore, Odisha

Brassware artisans across the country are still using age-old home based coal/coke fired furnace for melting brass and aluminum alloys which are fuel inefficient, polluting and hazardous.

CSIR-National Metallurgical Laboratory (CSIR-NML), has initiated steps to provide technological interventions to the brassware artisans of India. An eco-friendly and energy efficient brass and bell metal melting furnace has been designed and developed for the artisans of Balasore district of Odisha. The features of this developed furnace are: Reduced coke consumption (about 20%), Reduced harmful gas emissions and pollution (~80%), Reduced melting cycle per batch (20%), Minimum alteration of traditional furnace, increased productivity (30%).

Technology : Production of Ferrite and Pigment Grade Monodispersed Nano Iron Oxide from waste chloride pickle liquor

Technology transferred to : M/S. Tata Pigments Ltd

Synthesis and study of metal oxide particles in submicron and nano range has been the focus of intense fundamental research with emphasis on their dispersion. Monodispersed iron oxides of uniform shape, size and composition have a variety of applications such as for high quality pigments, catalysts for rocket fuel and is an important constituent for a variety of advanced materials. Due to increasing trend of production of galvanized steel, generation of waste pickle liquor is increasing day by day. The volume of pickle liquor generation is about 30-50 L/MT of steel containing about 20-30 g/L of acid and >100 g/L of iron. Utilization of these waste materials for production of high value iron oxide will not only generate revenue out of the recovered product, but will also prevent environmental pollution. A simple innovative process was developed at CSIR-NML for production of monodispersed iron oxide of uniform size and shape from waste chloride pickle liquor. The process is so tuned that a particular size and shape could be engineered with required magnetic properties. The major advantages of the process are that it involves low temperature synthesis and takes care of various impurities present in the system, and that it does not involve any major impurity removal steps.

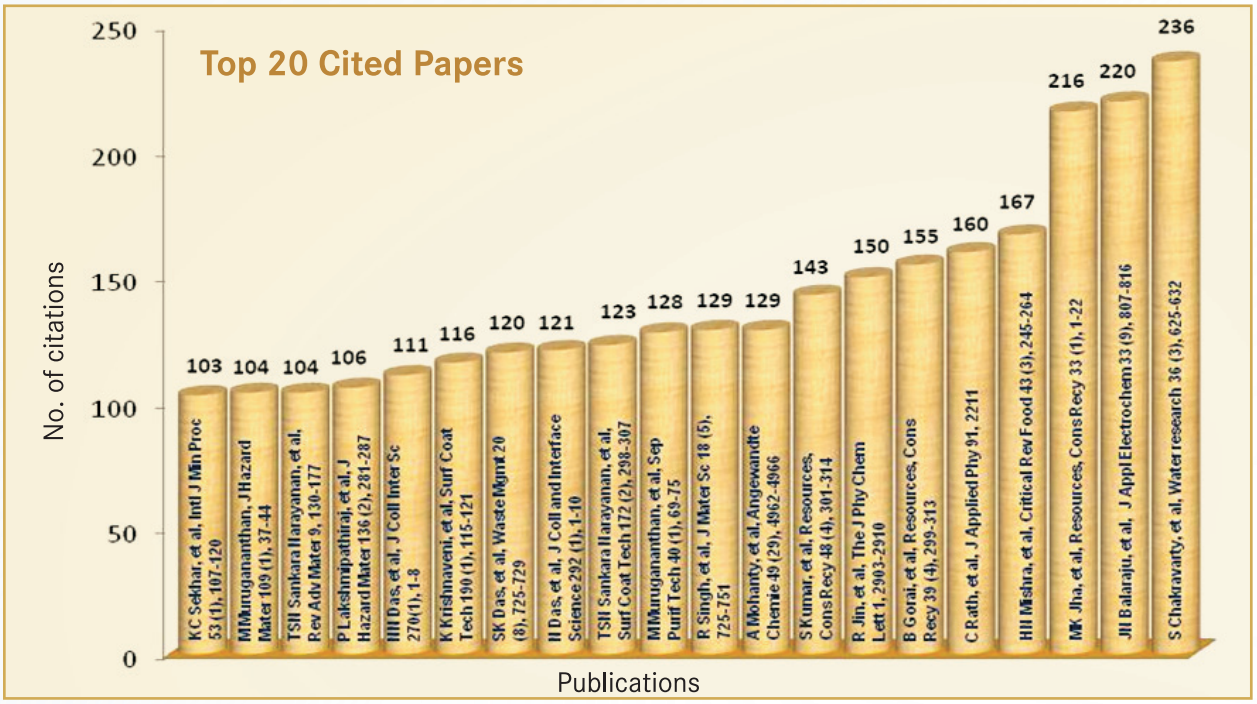
Under the joint collaboration with TATA STEEL, the process was further up-scaled on kilogram scale and a complete flow-sheet was developed. The submicron/nano size iron oxide produced were tested and were found to be promising with respect to its application as high grade pigment as well as a precursor for soft high end magnetic material.

The developed process was demonstrated and transferred to M/S. Tata Pigments Ltd. The process produced a variety of lighter grade iron oxide with superior pigmenting quality and necessary data are to be collected for design and commissioning of a 500 kg per batch iron oxide production plant. M/S. Tata Pigments Ltd., Jamshedpur, the largest producer of iron oxide pigments in the country, is aiming to produce about 5000 MT/y of iron oxide. An integrated treatment plant to produce high value iron oxide will not only generate revenue and reduce environmental pollution but will also generate substantial employment.

MoU was signed with M/S. Tata Pigments Ltd for transfer of technology on production of iron oxide from waste chloride pickle liquor

Comparative mass tone of iron oxide between TP 130 and iron oxide produced at CSIR NML

Impact Making Science



High number of downloads (11000 times) of publication (book chapter)

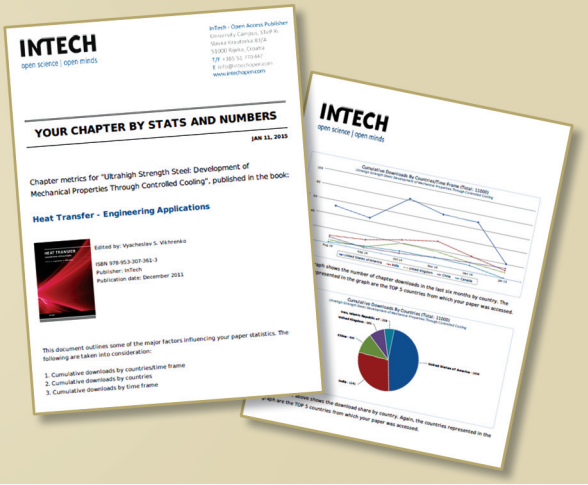
"Ultrahigh Strength Steel : Development of Mechanical Properties Through Controlled Cooling" published with InTech in the book "Heat Transfer - Engineering Applications"

Dear Dr. Maity,

We are pleased to inform you that your paper "Ultrahigh Strength Steel: Development of Mechanical Properties Through Controlled Cooling" has achieved impressive readership results. The chapter you have published with InTech in the book "Heat Transfer - Engineering Applications" has so far been accessed 11000 times. Congratulations on the significant impact that your work has achieved to date.

We congratulate you once again on your success.

InTech Author Stats



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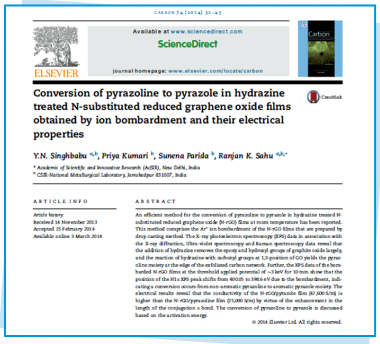
Publication having impact factor 7.578

Bhattacharya, S.; Sheikh, L.; Tiwari, V.; Ghosh, M.; Patel, J. N.; Patel, A. B.; Nayar, S. (2014). Protein - Polymer Functionalized Aqueous Ferrofluids Showing High T2 Relaxivity, 10(5), 811-819.

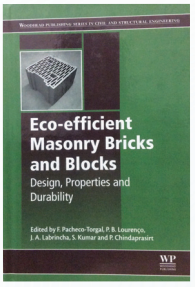
Protein-Polymer Functionalized Aqueous Ferrofluids Showing High T2 Relaxivity

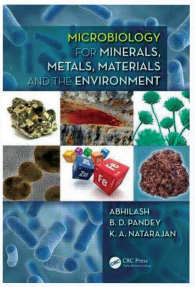
Publication having impact factor 6.16.

Singhbabu, Y. N., Kumari, P., Parida, S., & Sahu, R. K. (2014). Conversion of pyrazoline to pyrazole in hydrazine treated N-substituted reduced graphene oxide films obtained by ion bombardment and their electrical properties. *Carbon*, *74*, 32-43.


Conversion of pyrazoline to pyrazole in hydrazine treated N-substituted reduced graphene oxide films obtained by ion bombardment and their electrical properties

Publication of CSIR-NML's work under NML - TATA collaboration on "Desulphurisation of liquid iron through "in situ" generation of magnesium" on the cover page of "Steel Research International" (May 2014).



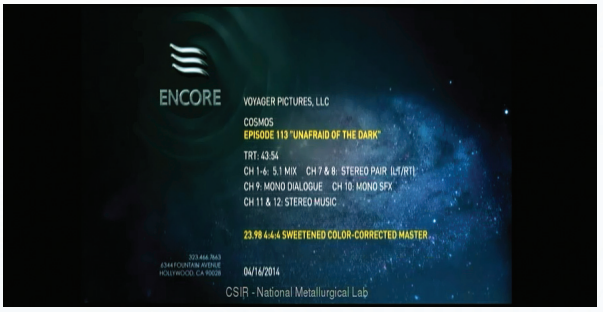


Books authored by CSIR - NML Scientists last year

Publication of CSIR-NML's work under the theme "Bio-mediated (bacterial) origin of the manganese nodules in the seafloor" in international print and visual media.

Paper : Nayak, B., Das, S. K. and Munda, P. (2013) : Biogenic signatures and ultra-microfossils in ferro-manganese nodules of Central Indian Ocean Basin. *J. Asian Earth Sciences (Elsevier)*, 73, 296-305 (IF: 2.831)

This work was cited and acknowledged by the visual media **National Geographic**. The scientific documentary series **"Cosmos: A Spacetime Odyssey"** in its final episode (episode 13; entitled **"Unafraid of the Dark"**) telecast some images/visuals from this work. "Cosmos" was aired by both FOX and National Geographic channels worldwide. The Voyager Pictures LLC, Los Angeles has used the concept of bacterial origin from this paper.



Impact on Society

Preparation of Anti-tarnishing lacquer for Copper based Alloys, Silver

Metal handicrafts and architectural work made from copper and its alloys (brass, bronze) tarnish (surface becomes black) when exposed to humid sulphide environments resulting in loss of aesthetic appeal. Prevention of tarnishing of copper and its alloys is required to preserve the natural color and beauty of metal architectural work made from copper and its alloys. Tarnishing is a major problem in the commercial exploitation of copper based alloys. For example, tarnishing of brass handicrafts has led to a decrease in sale of Indian made brass/bronze handicrafts in the international and domestic market threatening the livelihood of the brass artisans of India and the survival of the age old profession of brass artifacts' production.

A lacquer was developed at CSIR-NML to prevent tarnishing of copper based alloys and silver for long durations. Field trial of the lacquer was conducted at brass cluster, Moradabad, Uttar Pradesh in association with National Innovation Council of India, successfully. Finally, to make the lacquer available to the brass artisans of India, lacquer production technology was transferred to M/S. Mahashraya Chemicals Private Limited, Balasore, Odisha in April 2014 for commercial production of lacquer. The company has started commercial production in September 2014 and the product is available in the brand name of “Brass Care”.

CSIR-NML Interactive Programs (School-NML Interactive Programme (SNIP), Teacher-CSIR-NML Interactive Programme (TECNIP) and Industry sponsored students-NML Interactive Programme (INDSS-NIP)

These programs have been designed to give the students, teachers and professionals an exposure to modern laboratory conditions and to develop a science temperament in them for their career development. Under SNIP, CSIR-NML helped 58 schools to set up science clubs in their campus to ensure that budding young minds who had earlier visited the laboratory, maintain their focus and develop a passion towards science. As a part of this initiative, the laboratory also shared science literature, scientific video clippings, and provided expert advice in putting up the science club. Since, June 2011, more than 16,000 students from 178 schools along with their teachers have already participated in the program and derived the benefits. Under TECHNIP, proposed by the District Education Officer, East Singhbhum, which is a capacity building exercise for about 270 Government school Science teachers across the district is being conducted at CSIR-NML. The program comprises of motivational orientation towards fundamental science, information on ways to upgrade school infrastructure and insights into recent scientific developments. Already more than 268 teachers in five batches across East Singhbhum district have undergone the course. Under INDSS-NIP, CSIR-NML has initiated an interactive programme with Industry sponsored students deputed by academic institutes. Under this programme, three batches of students from Aditya Institute of Technology, Adityapur representing different sponsored Industries (Tata Steel Ltd.; Alfa Motors; Mahindra & Mahindra; RSBT Ltd.; Brakes India Ltd.; JMT Auto Ltd.; Ramakrishna Forging Ltd.; Tata Consultancy Engineering Ltd.; Tayo Rolls Ltd.; RSB Transmission India Ltd.; Kross Manufacture Ltd. and Adhunik Alloys & Power Ltd.) have visited CSIR- NML and interacted with the scientists and technical officials.

Targets Achieved for 2014 - 2015

Performance Targets

	Objectives	Planned	Achieved
1.	External Cash Flow (ECF)	20 Crores	30.12 Crores
2.	Industrial ECF (a part of ECF)	14 Crores	20.0 Crores
3.	International ECF (a part of Industrial ECF)	2 Crores	1.98 Crores
4.	Laboratory Reserve to be generated	10.5 Crores	8.31 Crores
5.	Expenditure (other than salary & pension & allowances)	18.30 Crores	15.1 Crores
6.	Customer Satisfaction Index	4.4	4.42
7.	Publications	125 Nos.	135 Nos.
8.	Patents	15 Nos.	28 Nos.
9.	Copyrights	5 Nos.	1 No.
10.	Technologies to be Developed	5 Nos.	10 Nos.
11.	Technologies to be Transferred	4 Nos.	8 Nos.
12.	M. Tech/Ph. D students for AcSIR	15 Nos.	13 Nos.

Technologies/Knowhow Developed

S. No.	Title	Type
1.	Graphene Coated Steel	Knowledge-base
2.	An Improved process for preparation of cold bonded carbon composite pellets for utilization of iron ore micro-fines and carbon bearing fines.	Proof-of concept
3.	Development of a process and design of a closed cell for production of sodium metal by fused salt electrolysis of sodium chloride.	Technology
4.	Injectable scaffold derived from biomimetic hydroxyapatite nanoparticles.	Technology
5.	Biomimetic polymer based hydroxyapatite block.	Technology
6.	Development of biphasic blocks.	Know-How
7.	Design, development and fabrication of annealing simulator.	Knowledge-base
8.	Cu-based ductile bulk metallic glass and a process for the preparation of the same.	Proof-of concept
9.	An improved suction casting assembly for the preparation of bulk metallic glass.	Proof-of concept
10.	A Process for Production of Highly Metallised Low Sulphur Directly Reduced Iron (DRI) from Iron Ore Slime and Rejected Coal	Knowledge-base

Technologies Transferred to Industry

I) Preparation of Anti-tarnishing lacquer for Copper based Alloys, Silver and Gold to M/S. Mahashraya Chemicals Pvt. Ltd., Balasore, Orissa.

ii) Energy efficient Coke based Brass and Bell Metal Melting Furnace to M/S. Technical Training Institute, Balasore, Odissa .

iii) Preparation of Anti-tarnishing lacquer for Copper based Alloys to Multicoat Surfaces Private Ltd., West Bengal.

iv) Energy Efficient Coke based Brass Melting Furnace to M/S. West Bengal Khadi & Village Industries Board, Kolkata.

v) Production of High Pure W-Powder from Supplied WC-Hard Metal Scraps to M/S. Wolfram Metchem Private Ltd., Kolkata.

vi) Production of Ferrite and Pigment Grade Monodispersed Nano Iron Oxide from waste chloride pickle liquor to M/S. Tata Pigments, Jamshedpur.

vii) Titanium diboride powder by single step carbothermal process to to M/S. Aum Techno Ceramics, Anand, Gujarat.

viii) Zirconium diboride powder by single step carbothermal process to M/S. Aum Techno Ceramics, Anand, Gujarat

Major Technological & Scientific targets Planned and Achieved in 2014-2015

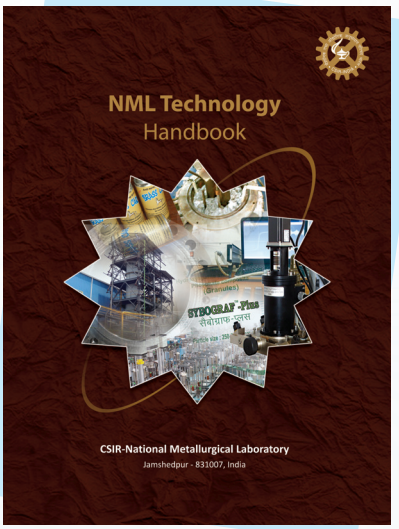
Targets Planned	Targets Achieved
Development of zero waste technology for processing and utilization of thermal coal: ● Flow sheet development for dry beneficiation of fine coal. ● Large scale demonstration of bulk utilization of fly ash. ● Bench scale processing for dry separation of cenosphere.	● Flow sheet developed for dry beneficiation of fine coal (<1 mm size) at laboratory scale (100 kg batch) ● The process of making paving blocks from the geopolymerisation of fly ash has been demonstrated at large scale. Around 20 tons of paving blocks has been produced which are meeting IS 15658 specification. Some of these paving blocks has been laid at different places at Jamshedpur for field trials. ● Fly ash samples from various units/fields of three different power plants (about 30 Nos) have been assessed for their cenosphere content using wet separation method. Bench scale processing for dry separation of cenosphere is in progress. ● Detailed characterization of two coal ash samples has been carried for their rare metal content. Preliminary leaching for Ge, Se, Te and Ga dissolution in alkaline and acidic medium and their enrichment studies were carried out.
Development of Magnesium Metal Production Technology: ● Process modeling of the electrothermal process of magnesium production. ● Magnesium production process at the scale of 300 kg Raw Material (~40 kg Mg)/batch. ● Final specification for the 1 ton Raw Material (~125 kg Mg) capacity pilot plant working in semi-continuous mode. ● Order placement to the Engineering Consultant, fabrication, erection, installation and commissioning of 1 ton Raw Material (~125 kg Mg) capacity pilot plant working in semi-continuous mode at CSIR-NML site and conducting of campaigns.	● Process modeling of the electrothermal process of magnesium production was completed. ● Optimization of Magnesium production process at the scale of 300 kg Raw Material (~40 kg Mg)/batch is in progress. ● *Second patent submitted on 'A process for the electrothermic production of magnesium metal [Ref. No: PAT-0440/2014/IN]* ● Since the process optimization at 300 kg scale has not yet been completed, no activity has yet been initiated towards the design, fabrication and commissioning of the 1 ton pilot plant
Non-destructive assessment of Creep: ● Preparation of simulated creep damaged specimen of P22 grade steel and initiation of creep experiment for P91 steel. Fabrication of device MagStar which will be used for magnetic measurement for creep damaged sample and will be handed over to NTPC for field activity. Initiation of generating NDE parameters using magnetic and non-linear ultrasonic techniques.	● Varying extents of creep damage in P22 steel were incorporated in specimens through appropriate creep exposure. ● Electromagnetic and non-linear ultrasonic (NLU) parameters were obtained from creep damaged P22 steel specimens. ● A MagStar system, which will be given to NTPC, has been fabricated by M/s Technofour, Pune. ● Experiments to simulate creep damage in specimens of P91 steel have been started.

Remaining Life assessment and failure analysis of strategic components: RLA and root cause failure analysis of strategic components like aero engines, buffer couplers, power plant components, etc. will be continued for the strategic sector in the current year also	Failures analyses of aircraft components of Indian Air Force and HAL, Koraput. Analysis of failures and investigation of product quality of CB couplers for RDSO, Lucknow. Failure analysis of turbine blades of a NTPC plant. RLA and Failure analysis of other power plant components of DVC, Tata Power, Essar Power, Adhunik Steel & Power Ltd., West Bengal Power Development Corp, KSK Mahanadi Power Ltd., Sasan Power Co. Ltd. conducted. RLA of power plants components of BPCL, NTPC, ONGC, PUSEB, MPEB, CESC, HPCL, TBW, IFFCO, Essar Steel, Kalyani Carpenters, Adhunik Steels. Failure analysis of engineering components for large industries like Lafarge India, Sesa Sterlite, Northern Coalfields etc
Coal core analysis: In collaboration with CIMFR, Dhanbad & CMPDIL, this programme will provide coal core analysis of at least 5000m of coal core samples	● During the period of April 2014 to March 2015, 6000m coal core samples have been analyzed along with the other R&D projects sponsored by different industries. ● From coal projects Rs. 1.84 Crore has been generated as ECF during 2014-2015. ● One publication in SCI Journal "Fuel" has been achieved.
High strain rate deformation of automobile grade steels: ● Determination of tensile properties of IFHS, DP 600 and 800 and C-Mn-440 steels at different strain rates (0.001 to 800 /s) ● Study the deformation mechanisms of these materials undergoing tensile deformation at different strain rates.	● Tensile behaviour of IFHS, DP600/800 and C-Mn 440 steel at strain rates of 0.001/s to 800/s. ● SEM-EBSD/TEM based investigation on understanding mechanisms of high rate deformation. ● Constitutive relation for high strain rate deformation. ● Validation of constitutive relation through bi-axial high rate deformation experiment.
Development of GMI-based Portable Magnetic Sensing Device for Detection of Carburization of Structural component of petrochemical / Refinery Industry : ● Development of GMI-based portable magnetic sensing device and measurements using carburised samples to be developed in the laboratory.	Rapidly solidified ~ 100 micron diameter wires with excellent GMI properties were developed. Using above wire, GMI-based portable sensing device MagSys-II was designed and developed. Carburised 321SS steel blocks were prepared for calibration of the device. The calibration was validated using service exposed Johnson screen materials. The device was demonstrated successfully at the R&D centre of Indian Oil Corporation Ltd (IOCL) and the device has been handed over to IOCL for field trials.
Development of Gas based Brass Melting Furnace for Rural Artisans: ● Transfer of technology of energy efficient coke based brass melting furnace to the brass cluster of Balasore district in Odisha	Technology transferred to Technical training Institute, Balasore, Odisha on 08.05.2014.

Tailoring of geopolymer properties by mechanical activation of fly ash: ● Building material using mechanically activated flyash will be developed, tested and evaluated.	Building materials with tailored properties from the geopolymerisation of mechanically activated fly ash has been developed. Studies on micro and nano structure of reaction product and its relationship with properties has been studied. This work resulted in 2 SCI papers and 4 papers in Proceedings of International Conference.
Potash recovery from feldspar with Simultaneous recovery of Ferro Silicon: ● Installation and commissioning of the arc furnace with suitable fume condensation unit. Experiments to be initiated for the production of potash	● A closed type 75 kVA electric arc furnace along with a fume condensation unit was designed, fabricated and commissioned for recovery of potash from feldspar. ● The smelting condition for volatilization of potash from feldspar was established using thermochemical analysis and experiments on 10 kg scale. ● About 9 smelting campaigns were successfully conducted for recovery of potash from the fume with simultaneous production of ferrosilicon.
Microstructural characterization of fusion boundary of ferrite - nickel based alloy in dissimilar metal weld : ● Study effect of welding nature, filler alloy and electrode on the characteristics of HAZ, martensite layer, Type-I and II boundary near fusion zone ● Study effect of re-distribution of alloying elements adjacent to fusion boundary on the development of Type-II boundary and martensitic layer These two will be applicable for dissimilar welds consisting of LAS and 304LN SS using 309L SS and IN 182 butter layers	● Microstructural characterization of two transition joints consisting of 309L SS and IN 182 buttering layer were investigated in detail using optical and scanning electron microscopy and X-ray diffraction. ● In-situ deformation has been done in SEM ● Quantification of structural features has been performed at different regions of joints. ● It was revealed that Type-I & II boundary as well as martensite layer were formed for both of them with varying dimension and distribution. Deformation occurred from buttering layer for both; however 309L SS butting exhibits better mechanical properties than the other
Graphene coated steel : ● Evaluate the feasibility of replacing galvanized coating with graphene coating on steel	A protocol has been developed for the graphene coated steel and its corrosion resistance properties are being evaluated. The results show that the graphene coating as an intermediate layer suppresses the corrosion of steel. The red rusting of the coated steel initiates after 200 h in salt spray, whereas the bare steel initiates after 6 h. The evaluated properties suggest that graphene can be used as a replacement of Zn in galvanized steel from the aspect of corrosion. Discussions are on for coming out plant trials at Tata Steel, Jamshedpur.

Business, Administration & other targets Planned & Achieved in 2014-2015

Business	
• Create and disseminate Technologies and Facilities brochures • Enable instrumental, infrastructure and facilities usage by industries and other clients • Attain online project monitoring in-toto • Strategize public private partnerships	• Equipment Brochure published, Technology brochure to be released on Technology Day '2015 • Equipment usage by externals significantly increased. • Online project monitoring for all ERP allowed activities implemented. • In process through mega projects.
Human Resources	
• Induct core manpower to the mission projects (Mg Technology, CRGO Technology & Coal dry beneficiation technology)	• Cross-divisional teams formed for mission projects. • Recruitment and assignment of Scientist Fellows and Project Assistants for mission projects.
Administration	
• Complete switchover to all online ERP processes • Integrate the biometric time attendance to online leave records • Implementation of RF-ID tracking on all PIR items • Improvement in overall speed & efficiency	• Biometric attendance and online record synchronized. • Administrative processes online.



A Critical Analysis of Revenue & Expenditure over the past three Plan Periods.

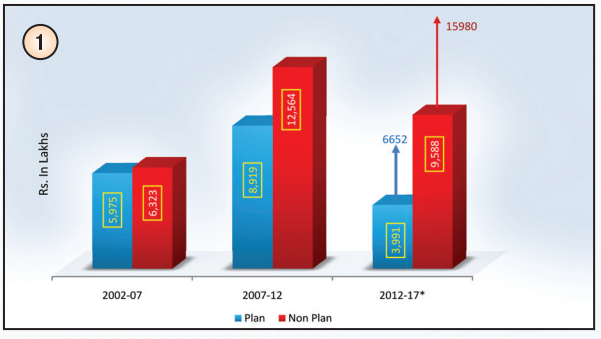
(10th, 11th and 12th Plan* Period)

LIST OF PLOTS

1. CSIR Grant + Lab Reserve Fund Position(LRF) – Plan & Non-Plan Expenditure
2. CSIR Grant + LRF – Plan & Non-Plan Expenditure (Year Wise)
3. Total Expenditure – CSIR Grant + LRF
4. LRF Position
5. Total Expenditure : Plan, Non Plan & Projects
6. Total Lab Expenditure Under Major Heads
7. Total Expenditure (from CSIR Grant + LRF) – Salary& Allowances
8. Total Expenditure (from CSIR Grant + LRF) – Consumables
9. Total Expenditure(from CSIR Grant + LRF) – Contingency
10. Total Expenditure(from CSIR Grant + LRF) – Capital
11. Total Expenditure (from CSIR Grant + LRF) – Travel
12. Total Expenditure (from CSIR Grant + LRF) – Maintenance
13. R & D and Non-R & D Expenditure
14. Expenditure per Scientist
15. Average Expenditure per Scientist from CSIR Grant + LRF

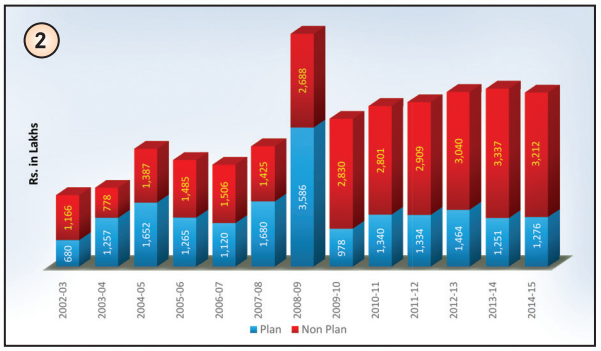
CSIR GRANT+LRF – PLAN & NON-PLAN EXPENDITURE

Plan Expenditure: Public expenditure that results in asset creation including all plan project allocation, P50 Apparatus & Equipment and P50 Works & Services; Non-Plan Expenditure: Recurring expenditure and includes all grants not covered under Plan.

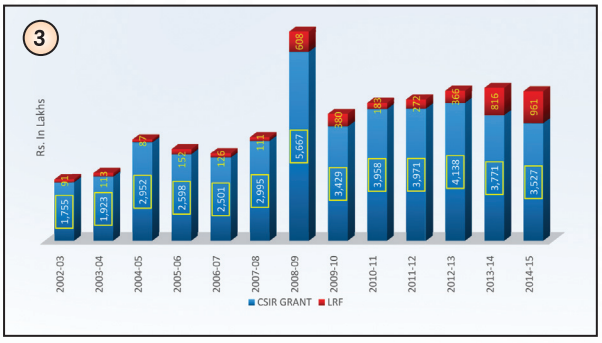


*upto FY:2014-15
10th Plan: 2002-2007, 11th Plan: 2007-2012 and 12th Plan: 2012-2017

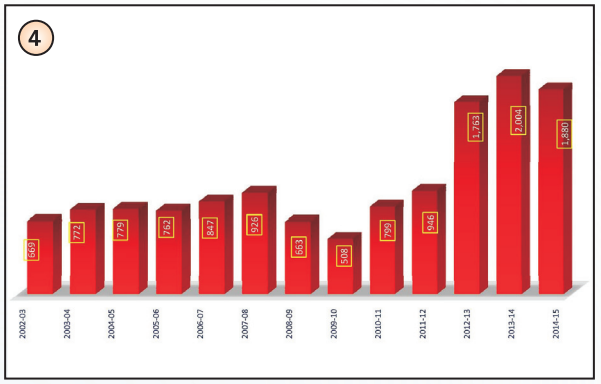
CSIR GRANT+LRF – PLAN & NON-PLAN EXPENDITURE (Year wise)



TOTAL EXPENDITURE – CSIR GRANT + LRF

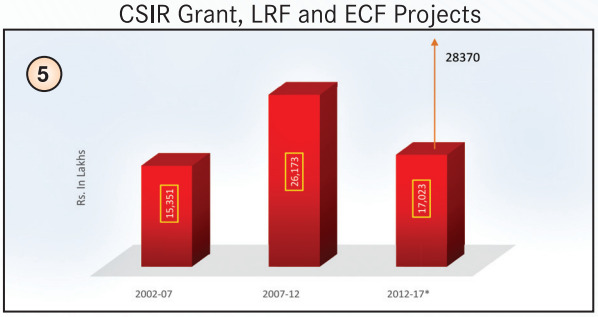


LRF Position



TOTAL EXPENDITURE: PLAN, NON PLAN& PROJECTS

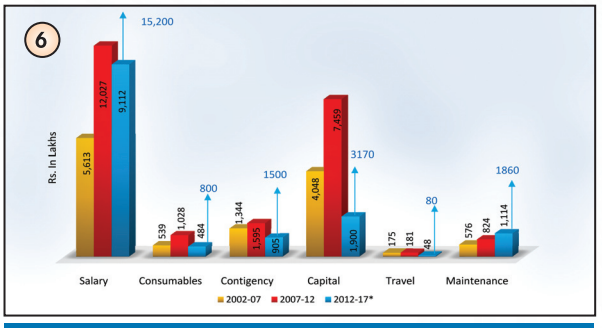
CSIR Grant, LRF and ECF Projects



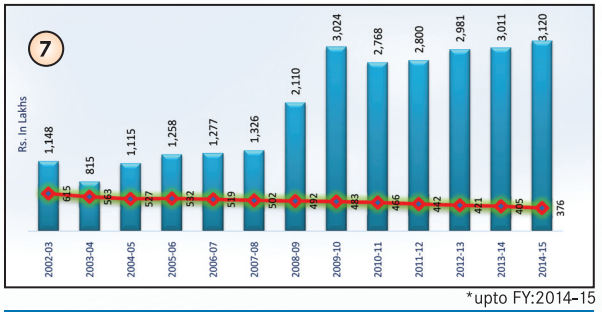
*upto FY:2014-15

10th Plan: 2002-2007, 11th Plan: 2007-2012 and 12th Plan: 2012-2017

TOTAL LAB EXPENDITURE UNDER MAJOR HEADS

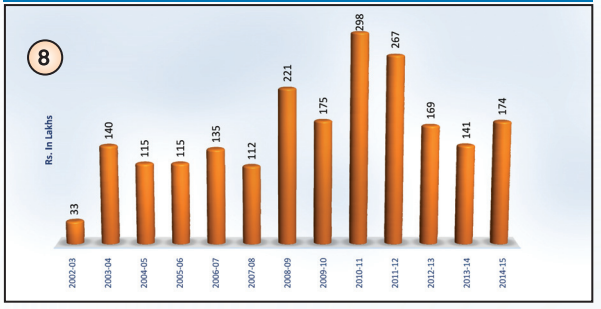


TOTAL EXPENDITURE (from CSIR Grant + LRF) – SALARY& ALLOWANCES

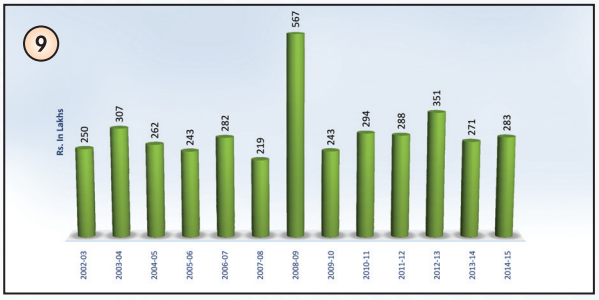


*upto FY:2014-15

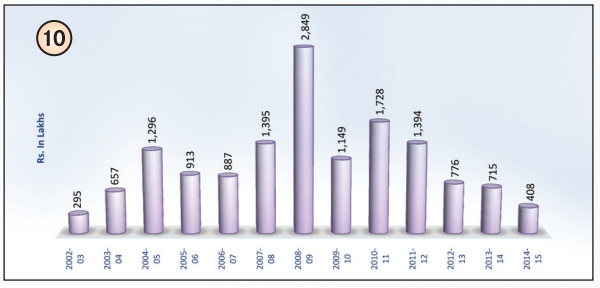
TOTAL EXPENDITURE (from CSIR Grant + LRF) – CONSUMABLES



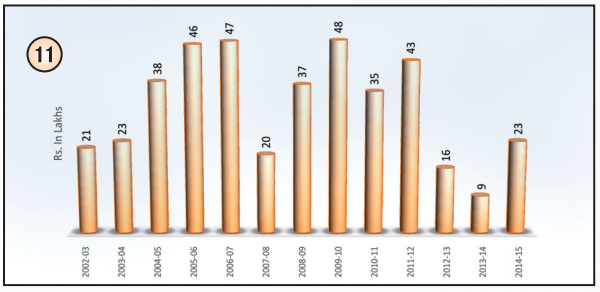
TOTAL EXPENDITURE(from CSIR Grant + LRF) – CONTINGENCY



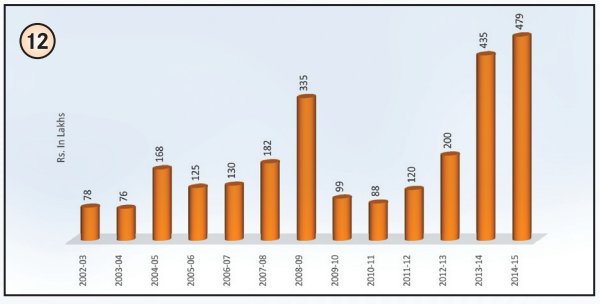
TOTAL EXPENDITURE (from CSIR Grant + LRF) – CAPITAL



TOTAL EXPENDITURE (from CSIR Grant + LRF) – TRAVEL



TOTAL EXPENDITURE (from CSIR Grant + LRF) – MAINTENANCE

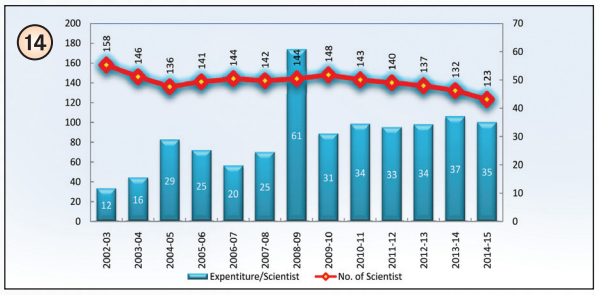


R&D AND NON-R&D EXPENDITURE

R&D expenditure: Capital & Consumables cost, Non-R&D expenditure: Salary, Contingency and Travel cost

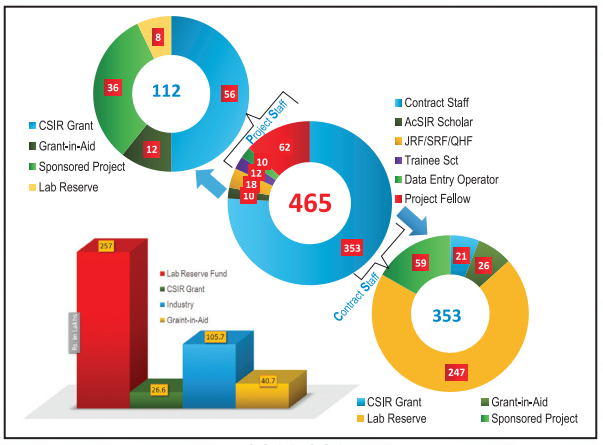
EXPENDITURE/SCIENTIST

Average expenditure per CSIR-NML Scientist from CSIR Grant, LRF



AVERAGE EXPENDITURE PER SCIENTIST FROM CSIR GRANT + LRF

EMPLOYMENT GENERATION



2014-2015

SKILL DEVELOPMENT

Societal

200 Rural Artisans of Moradabad &Balasore trained to operate brass melting furnace and lacquer develop by NML

50 Brass artisans from Bankura, West Bengal trained to make Dokra style brass handicrafts

17000 school students, teachers invited for science awareness and imparted capability building skills

Industry

Trained entrepreneurs of various industries in metallographic techniques, creep behavior of metals & Alloys and other materials evaluation techniques

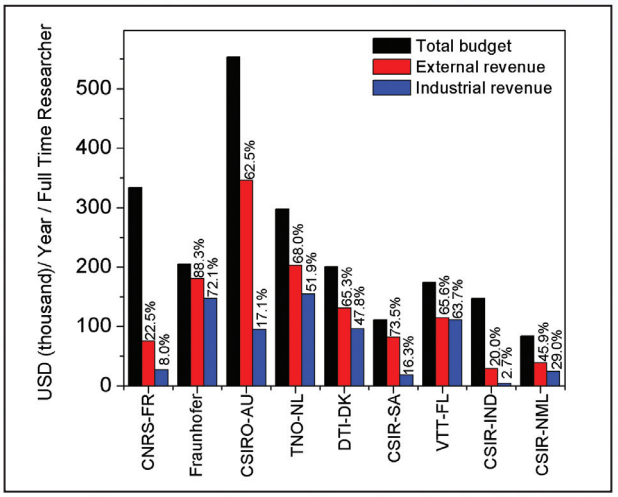
S&T Community

35 students enrolled for AcSIR Ph.D program

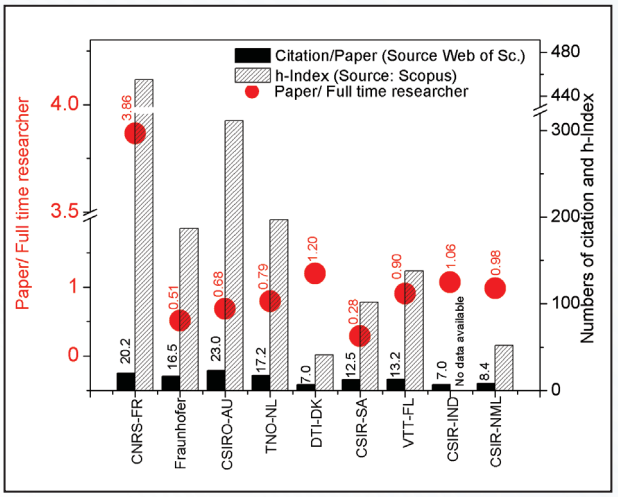
600 students from IITs, NITs and various universities trained through vocational training programs

Global Positioning of CSIR-NML

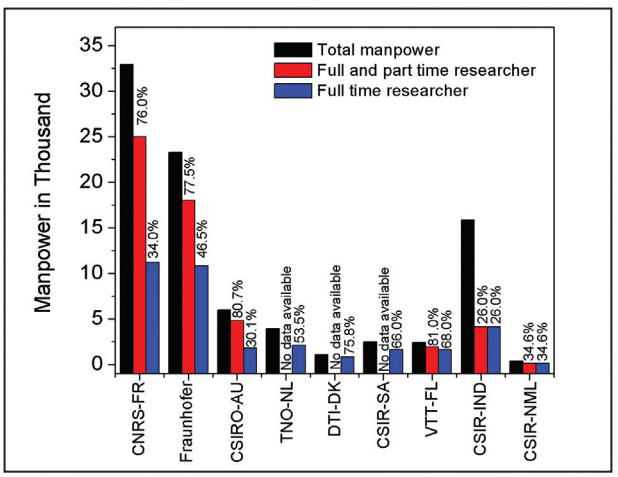
Budget



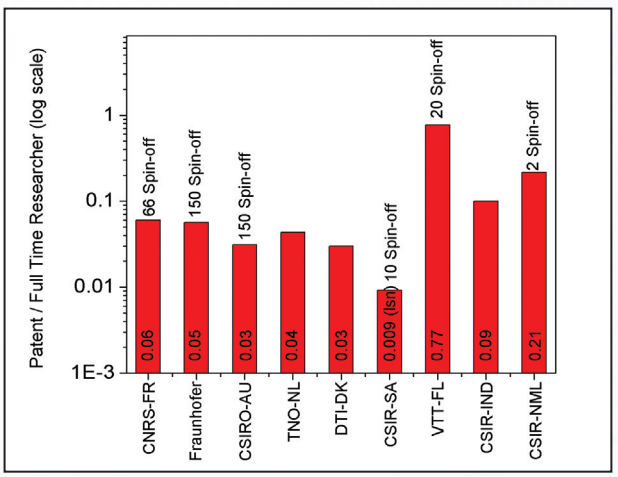
Scientometric



Manpower



Patent/ Technology



Sources of Data

Annual reports
Official Website
Scopus
Web of Science

Year(s) of Data

CNRS = 2013
Fraunhofer = 2013
CSIRO = 2013-14
TNO = 2013
DTI = 2014
CSIR-SA = 2013-14
VTT = 2014
CSIR-IND 2012
CSIR-NML = 2014-15

Flagship Projects

Development of Magnesium Metal Production Technology (MPT)

Magnesium is used for a diverse range of applications in the defence, automotive, aerospace industries and steel making. The objective of this 12th plan project is to enable production of magnesium commercially by the electrothermal process. The project is being pursued in in two phases: (i) at a 300 Kg capacity (raw material) pilot plant working in batch mode and (ii) at a pilot plant of 1 ton capacity (raw material) working in semi-continuous mode. Our engineering partner (Hindusthan High Vac) have done full system design, upgrading and integration of the existing facility at NML's pilot plant site. A large number of pilot trials were conducted to optimise operating conditions viz; temperature and pressure of the reactor chamber and condenser -crucible, and slag conditions of CaO, Al2O3 and SiO2. These pilot plant trials consisted of maintaining desired vacuum through proper sealing, maintaining the desired melting temperature through the proper control of voltage, current and electrode position of single phase single electrode 350 KVA submerged arc furnace. Results of these trials showed that the solid crowns of magnesium gets deposited in the condenser and crucible is of more than 97 % purity. The main impurity was MgO and other minor impurities like CaO, Al_2O_3 etc. were below 5%. The overall yield of magnesium varies from 75-85 %.

After 6 campaigns, lining near the slag tap hole was found to be severely damaged. Therefore, relining of the reaction chamber with carbon temping paste and its curing had to be done. An improved redesigned and fabricated ladle-heater was used for curing process.

In addition to pilot plant campaigns/trials, in collaboration with IIT Kharagpur, a FLUENT based model of the entire set-up was developed for detailed understanding of the spatial accumulation of magnesium and alkali metals with time. These predictive tools were validated during the trials. These tools will be useful for better control and operation of the process during scale-up.

Initially, few runs were carried out to tune the model after drawing and meshing, to see the effects of radiation, convection and conduction parameters to resemble the actual furnace. Then, simulation and experimental validation was carried out validation using the thermocouples embedded in the reactor. Modeling the condensation phenomena for one charge cycle considering three phase transport and the alkali vapour condensation was also carried out to study the condensation phenomenon in the reactor.

Fig.1: Magnesium Pilot Plant Set-up at CSIR-NML

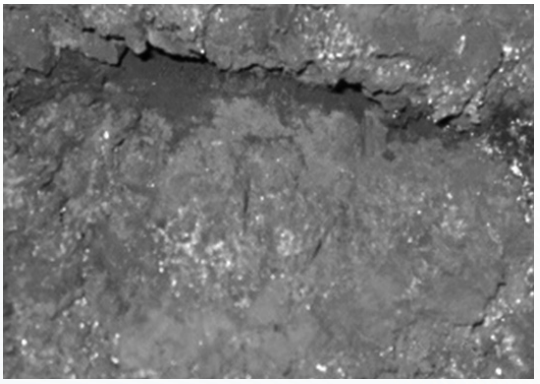


Fig.2 : Magnesium Crowns

Development of CRGO steels

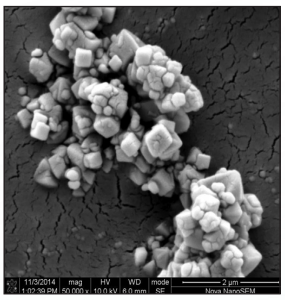
The objective of this project is to develop a technology for the production of Hi-B CRGO steels at pilot scale with core loss <0.6 watt/kg at a magnetic field strength of 1.7 Tesla. Towards this purpose, several smaller exploratory projects were taken up.

A. Design of a novel fabrication route for CRGO hot band production

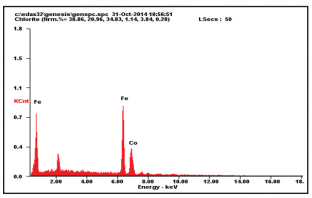
The aim of this project is to obtain the necessary Goss components in the hot band structure by directional solidification, texture use of soft magnetic inoculants & external magnetic field. The parameters will be optimized to obtain the optimum extent of directionality in solidification and the study of the effect of this directionality upon the post processing will be done.

Composition of inoculants is such designed that it does not affect the magnetic properties of the end product.

Hot rolling of the so produced cast ingot under a suitable rolling schedule will be done so as to obtain the desired microstructural & texture gradient suitable for further processing. Optimization of hot rolling schedule is under progress.

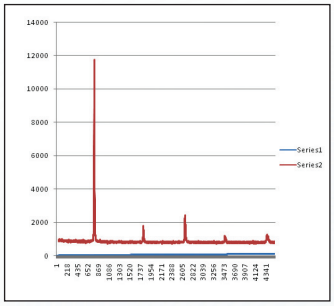


Designed Inoculant

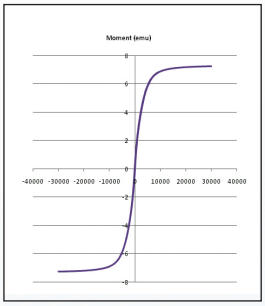


Element	Wt %	At %
FeK	67.86	69.03
CoK	32.14	30.97

EDAX Analysis



XRD Analysis of the innoculant



BH Curve of the innoculant

Fig.3 : Designed inoculants and their magnetic properties

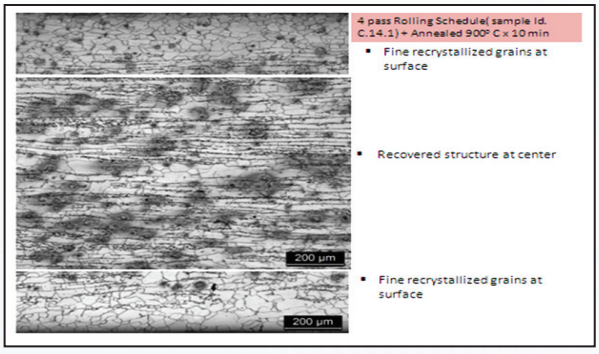
B. Producing the desired quality Hot Band required for subsequent process in production of Cold Rolled Grain Oriented (CRGO) steel

One of the major challenges in the production of CRGO steel is to produce a quality hot band , having the through thickness microstructure and texture gradient, at a lower slab reheating temperature. The main reasons for low slab reheating temperature is to avoid excessive formation of liquid slag on slab surface, avoid unwanted grain coarsening and at the same time reduce the energy consumption for slab reheating. Liquid slag if formed on surface of slab lowers the material yield and produces sedimentation in furnaces making too frequent furnace stops necessary.

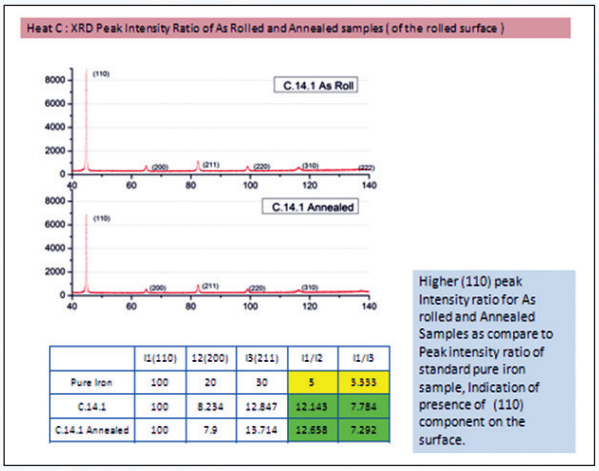
In the conventional process for producing hot band for subsequent CRGO steel production, MnS is usually used as inhibitor which requires high reheating temperature of 1350°C for its dissolution and re-dispersion.

Shifting from the conventional process, this work aims to achieve the desired quality of hot band through the solute drag effect of elements like Sn, Sb, Mo, Ti, Cu, thus eliminating the use of inhibitors in the hot rolling stages. This would also be accomplished at a lower reheating temperature of 1050-1100°C, thus eliminating the problems of high reheating temperature mentioned above.

Hot rolling simulations in Gleeble as well rolling in the mill are being done for different rolling schedules. Images of hot band obtained after rolling and subsequently annealed for 30sec at 1000°C are provided below.



Heat C : XRD Peak Intensity Ratio of as Rolled and Annealed Samples (of the rolled surface)



	I1(110)	I2(200)	I3(211)	I1/I2	I1/I3
Pure Iron	100	20	30	5	3.333
C.14.1	100	8.234	12.847	12.143	7.784
C.14.1 Annealed	100	7.9	13.714	12.658	7.292

Fig.4 : Hot band microstructure (a) and XRD line profile after hot rolling and annealing

C. Alloy design & Casting of CRGO Steels

A thorough literature search was first undertaken to get an idea of the kind of compositions in use worldwide. About 600 patents were scanned and it was found that three types of alloying additions are key to CRGO steels: Basic additions: C, Si; Inhibitor-forming elements: Mn, S, Al, N; Other additions: e.g. Bi, Sb, Sn, Ni etc.

- AlN, MnS, MnSe, CuS – these are well known inhibitors. The important parameters are their dissolution temp & precipitation kinetics.
- Elements like Sb, Sn modify the behaviour of precipitates, and change the distribution of grain orientation prior to abnormal grain growth that leads to Goss texture.
- Balance between alloying elements has to be maintained, e.g. Cr has to be balanced by Mn for ~30% austenite. Because Cr stabilizes ferrite whereas Mn, stabilizes austenite and 15-30% austenite is necessary for hot-rolling of CRGO steels.

With this background, several alloys were targeted. Often, it was a challenge to control the alloy chemistry precisely and Table1 shows the composition actually obtained. Al content was found to be low. The as-cast ingots were characterized. Micro-segregation, or coring was found to occur in the samples, as a result of non-equilibrium solidification. A suitable homogenization treatment was designed. Annealing at 1200°C for 45 min removed coring. Before the ingots are taken up for hot-rolling, the volume fractions of austenite and ferrite as a function of temperature were estimated using Thermocalc. Based on these data and discussions with Tata Steel, rolling schedules were designed. However, it was noted that after hot-rolling, the grain size was rather coarse, ~300-400 microns This could be reduced using a lower rolling temperature and lower holding time which led to a smaller grain size, ~ 200 µm, which is a step in the right direction. Also, the Al content in the steel was tweaked, so as to obtain better control over the hot-rolled grain size, which should be lower than 100 µm. The desired alloy chemistry was changed to the following as shown in the table 2 below. However, a number of problems were faced while melting these alloys, as listed below.

- The heats often showed too low S, not enough to form MnS inhibitors.
- Once again, low Al was observed, leading to too large grain size after hot-rolling.
- High Mn. Oxygen lancing could bring this down, but it also led to increased porosity/oxidation.

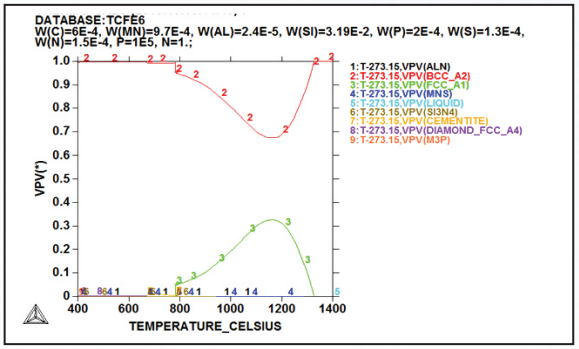
The as-cast structure of this ingot showed large grains, but devoid of inclusions and porosity. Further work on the thermo-mechanical processing of these ingots forms are being done.

C	Si	Al	N	S	P	Mn
0.06	3.19	0.0024	0.015	0.013	0.02	0.097

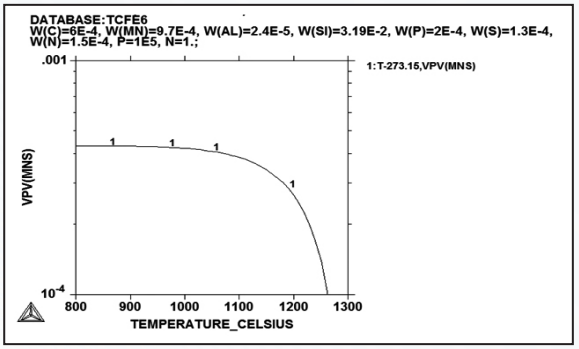
Table 1: An example of steel chemistry in initial melting trials

C	Si	Al	N	S	P	Mn
0.06	3.2-3.4	0.04-0.06	0.004-0.006	0.02-0.022	0.01	0.09

Table 2: Newer steel chemistry that was targeted



Thermocalc data showing the variation in austenite and ferrite volume fractions with temperature



Thermocalc data showing the variation in MnS (inhibitors) volume fraction with temperature

Development of zero waste technology for processing and utilization of thermal coal

A networked project on "Development of zero waste technology for processing and utilization of thermal coal" under the 12th five year plan was initiated by CSIR-NML Jamshedpur (Nodal Laboratory) with CSIR-IMMT Bhubaneswar andCSIR-CIMFR Dhanbad as participating laboratories with the following objectives:

- To develop suitable technology for dry beneficiation of thermal coals from India to produce 34% ash clean coal for power sector and 25% ash coal for DRI/cement
- Wet beneficiation of the rejects of dry circuit for maximum recovery of combustibles from thermal coal
- To develop green technology for gainful utilization and recovery of valuables from combustion products

Three non-coking coal samples from Dakra, Gare Block and Rajmahal were collected for the studies. Complete characterization of three different coals namely Dakra, Gare Block and Rajmahal with different ash level have been studied. Washability at various top sizes was performed for all three coals. The dry beneficiation studies at coarser sizes were carried out using Ore Sorter. The results obtained for different top sizes show encouraging ash reduction. Fine coal processing using air table shows sizable reduction in ash level after multi stage operation. As planned, in order to enhance overall combustibles recovery the rejects of dry processing were processed by wet gravity and flotation techniques.

In the studies related to utilization of 'Coal Combustion Product', the geopolymer products developed at pilot plant has been tested for its durability (Fig.5). The results show better durability behavior than the equivalent product produced using Portland cement. Further a life cycle analysis study was carried out on a pilot scale, which has shown significant reduction in CO_2 emission compared to the equivalent product produced from cement (Fig.6). A patent on "An improved process to produce brick from sponge iron plant coal ash using geopolymerisation" has been filed along with Tata Sponge Iron Co Ltd. During this period, our industrial partner Tata Power Co Ltd. has sponsored the study on "Development of marketable geopolymer cement from their fly ash'. Also efforts are on to transfer the technology through (a) CSIR Tech, Pune and (b) C-FARM, New Delhi.

Fig. 5 : Geopolymer products

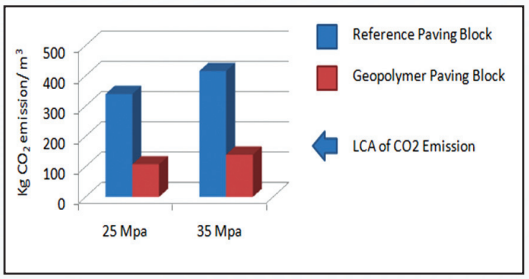


Fig. 6 : Graph showing reduction in CO_2 emission in comparison to the equivalent product produced from cement

Impression

I congratulate you and Srikanth that NML Repository ranks 14th in India

Best wishes

Ranganathan

....As you are aware we have commissioned the Beneficiation Plant and Pellet Plant - 1.2 MTPA , Technology and main equipment supplied by MCC Overseas Ltd, China. The Beneficiation plant is functioning reasonably well. The up gradation capability is also good. In put iron ore Fe at present is 55.5% to 56.5%. Concentrate Fe is averaging to 61.5% and the gangue total is +7%. The LOI in the feed is 6. and in the concentrate is +4. Our fines percentage has increased in the feed as mined , and as predicted in your report, the Fe carry over in the tailing is high in the range of +48...

Regards

C.S.Gururaja Prasad,
Usha Martin Ltd, Jamshedpur, India
08/06/14

...NML Publication providing so considerate service. That is helpful for researchers.

Thanks a lot. Best wishes for you.

Yours sincerely,

Shubin Wang, Japan
11/11/2014

Research Focus

Sir Chandrasekhara Venkata Raman (1888-1970),
Physics, 1930

He was an Indian physicist, born in southern India, whose ground breaking work in the field of light scattering earned him the Nobel Prize for Physics. He discovered that, when light traverses a transparent material, some of the deflected light changes wavelength. This phenomenon is now called Raman scattering and is the result of the Raman effect. In 1954, he was honoured with the highest civilian award in India, the Bharat Ratna.

Applied & Analytical Chemistry

Seam overall characteristics of coal core Samaleswari and Projapara, IB River coalfield, Orissa

The objective of the project was database generation of coal core of different region of Orissa with reference to geo-chemical characteristics. A detailed coal characterization with respect to macerals and their quantification was carried out. Macerals have been separated from mineral matter present in coal using density gradient separation method. Fig. 1 represents the composition of macerals in one of the identified coking coal of Indian origin. Coal contains 95% vitrinite in 1.2 density sink fraction along with minor concentration of inertinite and liptinite. It appears from the Fig. 1 (a, b, c) that vitrinite concentration increases with decrease in density.

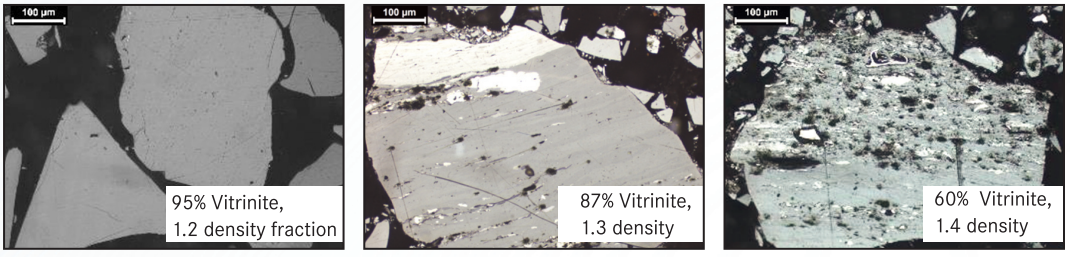


Fig.1 : (a,b,c) Composition of macerals (Vitrinite) at different density fraction

Evaluation of Coal Core Characteristics of different regions of Orissa

The objective of the project is database generation of coal core of different regions of Orissa

Coal macerals of some non coking coal as well coking coal samples of Indian and international origin will be characterized in detail for understanding the correlation between coal macerals and coking properties. Three different size fractions, -3.0mm + 1.0mm, -1.0mm + 0.5mm and -0.5mm, have been generated from three different categories of coal, Highly coking (HC), Semi coking (SC) and Non coking (NC). Macerals have been separated from each size fractions of HC, SC and NC. Fig. 2(a, b, c) represents the comparative study of quantitative separation of each maceral obtained from different coals in -1.0mm + 0.5mm size fractions. It appears from the figure that about 87-90% vitrinite has been obtained in 1.2 density fraction of HC and SC coal whereas in NC coal maximum 70% vitrinite is obtained.

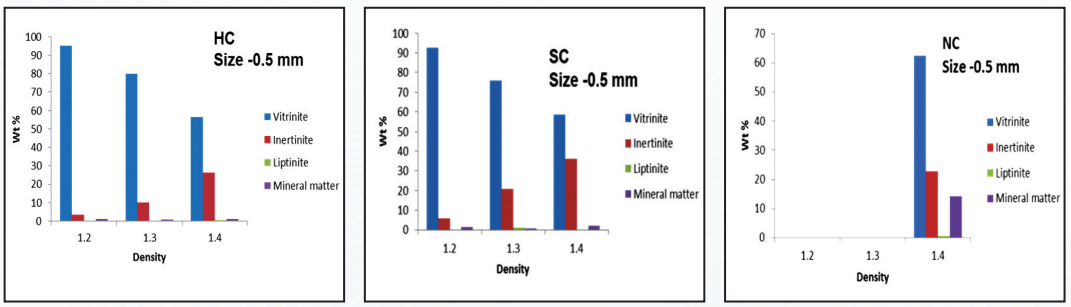


Fig. 2 : (a,b,c) Comparative study of quantitative separation of each macerals

Evaluation of Mozambique coal characterization

The objective of the project is characterization of Mozambique coal core with reference to proximate, ultimate and ash analysis. Coal Core characteristics of Mozambique coal has been investigated with reference to Proximate analysis. Coal Videsh group of Coal India Ltd. has sent the mined samples of coal core from 22 numbers of boreholes in two phases. In the first phase of mined samples, it was observed that the ash content in coal core samples was very high (more than 50%) with very low percentage of moisture. Lithologically most of the coal band showed the carbonaceous shale type. Some of the results with lithology is presented in Table 1.

Box No	BHN	FROM	TO	THICKNESS	RECOVERY	SAMPLE NO.	Lithology		
								Moisture %	Ash %
Box - 1	A1TM-02	60.50	61.30	0.80	0.80	C1	NCB	1.44	74.55
	A1TM-02	61.30	61.50	0.20	0.20	C2	CARBSH	1.53	65.46
	A1TM-02	61.50	61.70	0.20	0.20	C3	CARBSH	1.35	68.85
	A1TM-02	61.70	61.90	0.20	0.20	D1	NCB	1.20	79.50
	A1TM-02	61.90	62.30	0.40	0.40	C4	CARBSH	1.33	61.51
	A1TM-02	62.30	62.51	0.21	0.20	C5	CARBSH	1.29	65.41
	A1TM-02	62.51	62.72	0.21	0.20	D2	NCB	1.24	74.06
	A1TM-02	62.72	62.93	0.21	0.20	D3	NCB	1.46	90.02
	A1TM-02	62.93	63.98	1.05	1.00	D4	NCB	1.23	79.04
	A1TM-02	63.98	64.24	0.26	0.25	C6	CARBSH	1.24	63.59
	A1TM-02	64.24	64.56	0.32	0.30	D5	CARBSH	0.48	59.34
	A1TM-02	64.56	64.77	0.21	0.20	C7	CARBSH	1.06	62.72
	A1TM-02	64.77	65.30	0.53	0.50	D6	NCB	1.31	79.95
	A1TM-02	65.30	65.75	0.45	0.40	C8	CARBSH	1.31	69.82
	A1TM-02	65.75	65.98	0.23	0.20	D7	NCB	1.37	77.78
	A1TM-02	65.98	66.32	0.34	0.30	C9	CARBSH	1.41	72.48

NCB: Non combustable band, CARBSH: Cabonacious shale

Table 1 : Band by band analysis of Mozambique coal with reference to Lithology, Moisture and Ash

Investigation of hydride and valuable metal concentration in process and waste product samples of Hindustan Copper Limited.

A new method for estimation of hydride and valuable metal like Ag & Au has been established and used for chemical analysis of processed sample from Hindustan copper Limited, Ghatshila. Out of 1080 radicals, CSIR-NML has already generated results for 632 radicals and reported to Hindustan Copper Limited in the last eight months. Hydride generator AAS method has been used for Se, Te, As, Sb and Bi where as for Ni, Pb, Zn, Mo ICP-OES method has been used. For Au and Ag estimation ICP-MS has been used.

Evaluation of Materials

A. Non-destructive Evaluation

GMI based portable non-destructive magnetic sensing device for health monitoring through detection of carburization

A giant magneto-impedance (GMI) based sensing device called MagSys-II has been developed for non-destructive evaluation of carburization in Johnson Screens at refinery units of Indian Oil Corporation Ltd. MagSys-II (Fig.1) is a portable device using a nanostructured rapidly solidified wire, developed at CSIR-NML, as the sensing core. The device is capable of detecting very low magnetic fields and magnetic phases. The Johnson Screen, which is made of Fe-Cr-Ni alloy, is an austenitic stainless steel which is initially paramagnetic. Because of carburization during service in the reactors of refinery units, changes in the concentration of Cr, Ni and Fe imparts ferromagnetic properties to the material. This effect of carburization can be detected by the developed portable device MagSys-II.

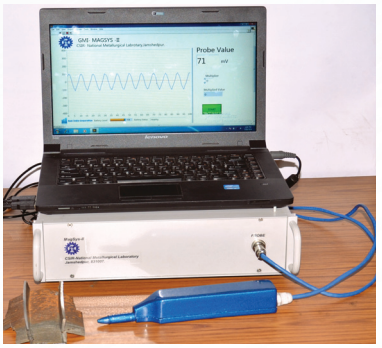


Fig. 1: Giant magneto-impedance based sensing device MagSys-II

Creep damage assessment using multi-parameter non-destructive examination

2.25Cr-1Mo steel specimens exposed to high temperature and stress of 600°C/100MPa and 550°C/115MPa for various time periods were assessed using electromagnetic and ultrasonic non-destructive techniques including Magnetic Barkhausen Emission (MBE), Magnetic Hysteresis Loop (MHL) and Non-linear Ultrasonic (NLU). The as-received microstructure of 2.25Cr-1Mo steel consisted of bainite and discrete carbides in a ferrite matrix. The microstructure is seen to be completely degenerated and creep voids are observed at grain boundaries with adjoining carbide precipitates in specimens subjected to creep damage (e.g. at 600°C/100MPa for 258 h as in Fig.2). The coercivity of creep exposed specimens initially decreases in the secondary creep region, then increases, and is followed by a continuous decreasing trend in the tertiary creep region. NLU parameter changes by 2-3 orders of its initial value towards the end of life. This change is observed for both conditions of creep exposure, i.e. at 600°C/100MPa and 550°C/150MPa.

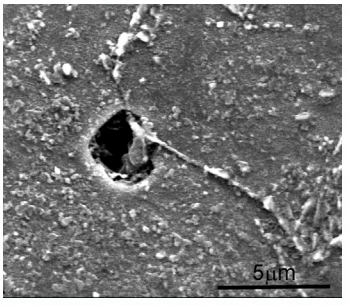


Fig. 2: SEM-SE image 2.25Cr-1Mo steel specimen failed at 600°C /115MPa for 258h

Assessment of central quality of high carbon cast billets using ultrasonic imaging

Casting often produces a thin chill zone of very small grains at the casting surface. This shell of solid metal grows into the remaining liquid as solidification continues, which is followed by a columnar and then an equiaxed zone at the core. The quality of cast billet is determined by the percentage of the equiaxed zone, carbon segregation at the centre and the central porosity. Desirable parameters for high quality steel billets are equiaxed zone greater than 16%, segregation index less than 1.12 and the central porosity less than 3 mm. Carbon segregation at the equiaxed zone may lead to localized cementite formation, thereby increasing the hardness and ultimately causing breakage during subsequent operations such as wire drawing. A large equiaxed zone is desirable, so that segregation per unit area is reduced. Current practice of caster plants is to assess the quality of entire length (typically 9 m) of billet from a 30 mm thick transverse section of the billet

through macroetching, chemical analysis, sulphur printing etc. Analysis of 30 mm of a billet cannot reveal the type of segregation (v-band, u-band or centreline), and is also not able to throw light on the uniformity in the distribution of porosity along the whole length of the billet. Moreover, the conventional techniques are time consuming, cumbersome and can evaluate only surface property. This project was aimed at assessing the central quality of longitudinally sectioned cast billet of length 3 m using ultrasonic imaging under varying casting conditions, obtaining the depth-wise distribution of defects through further processing of C-scan image and developing image processing software to separate segregation from pores. Under this project, trials were carried out at different casting strands under varying conditions at CC1 of LD1, Tata Steel, Jamshedpur, on high carbon steel billets. The major findings of this project are:

- Area of 95% of pores are within 0-6 mm² for 3 m long billet cast at high EMS (380 A), low casting speed (2.8 m/min) and low superheat (37°C), and defects are distributed along the centre line of the billet, which is desirable for quality billet.
- Distribution of pore density is non-uniform throughout the billet length.

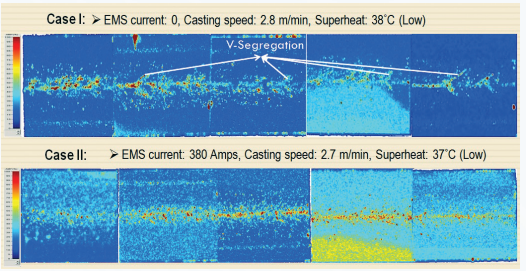


Fig. 3: Ultrasonic images of central zone of 1 m length billet casted at two different conditions

- Area of 90% of pores are within the desirable 0-6 mm² for 3 m length billet even when cast without EMS at low casting speed (2.8 m/min) and low superheat (37°C), but defect distribution along the centre region of such billets without EMS shows V-segregation, which is not desirable for quality billet.
- Ultrasonic imaging of only longitudinally sectioned sample could reveal the formation of V-segregation and non-uniform pore distribution throughout the length of the cast billets which otherwise was not revealed from transverse sectioned billet.

Fig. 3 shows the images of central zone of 1 m length billet as obtained using ultrasonic technique for two different casting conditions.

B. Material Evaluation

Creep-fatigue interaction in nickel based superalloy SU-718

Alloy GTM-SU-718 is used in many critical components of the gas turbine engine. During operation, these components are subjected to cyclic loading along with high temperatures. These operating conditions induce creep-fatigue damage. In order to predict realistically the life of these components, it is necessary to understand creep-fatigue interaction mechanisms, and also to generate creep-fatigue damage plots for use in life assessment. The present project aims at evaluation and characterization of damage arising due to creep fatigue interaction. The microstructure of the as-received material consists of γ' and γ'' precipitates. A dark field TEM image showing γ' and γ'' precipitates is illustrated in Fig. 4a. The cyclic hardening softening curves corresponding to isothermal LCF tests conducted at 600°C at different values of total strain amplitude is shown in Fig. 4b.

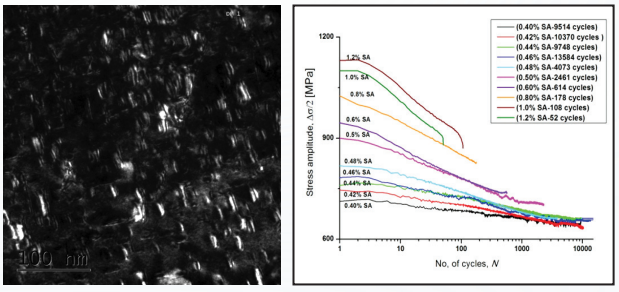


Fig. 4a : Dark field TEM image showing γ' and γ'' precipitates in as received IN 718 alloy; (b) Cyclic hardening/softening curves of isothermal LCF tests conducted at 600°C

High strain rate deformation of automobile grade steels

Tensile property evaluation of automotive grade steels has been carried out at different strain rates as shown in Fig. 5a for C-Mn-440 steel. Fractographic studies of the materials deformed at various strain rates have been conducted. For dual phase steels, the sub-structural information related to deformation behavior has been analyzed using transmission electron microscopy (Fig. 5 b). Fractographic studies reveal void nucleation and coalescence to be the predominant fracture mode. Through scanning electron microscopy, the possible sites and modes of the defects originating during deformation has been qualitatively analyzed to understand the fracture behavior (Fig.6a,b). In interstitial free steel, the dislocation density has been quantitatively evaluated for samples deformed at each strain rate through X-ray diffraction.

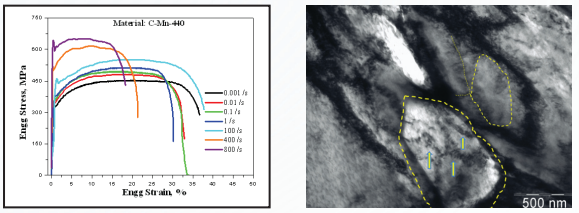


Fig. 5a : Engineering stress strain curves of C-Mn-440 steel deformed at various strain rates. 5b : Dislocation cell like structures obtained for DP600 steel deformed at 800 /s strain rate

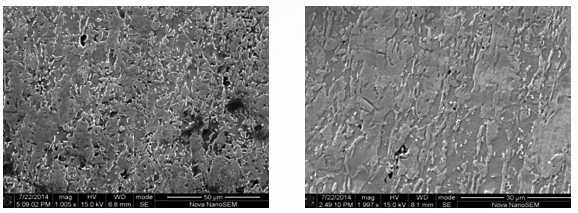


Fig.6a: Microstructure of DP800 deformed at 0.001/s strain rate shows voids and cracks originating from ferrite-martensite interface along with martensite cracking. 6b : microstructure of DP800 deformed at 800/s strain rate shows voids and cracks originating from ferrite-martensite interface only

Study on stress rupture behavior of Alloy 690 materials

Alloy 690, a Ni-based alloy, is used for fabrication of nuclear waste vitrification furnace pots. For reliable design at the service temperatures of 700-1100°C, an understanding of stress rupture behavior of this alloy is needed. Stress rupture behavior is being evaluated in the above temperature range at various stress levels to get rupture life ranging from 15 to 10,000 h. Tests completed so far indicated that creep behavior is different in the temperature regimes of 700-900°C and 1000-1100°C. Creep rate was observed to decrease rapidly reaching a minimum, followed by an accelerating creep rate stage which predominates through a major part of rupture life in the 700-900°C regime (Fig. 7a). No steady state creep rate stage was observed. At 1000-1100°C regime, a rapidly decreasing creep rate stage was followed by a steeply increasing creep rate stage which then continuously decreased until rupture for tests at 1000 and 1050°C. In contrast at 1100°C (Fig. 7b), an oscillatory creep behavior was observed with alternate periods of decreasing and increasing creep rate before reaching minimum level, followed by a prolonged period of continuously increasing creep rate stage leading to rupture. Crept samples show a higher and uniform elongation without necking at the rupture location.

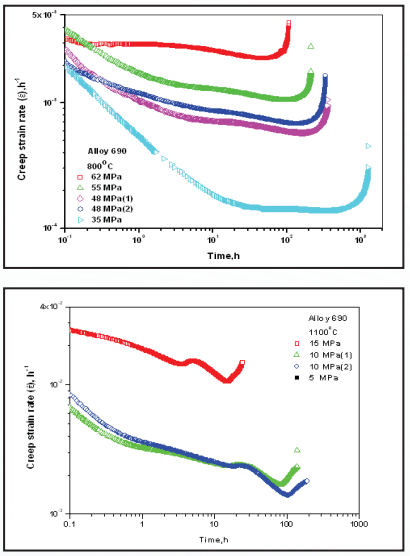


Fig. 7 : Creep behavior of Alloy 690 ; a) at 800° C; b) at 1100° C

Evaluation of creep rupture properties of ASTM A 387 Gr.22 steel

ASTM A 387 Gr. 22 material is a 2.25Cr-1Mo steel which is used in water wall tubes for sub-critical and super-critical boilers in thermal power plants. It is also used in re-heater, primary super-heater tubing systems, headers and in main steam piping system depending upon temperature. Creep rupture strength (S_r) in 1000 hour cycle has been evaluated at 500°C, 550°C and 600°C. Minimum creep rate values for different stress and temperature combinations has also been evaluated. Preliminary results are shown below (Fig. 8).

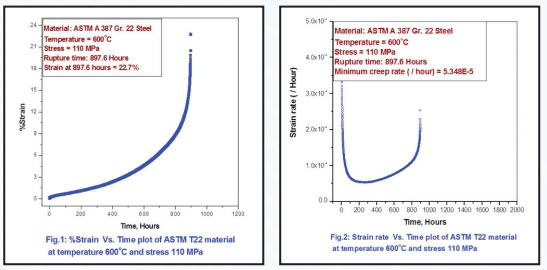


Fig. 8 : Creep properties of ASTM A 387

C. Material Characterization

Evolution of residual stress, crystallographic texture and cementite recovery during heat treatment of cold drawn pearlitic steel wires

Residual stresses, crystallographic textures and cementite recovery in cold drawn (drawing strain ~2.5) and heat treated pearlitic steel (0.8wt% C) wires have been studied by X-ray diffraction (XRD), transmission electron microscopy (TEM) and electron back scattered diffraction (EBSD). Heat treatment of the drawn wires was carried out in the temperature range of 260°C to 480°C for 1s. Diffraction stress analysis by d-sin$^2\psi$ method shows strong curvatures in the plots corresponding to {110} planes of ferrite phase of the cold drawn and heat treated wires which indicates considerable shear strain (and hence shear stress) components on the surface of the wire specimens. Measurements of crystallographic texture by EBSD confirmed the formation of (110)[$\bar{1}$10] circular texture in cold drawn and heat treated samples (Fig.9) which originates from the large amount of shear strains in the wire specimens. Early stage of cementite recovery during heat treatment has been studied by quantification of cementite phase fraction by Rietveld analysis. TEM micrographs show increase of cementite lamella thickness after heat treatment and formation of globular cementite at 480°C (Fig.10). Detailed analysis of broadening of XRD line profiles for the ferrite phase shows strain anisotropy (strong hkl dependence) due to high density of dislocations (~ 10^{16} m^{-2}) in cold drawn wires, which do not get annihilated even after heat treatment at 480°C for 1s. The work aims at establishing a correlation between cementite recovery, residual stress and crystallographic texture in cold drawn pearlitic steel heat treated under industrial conditions.

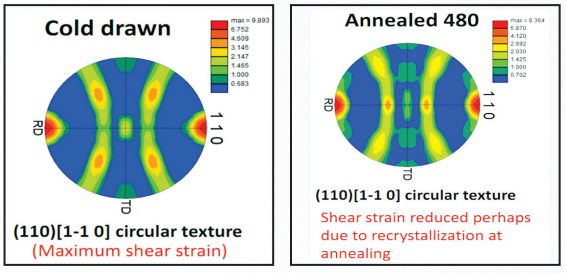


Fig. 9 : Circular texture development in cold drawn and annealed wires

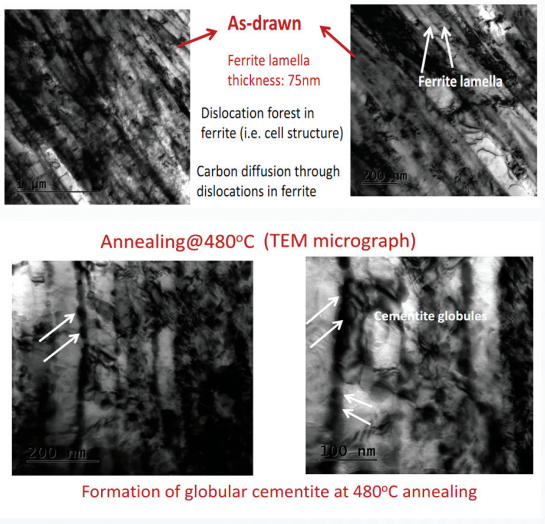


Fig.10 : Changes in cementite lamellae due to heat treatment.

Microstructural Characterization of Fusion Boundary of Ferrite-Nickel Based Alloy in Dissimilar Metal Weld

The main aim of this investigation is to identify the predominant microstructural factors for disbonding/reduced toughness of weld joints through structure-welding parameter co-relation. Three welded joints have been characterized (Fig. 11). For all of them, base material was low alloy steel (LAS, SA, 508 Gr.3 Class I) and SA 312 Type 304LN (304LN SS). Buttering alloy was IN 182, 309L SS, and IN 82 with weld metal of IN 182, 308L SS, and IN 182 respectively for three different joints. Characterization of welded joints involved optical and scanning electron microscopy, X-ray diffraction study and in-situ deformation experiments in SEM. LAS side exhibited fine grain tempered martensitic zone close to base metal and carbon depleted region adjacent to fusion boundary. Buttering alloy contained Type-I and II boundary and thin martensitic layer. Welding and post weld heat treatment propelled martensitic transformation, and through x-ray diffraction, except base material and martensite, no other phase evolution was identified. Weld metal showed typical solidification microstructure. Owing to crystallographic compatibility, weld metal - 304LN SS fusion boundary did not reveal any structural heterogeneity. For all welded joints failure occurred from buttering alloy during in situ deformation tests; however, distance of fracture location from fusion boundary was different for various welds. In that respect, buttering with 309L SS provided maximum weld strength with respect to others

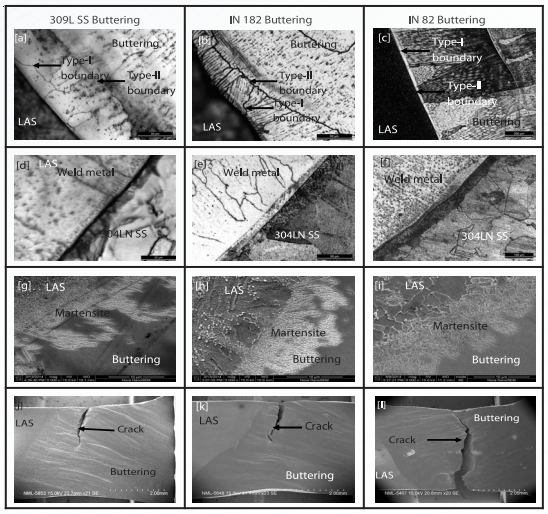


Fig. 11: Microstructural observations of different joints and joint regions. a-c: fusion boundary between LAS and buttering alloy (Optical), d-f: fusion boundary between weld metal and 304LN SS (optical), g-i: martensite layer formation near fusion boundary (SEM) and j-l: illustrated crack formation+ shear bands in buttering alloy during in-situ deformation study (SEM).

owing to higher extent of solid solution strengthening by diffusing species. Effect of other structural heterogeneities adjacent to fusion boundary on tensile strength was found negligible.

Microstructural analysis of LPTR Blades of R-29 aero engine

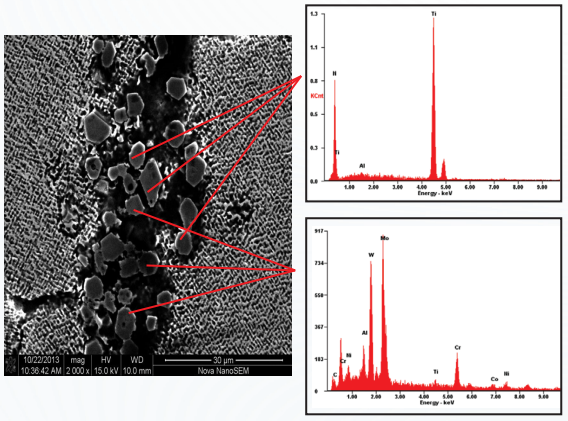


Fig.12 : SEM -EDS analysis of titanium nitrides (TiN) and alloy carbides (W-Mo-Cr-Ti carbide).

Studies on carbide segregation in the core microstructure of LPTR blades of R-29 aero engine along forging direction have been carried out. A set of seven blades and one round bar (raw material) made of Ni-base alloy-AP 220BD were selected for the study. The blades were manufactured by forging followed by solutionizing and aging treatment.

An uniform sampling/sectioning plan from core area of the blade material was executed for all items/components to assess the severity of carbide segregation. Two samples from each blade (i.e. longitudinal and transverse section) along the forging direction were cut and prepared by standard metallographic techniques. All the samples were examined by scanning electron microscope (SEM) and EDS attached with the SEM for microanalysis. Severe segregation of titanium nitrides (TiN) bands together with alloy carbides (W-Mo-Cr-Ti carbide) have been observed in the core of the blade material in forging direction as shown in Fig. 12.

D. Failure analysis and life assessment

Failure analysis of kneader components

There was repeated failure of solid cast flights and teeth in a kneader of an international aluminium manufacturer. Twenty two numbers of flights are mounted on a hollow shaft with a sliding fit as shown in Fig. 13. The shaft is attached with a gear box. The entire assembly rotates and simultaneously undergoes a reciprocating motion. This shaft revolves inside a hollow barrel jacketed with hot HTM oil (150°C). The purpose of the kneader is to mix dry aggregate (fed in kneader @157°C) with coal tar pitch (fed in kneader @200°C) and convey the same from the feed end to the discharge end. This mixture is called anode paste. The mixture travels through approximately 6-7 m before being discharged out of the kneader for further processing. There are teeth, bolted on the barrel, for cleaning anode paste from the space between the wings of two consecutive flights. The company had approached CSIR-NML to conduct metallurgical failure analysis. The major conclusions are collated in the next paragraph.

The microstructure/hardness (BHN) values of the failed and used kneader flights confirmed to ASTM designation A532/A532M Class III high chromium white cast iron.

Fig. 13 : Kneader used to mix dry aggregate and coal tar pitch to make anode paste in the green anode plant of aluminium industry.

However, the impact energy of specimen machined from the failed kneader flight was very low (4 J) and failure was attributed to lower tolerance of the material to impact loading. The un-notched specimen from the used kneader flight also showed very low impact energy value (i.e. 4 J). However, this kneader might have survived the impact due to a tougher metal matrix in the microstructure in comparison with the failed kneader flight, which was confirmed through micro hardness testing. The microstructure of the tooth material confirmed to the ASTM designation A681 S7, but the hardness value (BHN) was observed to be much higher.

Analysis of failed thimble of 20/90 Bajrang dragline of Nigahi project

Failure analysis of the thimble of 20/90 Bajrang dragline from Northern Coalfield Limited, Singrauli (MP) has been carried out (Fig.14). Experimental results confirmed that the thimble failed because of fatigue failure. The component failed approximately after 90,000 cycles of loading and unloading. Generally, a typical Dragline takes around 1 minute for its loading and unloading cycle. Fatigue was initiated from the surface /subsurface defects. Chemical analysis result shows that the thimble is made of low alloy steel with Ni, Mn and Cr as major alloying elements and with medium carbon. The chemical composition of the thimble is equivalent to SAE-AISI 8617 grade which is a forging grade steel. However Si content of the component is relatively high (~0.80 wt %) which generally happens in case of cast low alloy steel. Microstructure of the thimble consists of 75 vol.% ferrite and 25 vol.% pearlite and their average grain

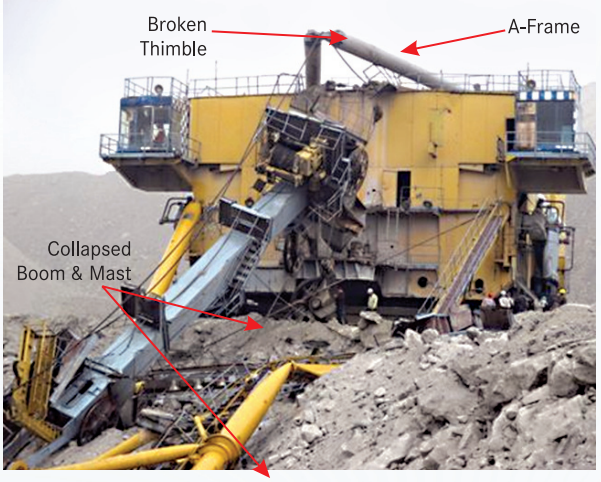


Fig. 14 : Photograph of the failed Dragline

size is 45µm. Banding of pearlite had occurred. Pearlite banding occurs because of Mn and Cr segregation and the degree of banding increases with hot forging or rolling. Microstructure banding and fully grown equiaxed recrystalized grains confirm that the thimble was hot forged. Mechanical properties of the thimble material were normal for the design application.

From the experimental results it is evident that the material integrity of the component was compromised by welding on its surfaces. Welding on the surfaces was carried out at varying depths up to 1cm on the entire half of the top and bottom surfaces of the Thimble. Welding passes were along the width direction which resulted in uneven surfaces. SEM-EDS analysis confirmed that the welding was carried out with similar metal as that of the thimble. However analysis of the welding zone revealed severe welding defects in the weld metal as well as in the interface between base metal and weld metal. Welding defects are typical slag entrapments and welding cavities/porosities. Fatigue was initiated from the welding defects and caused the failure of the thimble.

Failure analysis of boiler tubes

The failed economizer and low temperature super heater (LTSH) boiler tubes of a thermal power plant have been investigated. The economizer tubes were of SA210A1 grade steel and the LTSH tube was made from SA210C grade steel, comprising of ferrite and pearlite microstructures, some degree of spherodisation was observed in the microstructure of economizer tubes, however, there was no degradation of microstructure in LTSH tube. The spherodisation of pearlite was due to the long time (~105 h) service exposure at the operating conditions (Fig.15). The chemical compositions, hardness and tensile properties of the tubes were found to be as per the standard specifications. The economizer tubes failed due to pin-hole leakage at the welding region due to inner surface corrosion, as evident from the numerous pits in the inner wall of the tubes near the pin-hole. It was attributed to aggressive corrosion environment at the fusion zone. Cu was present on the inner tube surface, dominating the galvanic corrosion between the contact of dissimilar metals of iron and Cu. Moreover, the inner tube surface was also exposed to high amounts of oxygen, leading to oxygen pitting of the tubes. Therefore, both oxygen pitting and galvanic corrosion are the main reasons behind the failure of the economizer tubes. In contrast, one LTSH failed through a diamond shaped fish mouth opening at tube wall, which was due to initial thinning of outer wall as well as non-linear heating.

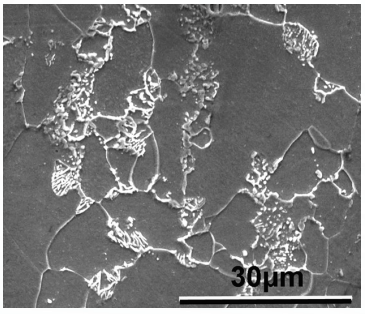


Fig. 15 : SEM-SE image of cross section of a service exposed (~ 10^5h) economizer tube

Failure analysis of damaged 1st stage Fan Rator blade of aero engine

Metallurgical analysis was carried out to find the cause of damage to the blades. These blades are made of Ti alloy with Al, Mo, Cr and Si as major alloying elements. The chemical composition conforms to Russian grade BT 3-1 Titanium alloy. Both the blades had a microstructure consisting of α and α+β phases. The damage of fan blades occurred due to impact with foreign object (Fig.16). The EDS analysis of the foreign object showed presence Fe and Zn. Therefore it was concluded that the blades were damaged by the impact of galvanized iron based metallic material.

Fig. 16 : Photographs of the as received 1st stage Fan Rotor Blades (a) Blades No. 4 and (b) Blades No.21, as seen from the pressure side. The damaged region of blades is indicated by red arrow.

Remaining life assessment of Hydrogen Reformer and Pig-tail Tube

Service exposed materials in petrochemical industries and power plants have finite life because of prolonged exposure to high temperature, stress and aggressive environment. Most of these plants are over 25 years old and RLA has become an imperative. In real life situation both premature retirement and life extension (in relation to design life) can be encountered. The decision for retiring a component is not purely technical but also one of economy and safety.

The subject hydrogen reformer and pig tail tube had been in operation for the past 13 years. It was constructed of 25Cr35NiNb (HP 40) and 20Cr33Ni steel respectively. From the plate supplied by the sponsors, standard specimens were machined out for hardness test, accelerated stress rupture test and for metallographic studies. SEM micrograph of as received (uncrept) pigtail (Fig.17) revealed presence of creep cavitation/voids (indicated by white arrows).

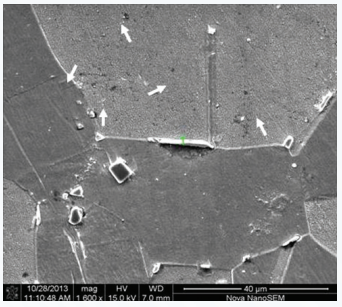


Fig. 17 : SEM micrograph of as received (uncrept) pigtail

RLA of crude distillation and Visbreaker unit heater

The main objective of the present investigation was to assess the remaining life of Visbreaker and crude distillation column material after 16 years of service exposure while operating at temperatures of 450 and 360°C and hoop stress of 8.78 MPa and 11.12MPa respectively. The as-received material confirmed to P9 and P5 grade of steel. The microstructures of these steels revealed that the materials were free from creep cavitations and decarburization, and showed fine precipitate of carbides, prior austenite grain boundary, and martensitic laths. Tensile properties of these steels were evaluated at ambient, as well as, at elevated temperatures. For an estimation of remaining life of the component, creep tests were performed at higher temperatures (500 and 450°C) as compared to the operating temperature (450°C) of the component in the stress range of 178-291MPa. Visbreaker and crude distillation column data were superimposed on stress vs. LMP plots of standard NRIM data (Fig. 18) and it showed that the data conformed to the standard data line. Both the components are in healthy condition and have balance lives of greater than 10 years.

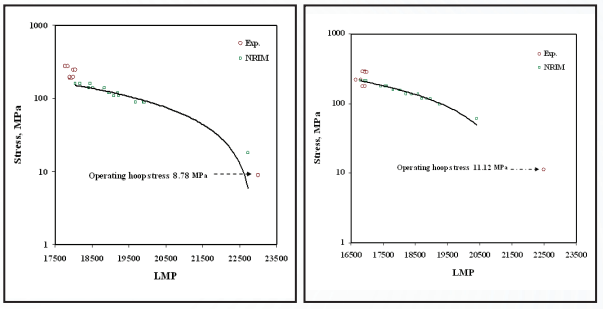


Fig. 18 : (a)Stress vs LMP Plot for 16 years service exposed Visbreaker material. All data fall above NRIM standard data line. (b) Stress vs LMP Plot for 16 years service exposed crude distillation for comparison with NRIM standard data line. Most of the data fall around and above the NRIM virgin data and within the –20% standard data line.

Extractive Metallurgy

Production of low phosphorus steel through induction furnace route using DRI as major ferruginous material – An Industrial Assessment

This investigation is the second phase of the previously completed project "Production of low phosphorus steel using DRI through induction furnace route adopting innovative fluxes and/or design (Refractory) change" which was sponsored by the Ministry of Steel, India, and in which the metallurgical conditions were established for removal of phosphorus from steel melt in a laboratory scale induction furnace. The objective of the current study was to test the findings of the first phase at an industrial scale and suitably amend the practice for converting it to a technology.

To conduct the industrial trial in an induction furnace, approximately 2 tonnes of pre-fused flux was prepared at CSIR-NML. The pre-fused flux were analysed for its desired composition. Laboratory experiments were conducted to ascertain the feasibility of the flux prepared in bulk. Thereafter, the pre-fused fluxes were tested at bulk scale in industrial induction furnace for phosphorous removal. CSIR-NML team visited M/s. Young Steel Pvt. Ltd., M/S. Precon Technology and Casting Ltd. Bhiwadi, Rajasthan, and M/S. AC Steel, Raipur, industrial furnace designated by MoS and IIFA to explore plant trials and make necessary arrangements for the same. Finally, M/S. AC Steel, Raipur was selected for the plant trials. The first industrial trials were carried out in a 6 Tonnes commercial induction furnace. The initial metal pool was created by melting approximately 1 tonne of low phosphorus mild steel scrap, and 5 tonnes of sponge iron was subsequently dissolved in the metal pool through batch additions. The slag generated during melting/dissolution of sponge iron was removed from the liquid pool.

Two major variables namely (a) the amount of flux (b) oxidation potential of the slag have been investigated under these trials. Varied amount of pre-fused flux and required amount of mill scale were added in the slag free bath in three batches. Roughly 5 minutes was allowed after addition of each batch for the reaction and the slag generated was removed. Final adjustment of alloy was made and poured into pencil ingot mould. A total number of eight trials were conducted. After addition of pre-fused flux the P was reduced from an initial range of 0.080 - 0.086 to 0.046 – 0.050. It was also observed that there was a negligible attack on the lining. The melting behaviour and refining capability were found to be good. A composite refractory has been decided in consultation with the plant personnel. The concept of complete composite lining of the furnace vis-à-vis sleeve at slag line is being evaluated with the help of refractory experts. The next set of trials are planned in higher capacity induction furnaces in order to optimize the process parameters such as bath composition, amount of flux and mill scale consumption, lining erosion pattern and slag removing device.

Fig.1 : Industrial Trail for De-Phosphorisation at M/S. AC Steel, Raipur

Effect of varying ratio of ore type on properties of iron ore pellet

Tata Steel is presently using blue dust (30-70%), low alumina friable ore (15-25%), high alumina friable ore (10-50%) and hard ore (1-5%) of Noamundi for iron ore pelletization. However, the properties of pellets especially, swelling is observed due to the fluctuation of above ore ratio in raw material from time to time in spite of identical basicity and MgO. The present work aims to study the effect of varying ore types (Blue Dust, Friable ore and hard ore) in pellet to assess their usability and development of a technique for good quality pellet making with optimum ratio. It has been observed in the first stage of experiments that pellets made of 100% hard ore shows very poor green properties, blue dust shows very high swelling index (45%) and friable ore shows good pellet properties. Therefore, suitable mixing ratios of these three ores are necessary to get optimum pellet properties. The study is ongoing.

Studies on improving reducibility of iron ore pellet

Reducibility of hematite pellet in Tata Steel is presently 65-67%. In order to increase the performance of pellet in blast furnace, improvement on reducibility index (RI) of hematite pellet is one of the important factors. The objective of the present study is to explore the possibility of improving RI by 3-5% point or above by optimizing induration temperature, changing size distribution of pellets, changing pellet chemistry (using fluxes/additives) and improving apparent porosity. Based on the studies carried out, it has been found that reducibility index (RI) of pellets increases with decrease in induration temperature. 4-5% points RI improvement has been observed along with improved compressive strength (390 kg/pellet) when induration temperature was reduced to 1275°C from usual induration temperature of 1325°C. Swelling and RDI properties are also very good and well below the acceptable limit at this induration temperature. Reducibility improvement up to 4% points has also been found when size range of pellets has been reduces to 8-10 mm from its standard size of 10-12 mm. Other possibilities to improve RI of pellets are ongoing.

Effect on pellet properties due to partial replacement of bentonite by designated organic binder

Bentonite is widely used as binder for iron ore pelletization in India. However, availability of bentonite in future is in doubt. Further, bentonite is also a source of silica. Worldwide, there are some organic binders available like Peridure, Funa etc. which are commercially used. Details of their chemical composition and method of processing is not available. Tata Chemicals have developed organic binders such as carboxy methyl cellulose (CMC), ground nut shell (GRN) and lignin from natural resources which have the potential to be used in pelletization process. The present investigation aims to use these organic binders developed by M/S Tata Chemicals as partial replacement for bentonite and study their effect the pellet properties.

Iron ores were prepared (at 2-3 kg scale) from the raw materials of Tata Steel by adding different doses of organic binders along with bentonite at 0.25 basicity and 1%MgO. The total binder percentage was kept at 0.4%. The green pellet properties such as green compressive strength, drop number and dry compressive strength were measured. The green pellets were indurated at 1300°C for 7min. The compressive strength (CCS) was measured. The physicochemical characterization of the indurated pellets such as RI, RDI and swelling is being carried out.

The results indicate that with more than 0.1% increase in CMC, pellet making was difficult. However, GRN and lignin percentage could be increased to 0.3% without compromising the metallurgical properties. Therefore, GRN and lignin can replace 0.4% bentonite; while 0.1% replacement of bentonite is possible in case of CMC. Further, use of 0.2% GRN can provide good pellet properties without addition of any bentonite.

Effect of an organic binder and copper slag on pelletization of hematite ore eliminating bentonite

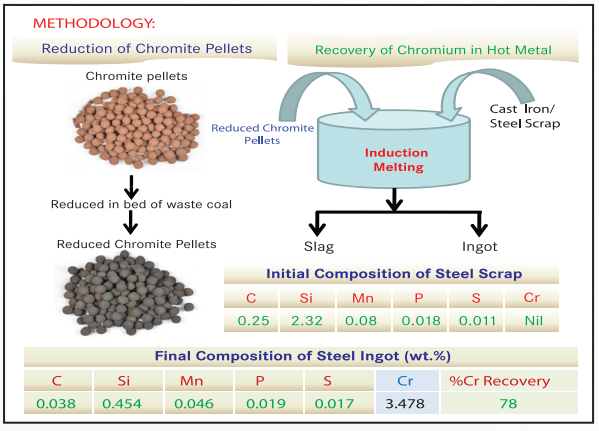
Bentonite has very good bonding property in green pellet and dry pellet at ambient as well as elevated temperature. However, due to its high alumina and silica content, it increases the slag volume and energy consumption in downstream processes. An organic binder may be used to replace bentonite. However, it fails to provide strength at high temperature (600-900°C) due to its poor thermal stability, during pellet induration. In the present study, an organic binder Na-Lignosulphonate (NLS) has been used to provide pellet strength at low temperature. However, to retain the pellet strength at high temperatures, during drying, Copper-smelting slag (Cu-SS) has been used. It contains a considerable amount of iron oxides. FeO present in Cu-SS oxidizes in induration atmosphere and provides diffusion bond above 500°C and recrystallization of hematite which, maintain the strength of the pellet during drying inspite of the evaporation of NLS. 1.0% Cu-SS addition with 0.5% NLS in pellet has been found to be optimum to provide around 300 kg/pellet cold crushing strength (CCS) at 1250°C induration temperature. However, the hematite pellet of similar basicity with 0.5% bentonite requires higher induration temperature (1300°C) to achieve similar CCS; i.e. induration temperature of hematite pellet could be lowered by 50°C. The developed pellet also shows better reducibility (80%), similar reduction degradation index (18%) and swelling index (10%) than the usual bentonite pellet. Thus, the use of NLS and Cu-SS combination in place of bentonite in pellet can provide a considerable energy and cost saving.

Scaling up of process developed for utilisation of LD slag as flux

In the previous work carried out in a 50 kVA Electric Arc Furnace, a new product was generated from LD slag which was rich in lime (>60%), low in FeO (<1%) and low in P (<0.5%) and was suitable for recycling within the steel plant. The work was carried out at 10 kg scale. The present study was undertaken to generate the product at a higher scale (100 kg) and optimize the process parameters to make the process commercially viable. Based on trials in a 150 kVA Electric Arc Furnace (EAF), it is now possible to melt the slag at 100 kg scale and, treat it with carbonaceous material for iron and phosphorous removal. Further trials would be carried out to produce the material in bulk quantity for testing recyclability in steel plants and in cement industries.

Recovery of Chrome Value from Chromite Ore

In this study, an attempt was made to directly recover chromium in hot metal (iron) from chromite ore. Experiments were designed for recovery of chromium in a 5 kg Induction furnace by : (a) Addition of chromite ore in the form of pellets in the metallic pool of cast iron; and (b) injection of partially reduced chromite ore pellets in the metallic pool of cast iron. Jhama coal was used as a reductant for reduction of chromite ore pellets. Process parameters were optimized for the reduction of chromite pellets with Jhama coal as reducing agent. It is interesting to note that a maximum recovery of chromium was found to be 75 to 78%, in case of addition of partially reduced chromite ore pellets in hot metal.



Initial Composition of Steel Scrap

C	Si	Mn	P	S	Cr
0.25	2.32	0.08	0.018	0.011	Nil

Final Composition of Steel Ingot (wt.%)

C	Si	Mn	P	S	Cr	%Cr Recovery
0.038	0.454	0.046	0.019	0.017	3.478	78

Reduction smelting of copper slag

High volume of slag is generated from copper smelting and it contains significant amount of oxides of both iron and silicon. Together they constitute around 75-80% of the slag. The complete recovery of Fe, Cu and partial recovery of Si from the slag reduces the slag volume and thus minimizes the disposal problem. Therefore, a study was carried out to recover the above mentioned metals from the slag through smelting reduction in a 50 kVA EAF (10-12 Kg scale) using metallurgical coke. Smelting studies revealed that almost all the copper could be recovered from the slag. More than 80% recovery of iron was obtained. Some amount of silicon recovery from the slag was also obtained.

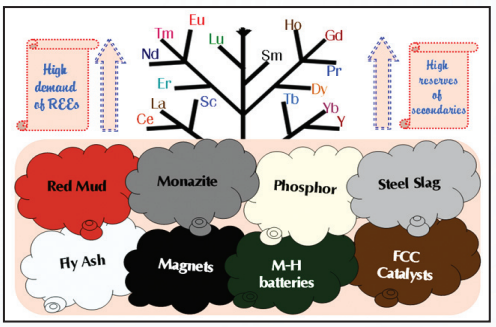
Dephosphorisation of High Carbon FeMn alloy produced at Ferromanganese Plant, Balaghat Mine MOIL

The average phosphorus content in the manganese ore produced from Balaghat Mine of MOIL varies in the range of 0.10% to 0.30% and as the low phosphorus ores are depleting fast, the ferromanganese produced will continue to have phosphorus content more than 0.3%. For producing quality steel, the phosphorus content in the ferromanganese should be less than 0.2%.The present study was undertaken to develop a process to reduce the phosphorus content in the ferromanganese to the desired (<0.2%) levels.

50 kg ferromanganese sample (phosphorus 0.34%) received from MOIL Limited Balaghat Mine was used for the study. On the basis of the work carried out earlier at CSIR-NML, five flux compositions were identified for selecting the most effective flux. Once the flux composition was selected, other parameters like mass of the flux, additives, furnace lining, temperature, time were varied to see their effect on selective removal of phosphorus. Before addition of calcined pellet, desiliconisation was carried out with a mixture of mill scale and lime powder and the resulting slag was removed from the melt. Metal and slag samples were collected at 5 minutes interval after addition of calcined flux pellets. The degree of deposphorisation varied in the range of 32% to 55%. The Mn loss was at moderate level 3% when about 30% MnO was used in the flux. The energy consumption was in the range of 2-3 KWH per kg of Fe-Mn treated which is expected to come down significantly when experiments would be conducted at higher scale.

Rare Earths Extraction Research at CSIR-NML

Rare earths are in high demand due to their usage in key energy, environment and strategic sectors (space, defence, etc). Out of the total global production, 97% of rare earth production comes from China. India being in the 2nd position with respect to reservers produces about 3000 metric tons of rare earth oxides every year. Restrictions on the export of rare earths by China coupled with the presence of fewer minerals worldwide, having extractable concentration of rare earths, has opened up the options for improved process for the extraction of rare earth elements from primary resources, and recycling of rare earths from wastes, popularly known as urban mining. Rare earth magnets, NiMH batteries, lighting phosphors, spent catalysts, etc are suitable for recycling because of the presence of high concentration of rare earths in these wastes. The major focus of rare earth extraction research at CSIR-NML is on these materials. Efforts are also underway to



explore extraction of rare earths from red mud, fly ash and blast furnace slag. In parallel efforts, the programme on secondary resources of rare earths is complemented with development of processing strategies for primary ores, such as monazite. The research is supported by CSIR (under 12th five year plan), National Aluminium Company, Tata Steel and KIGAM (South Korea).

Rare earth separation and recovery from Korean Monazite/ REOs

In order to recover the rare earth metals (REMs) from the Korean domestic rare earth (RE) oxide/monazite concentrates, the sample supplied by KIGAM was initially characterized to know the composition of different metallic and non-metallic constituents and the phases present. The chemical analysis of Korean monazite was found to contain ~ 50% REOs with 29.44% phosphate content in the form of P_2O_5, minor/ trace other REMs and non-metals. The morphological and phase characterization of the original monazite sample was carried out which confirms the presence of monazite (~69%), sillimanite (20%), ilmenite (6%) and zircon (5%) (Fig.4).

The phosphate content of monazite hinders the leaching reaction between REMs and acids due to the formation of various phosphides. Therefore, alkaline leaching of monazite using NaOH was performed to remove and recover phosphorus as a valuable product. Leach liquor generated after acid dissolution contains 0.68 g/L La, 1.10 g/L Ce, 0.12 g/L Pr, 0.37 g/L Nd and 0.05 g/L Sm which was further subject to solvent extraction studies to extract and separate REMs from the liquor. Different extractants viz. D2EHPA, LIX 54, CYANEX 272, etc. were used to see selectivity and capability of the solvent. Experiments were carried out to optimize various parameters viz. phase ratio, contact time, pH, concentration of organic, etc. It was found that at optimized condition, 97.80% Nd, 96.99% Sm and 99.99% La was extracted using 10% CYANEX 272. The remaining trace metals at low concentration present in the solution could be recovered using ion exchange process. A flow-sheet for the recovery of REMs from Korean monazite using alkaline leaching followed by solvent extraction is presented in Fig. 5. The lab scale studies indicate that the metal salt/ metal of La, Nd and Sm could be produced using evaporation and electrolysis, respectively. The process has potential for commercialization after some scale-up studies.

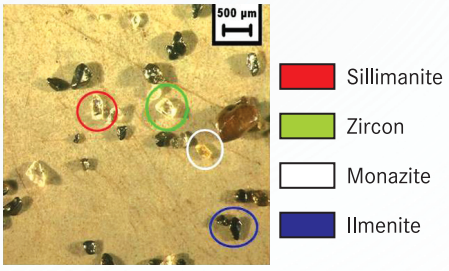


Fig. 4 : Korean Monazite minerals

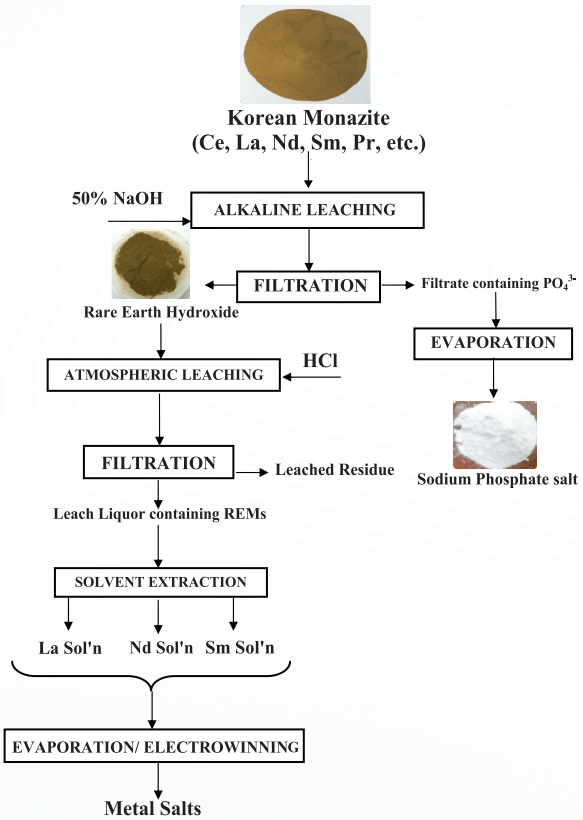


Fig. 5 : A flow -sheet for the recovery of REMs

Recovery of high pure yttrium oxide from phosphor powder of fluorescent tubes

As a part of CSIR network project, CSIR-NML has developed a hydrometallurgical process comprising of leaching and precipitation to recover rare earth metals from the phosphor powder of waste fluorescent lamps. Phosphors contain ~ 40% of rare earths and the major element is Y along with Eu, Ce, La and Tb. A two-stage leaching process was developed for the complete recovery of REMs. In the first stage, leaching with low acid concentration (HCl), a maximum of 96% yttrium and 94% europium were selectively leached out from the phosphor powder. With the second stage leaching of the residue with concentrated HCl solution, about 95% La, 90% Ce and 70% Tb were leached out. After leaching, yttrium from the first stage liquor was recovered as high purity Y_2O_3 (~97% pure) by the precipitation method.

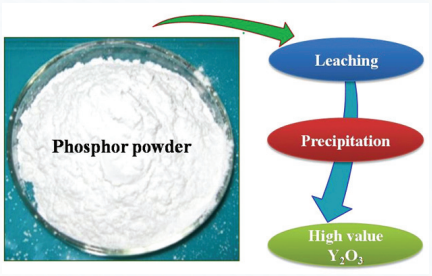


Fig. 2 : Recovery of high pure yttrium oxide from Phosphor powder

Extraction of rare earth elements from red mud

This research aims at establishing the lab scale feasibility of a hydrometallurgical process for the extraction of La, Ce and Sc from red mud to produce pure/mixed REE's. Chemical analysis showed the presence of 70 ppm La, 140 ppm Ce and 80 ppm Sc in the red mud used for the study. Various parameters like effect of acid concentration, solid:liquid ratio, particle size, stirring rate and temperature were tested to determine the critical/optimum conditions for maximizing REE recovery. It was observed that leaching efficiency of La, Ce and Sc was better in the presence of sulfuric acid as compared to nitric acid and hydrochloric acid. 99.9% La was recovered in 1 h by leaching with 3M H_2SO_4 at 35°C at a solid:liquid ratio of 10 g/L. However, it was unexpectedly observed that the maximum recovery of >99% for Ce was obtained by leaching with 3M H_2SO_4 at 75°C. Scandium recovery was found to be maximum (80%) at 75°C under similar conditions. Separation of REE's was investigated by solvent extraction using CYANEX 301 and CYANEX 272. CYANEX 301 was selective for separation of La and Ce at 0.15 M concentration in kerosene in 30 min with an A/O ratio of 1:1, whereas, CYANEX 272 was found very effective in separating maximum Sc at A/O ratio of 3:1. Efforts are underway for improving REE separation by single/synergistic system of extractants and synthesis of products by selective precipitation.

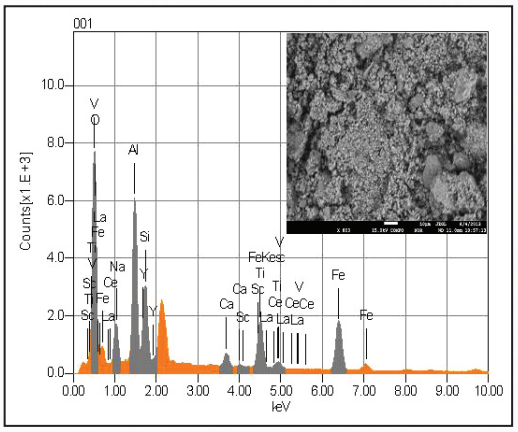


Fig. 3 : XRD analysis of red mud used for the study

Extraction of rare earths (in pure/mixed oxides) from blast furnace slag

Blast furnace slag contains significant amounts of valuable rare earth eliments (REEs) like La, Ce, Er and Nd. It can be an useful resource for extraction of rare earth elements. The scope of this project is to develop a proof of concept for the feasibility of extraction of REE's from blast furnace slag on a 1kg scale. Initial experiments were carried out to select a suitable acid lixiviant. Good recovery of La was observed as compared to Ce, Er and Nd with sulphuric acid at ambient temperature. At higher acid concentrations, recovery of REE's was found to be low. Process optimization is also underway with other acids.

Green separation of rare earth metals using Ionic Liquid as extractant

Separation of individual Rare Earth Metals (REMs) from each other is one of the most challenging jobs because of their similar chemical properties. Solvent extraction is one of the prominent techniques for separating these trivalent lanthanides. Commonly used acidic or saponified extractants release H^+, NH_4^+, Ca^{2+}, and Na^+ ions into the aqueous phase; which either affects the extraction efficiency or increases the salt concentration in the effluent. Ionic Liquid (IL) is a new class of solvent which comprises of bulky organic cation and organic/inorganic anion, which have the potential to avoid the problems associated with conventional acidic and saponified extractants. In the present investigation, an ionic liquid Cyphos IL 104 (R4PA) was used as an extractant in kerosene (diluent) for the separation of light (La & Nd), middle (Gd) and heavy (Lu) REMs. It was observed that equilibrium pH increased after extraction, which implied that H^+ ions got extracted into the organic phase during the equilibrium process. Extraction of all the lanthanides increased with the increase in initial pH and extractant concentration. Extraction followed the order of ionic radii: Lu(III) > Gd(III) > Nd(III) > La(III). This study demonstrated higher value of selectivity for different pair of lanthanides at optimized condition. The mechanism for the extraction of metal was also established. Counter-current extraction process was simulated for the separation of heavy lanthanides (Lu) from the remaining mixed lanthanide solution and it showed that 93% of Lu(III) was loaded in the organic phase in 2 stages at Organic/Aqueous (O/A) ratio of 1:3. The work highlights the potential of using ionic liquid Cyphos IL 104 as extractant for the efficient separation of lanthanides, which could also overcome the problems associated with commonly used acidic extractants.

Development of Online Temperature Monitoring System for Mould in Billet Caster using FBG Sensors

It has been observed that two of the major reasons for rejections at LD1, Tata Steel have been rhomboidity and cracks which account for a loss of few tens of thousand tons of products every year. Both of these phenomena possibly have their origin in the non uniform cooling occurring in the mould. Additionally, as a result of recent investigations into break outs (termination of casting due to breakage of the solidifying billet), it has come to light that most of the break outs are taking place due to sticking/binding inside the mould.

There is scarce knowledge on what takes place in the mould in the billet casters because of non availability of suitable instrumentation that can generate information on the temperature at the cold face of the mould across and down the mould under different casting conditions. Further, because of the small size of the moulds and the tubular nature of the mould, it has never been possible to install thermocouples in the moulds on a commercially operating billet caster on a continuous basis.

Once the information on the temperature at the cold face of the mould is obtained, mathematical models can then be used to derive the heat flux profiles, the extent of the air gap formed, the effectiveness of the taper being employed, whether there is some temporary abnormality in the casting process causing sticking /binding, etc. This knowledge could help in identifying the countermeasures needed to eliminate the defects mentioned.

Presently efforts are on at CSIR-NML to develop: a) an optical fiber sensing technique based on Fiber Bragg Grating (FBG) transducers for online monitoring of the cold face temperature of a billet casting tube mould for use at CC3, LD1 of Tata Steel; and b) a mathematical model for using the temperature data to predict surface cracks and breakouts in the billet caster. This project is being carried out jointly with CGCRI, Koklata.

Study on Smelting Reduction of Chromite ore in 50 kVA EAF

With increase in Cr:Fe ratio, the refractoriness of chromite ore increases and smelting and reduction becomes very difficult. In the present practice, this high grade ore is being blended with low grade ore to maintain Cr:Fe ratio of 2.6. However, in practice, difficulties in furnace operation and Cr loss in slag occurs due to the frequent fluctuation of blend percentage. In this work, the process parameters for smelting reduction of refractory chromite ore and their optimum utilization in existing submerged arc furnace have been developed. The experiments were conducted at 10-12 kg scale to study the metallic recovery and power consumption with varying ore grade in a 50 kVA EAF. Use of limestone and bauxite showed good performance in both South African ore and Indian ore of high and low grade. Power consumption for smelting reduction in the 50 kVA EAF was around 55 kWh for 10-12 kg heat. This study will help in utilizing high grade chromite ore with better Cr recovery to produce good quality ferrochrome.

Materials Engineering

Development of fiber reinforced polymer-hydroxyapatite nanocomposites

For improving the mechanical properties along with porous structure of polymer- Hydroxyapatite nanocomposite, fiber reinforced polymer hydroxyapatite nanocomposites were synthesized using a cost effective wet precipitation method by using natural fiber such as jute fiber and synthetic fiber such as carbon fiber. Jute fiber reinforced composites showed varied range of compressive strength and elastic modulus depending on the weight percent of fiber which are 18.8MPa-58.7MPa and 0.3GPa- 0.6GPa, respectively. In the case of carbon fiber reinforced composites, by changing the polymer concentration, the compressive strength and elastic modulus varied in the range of 57MPa- 116MPa and 0.9GPa – 1.9GPa, respectively. The mechanical properties exhibited by these composites make them suitable for high load bearing orthopaedic applications.

Fig. 1 : Jute fiber reinforced nanocomposite

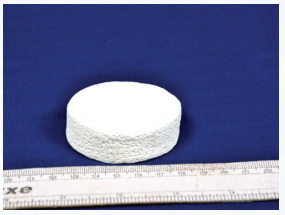


Fig. 2 : Carbon fiber reinforced nanocomposite

Development of novel CSIR Technologies for manufacturing tailored and patient-specific Bio-Ceramic implants and biomedical devices at affordable cost (Bioceram)

Novel three dimensional (3d) blocks of biphasic calcium phosphate (BCP) nanocomposites, comprising nanocrystalline hydroxyapatite (HA) and β-tricalcium phosphate (β-TCP) phases with three different weight ratios of HA and β-TCP (20:80, 25:75 and 30:70 respectively) having both porosity and mechanical strength have been developed for possible applications as synthetic bone grafts/scaffolds. Synthesized BCP nanocomposites were systematically characterized for their structure and mechanical properties by employing various techniques viz. scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), Fourier transform infra-red spectroscopy (FTIR) and Universal mechanical test. The results showed that the BCP nanocomposite blocks have micropores (35-60% porosity) with 0.10-0.5 μM pore diameter and compressive strength in the range of 6-27 MPa analogous to human cancellous bone.

Magnetic bioceramic nanoparticles have been synthesized through a biomimetic route by varying iron concentration in order to see the effect of iron on the bioactivity. Physical and structural characterizations have been done. Some of the samples have been electrospun in the form of fibrous mats. The initial structural characterization has been carried out.

Development of Biphasic Blocks (hydroxyapatite + β-tricalcium phosphate)

The problem was to develop three dimensional load bearing porous biphasic calcium phosphate (hydroxyapatite + β-tricalcium phosphate) blocks. For this purpose, a novel biomimetic route for in situ synthesis of Ca-deficient hydroxyapatite nanocomposites in cellulose based supramolecules matrix was developed at room temperature. A heat treatment of the

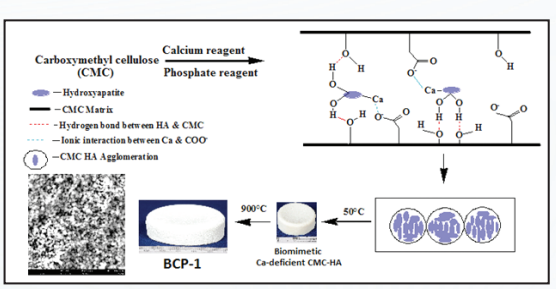


Fig. 3 : Shows the graphical abstract of the work

nanocomposites at 900°C led to load bearing porous biphasic calcium phosphate (BCP) blocks with controlled compositions. BCP exhibited compressive mechanical strength up to 30 MPa. This process was developed on a laboratory scale and exhibited a stringent control over the chemistry, particle size distribution, porosity, pore size distribution as well as mechanical properties making it suitable for cancellous bone grafts. More importantly in comparison with other available processes, this process was independent of any synthetic binder and multi-step process like gel casting as it was based on in-situ synthesis of bioceramic nanoparticles in a preorganized (bio)-polymer matrix. Bio- inspired in situ mineralization of the underlying polymer matrix and its physical cross linking by hydrogen bonds, provided the synthesized material a chemistry and self-assembled microstructure similar to bone. Biphasic calcium phosphates are particularly attractive for biomedical applications because they have optimum resorption rate, mechanical stability. They are also biodegradable and osteoinductive.

This know-how was transferred to M/S. G. Surgiwear Ltd., Shahjanpur.

Recrystallization Behaviour of Twin Induced Plasticity (TWIP) Steel

Although much of work has been devoted towards deformation texture in low Stacking Fault Energy (SFE) materials, there is limited research on the recrystallization behaviour and associated texture evolution in low SFE steels. Considering the importance of recrystallization mechanism involved in low SFE materials, the present project aimed to study the recrystallization behaviour of a cold rolled TWIP steel.

A high-Manganese TWIP steel with 0.35C, 1.5Al and 22.5Mn was cold rolled to 40% and 80% thickness reduction within 2 and 5 passes, respectively. The thickness of the rolled samples were 2mm and ~1mm after 40% and 80% cold rolling, respectively. After cold rolling, samples were cut from the rolled sheet and were subjected to annealing between room temperature to 700°C with soaking time of 30 minutes in air atmospheric tubular furnace followed by immediate water quenching. The microstructural evolution was studied through the evolution of dislocation density using X-ray Line Profile Analysis (XLPA) and Convolution Multiple Whole Profile fitting (CMWP) techniques. Evolution of microstructure was further analyzed by Electron Back Scatter Diffraction (EBSD).

Recrystallization in the present TWIP steels proceeded via twin relationship with the deformed matrix irrespective of degree of cold rolling. Recrystallization proceeded quite heterogeneously within the microstructure. There were quite a few places where there was signature of only recovery. In 80% cold rolled samples, the extent of recovery was high as compared to that in 40% cold rolled samples. This indicated that the driving force for recrystallization varied along the orientation of deformed bands. This kind of orientation dependent recovery dominated recrystallization process has not often been in other austenitic steels.

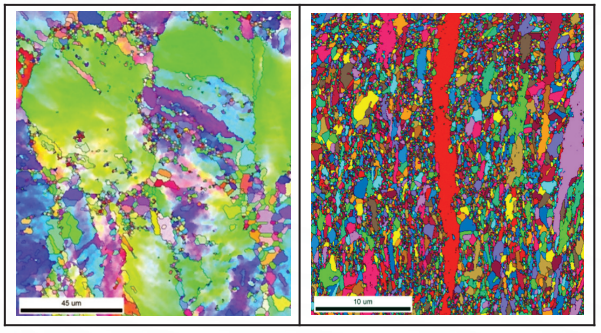


Fig. 4a : IPF map of sample annealed at 575°C after 40% cold rolling showing initiation of recrystallization

Fig. 4b : IPF map of sample annealed at 500°C after 80% cold rolling showing bands without any recrystallization

Synthesis of biomimetic electrospun collagen graphene nano- composite

The electrospinning process has attracted significant attention because of its ability to process a wide range of materials, as well as the straightforward nature of the process and its cost-effectiveness. The large surface area of electro spun nanofibers as well as that of the triple helical collagen favors adhesion. By coordinating the parameters of electro spinning , controllable fibrous structures can be successfully fabricated and therefore provide excellent prospects for construction of biomimetic structures.

Collagen was used to exfoliate natural graphite to graphene and this was electrospun with the addition of poly (vinyl)alcohol. The obtained electrospun fibres were structurally well characterized and tested for enhanced capacitance.

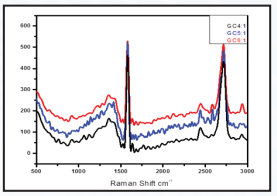


Fig. 5 : Raman spectroscopy of the three ratios of GC 4:1,5:1,6:1

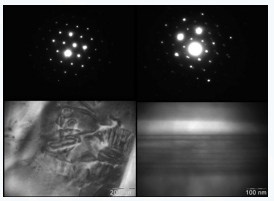


Fig. 6 : TEM of 1:1 Graphite: Collagen and the corresponding SAED

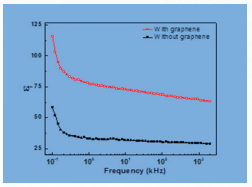


Fig. 7 : The variation of relative permitivity with the frequency of the samples with and without graphene

Development of rapidly solidified high induction alloys for transformer core

A group of high induction metallic (HINDMET) glassy alloys was designed within the compositional ranges of $(FeCo)_{79+x}(BSi)_{21-x}$ (where x= 0- 6 at%) with the additions of some growth inhibitor element (Nb) and nucleating agent (Cu). The alloys were processed through single roller melt spinning technique, and achieved saturation induction above or equal to 1.5Tesla. On devitrification, the magnetic properties were affected with the generation of α-FeCo nanocrystallites and $(FeCo)_{23}B_6$, Fe_2B phases, corresponding to post primary and secondary crystallization stages, respectively. A small amount Co was found to be advantageous for maintaining finer nanocrystallites in amorphous matrix even after annealing at 600C, leading to high saturation magnetization (>1.5T) and low coercivity (~ 35A/m) for some FeSiBNbCu amorphous glassy alloys. The nanocrystallites size also became finer in Co-substituted annealed alloys (Fig 8).

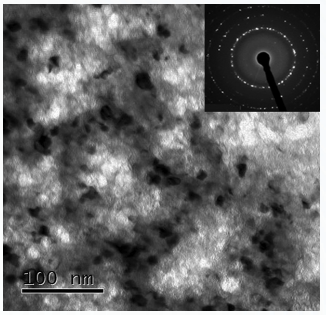


Fig. 8 : Distribution of fine (~ 13nm) α -FeCo nanocrystallites in amorphous matrix of a Co-substituted FeSiBNbCu amorphous glassy alloy at annealed condition

Advanced ceramic materials and composites for energy and structural applications (CERMESA)

Module : Non-oxide Ultra High Temperature Ceramics (UHTC) Components

Zirconium diboride (ZrB_2) is one of the most promising ultra-high temperature ceramics with melting point above 3000K and having excellent mechanical, electrical and chemical properties and has important applications in aerospace and defense applications. The inherent brittle nature of ceramics, poor sinterability due to covalent bonding, low self-diffusion coefficient and oxygen impurities, make the fabrication of large or complicated shaped components difficult and cost prohibitive. Joining of small sized ZrB_2 ceramics with

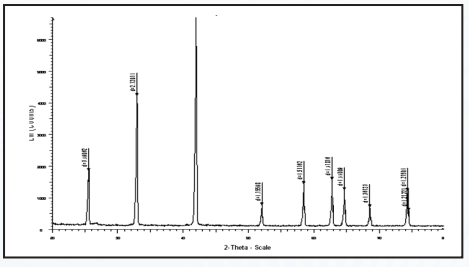


Fig. 9 : XRD pattern of single phase ZrB_2 powder single step carbothermal process

other ceramics or metals can be an alternative to the use these materials in large components. Besides joining, Zirconium diboride based composites being electrically conductive, can be machined using Electro-Discharge Machining (EDM). The studies on joining and EDM machining of these ceramics are limited. In this project and under the module on "Non-oxide Ultra High Temperature (UHTC) Ceramics", National Metallurgical Laboratory, Jamshedpur is investigating the fabrication of ZrB_2 joints using active filler based brazing alloys, development of high temperature joining materials and the EDM of ZrB_2-based composites. Because of its importance as a strategic material, developing capability for the indigenous production of ZrB_2 powder was also a necessity. At CSIR-NML, a process for the production of single phase ZrB_2 powder by one step carbothermal process has been developed. Normally, it is difficult to prepare single phase ZrB_2 powder and it requires several steps of mixing, grinding and heating. These powders were sintered at CSIR-CGCRI by hot pressing and Spark-Plasma Sintering (SPS) and the sintered samples were used for joining and EDM study.

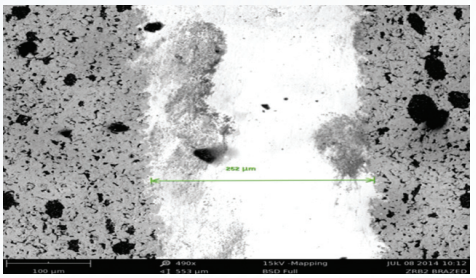


Fig. 10 : SEM image of ZrB_2 joints using-Ag-Cu-made by Ti brazing alloy

Synthesis and characterization of water based graphene-ferrofluids (G-FF)

The aim of this work was to develop a simple, non–hazardous and scalable process for the exfoliation of natural graphite directly to colloidal graphene using collagen. The exfoliated graphene was subsequently used as biomimetic templates to synthesize ferrofluids consisting of nanosized iron oxide-graphene composites stabilized in an aqueous base. The material was to be tested to evaluate its performance in medical applications such as hyperthermia and magnetic resonance imaging (MRI) for the diagnosis and treatment of cancer. The exfoliation of graphite in acylated collagen has already been achieved and patented; detailed characterizations have revealed the formation of nano-graphene flakes showing average dimensions of ~ 500 × 200 nm. An international project has also been initiated with John Keels Research, Srilanka in this regard . In order to study the effects of graphene on the magneto-structural properties of iron oxide nanoparticles Iron Oxide Nano Particles (IONPs), pristine Fe_3O_4 nanocrystals were synthesized in different biomimetic templates; the magnetic properties were found to enhance with the choice of the templating agent and very high Specific Absorption Rate (SAR) and relaxivity was achieved. Using the same templating agent, graphene ferrofluids were synthesized; the fluids are being currently characterized. Work on modeling the heat transfer in tumor tissue loaded with IONPs before and after graphene incorporation has been initiated. The effect of particle concentration, distribution, magnetization, blood perfusion and tumor properties and geometry on the heating ability of such nanocomposites will be investigated. The Pennes bioheat transfer model is being used as the standard model whereas the temperature distribution in such tissues will be simulated in COMSOL Multiphysics Software.

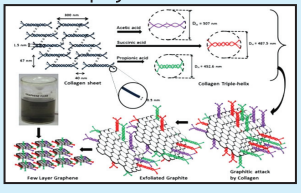


Fig. 11a: Schematic graphite foliation

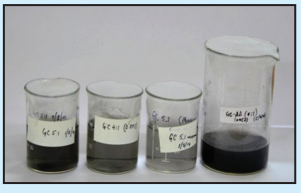


Fig. 11b: Graphene dispersions

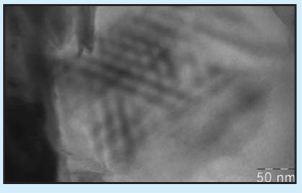


Fig. 11c: Graphene

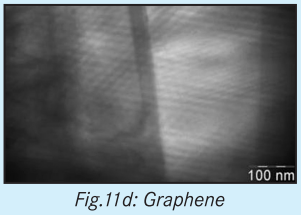


Fig.11d: Graphene

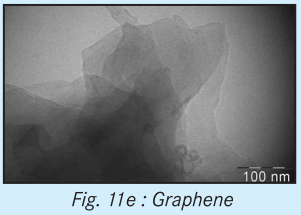


Fig. 11e : Graphene

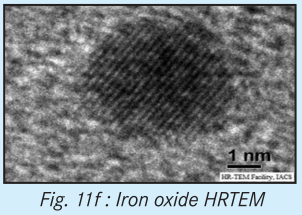


Fig. 11f : Iron oxide HRTEM

Development of API X80 line pipe steel

The development of micro-alloyed steels for line pipe applications has attracted a lot of interest from steel industries. The studies being undertaken are mostly aimed at suitable steel composition, appropriate thermo mechanical processing schedule and cooling conditions. The major concerns are to refine ferrite grains and modify the microstructural constituents e.g. acicular ferrite, bainite, martensite/austenite etc. In the present study, alloy design was done based on extensive literature search and Nb-V-Mo containing compositions were prepared with varying Mn content. The cast ingots were conventionally rolled to see the variation of structural constitution with cooling rate. The hardness and strength increased with cooling rate, which actually determines the microstructural constitution. With increasing cooling rate, the microstructure changes from ferrite, acicular ferrite to bainite, with varying fractions. Controlled thermo-mechanical simulations were carried out on Gleeble 3800 using different process schedules akin to industrial practice for thin slab casting and rolling. The main variation in process parameters were strain in different passes, cooling rate and the finish cooling temperature. The deformed microstructure showed drastic ferrite grain refinement, up to 5-6 µm, when finish rolling was accomplished below the recrystallisation temperature (T_{nr}). Further, grain size reduction was achieved with increasing cooling rate from 10 to 30°C/s. The finish cooling temperature, varied from 600 to 300°C, showed a further grain size refinement. It was found that the strength and the hardness decreased with decreasing Mn content. The yield and the ultimate tensile strength of simulated samples, estimated from the correlation developed between strength and hardness in the present study, showed the values of 564 and 707 MPa, respectively. These values are well within the prescribed strength levels for X80 grade line pipe steel. This strength level is attributed to the microstructure containing a combination of acicular ferrite and bainite. Further improvement in the properties can be achieved by exploring modified thermo-mechanical treatment schedules.

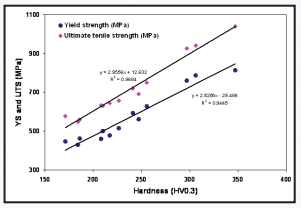


Fig 12 : Correlation of hardness with strength

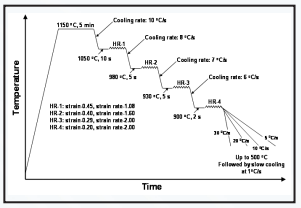


Fig 13 : TMCP schedule

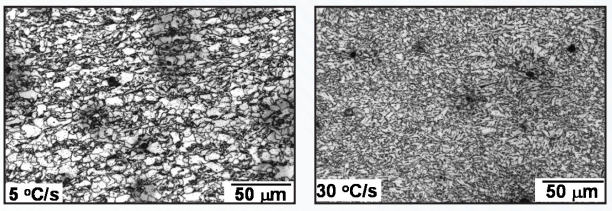


Fig. 14 : Microstructure variation with cooling rate

Optimization of Annealing Parameters for high $\bar{r}$ in IF and IFHS steels

High r values are recommended in these grades of steel for their intended end use as formable class of steel. This parameter very strongly depends on type of texture evolved during annealing processes. In this project, a unique batch annealing simulation that was very nearly akin to the conditions that prevail in steel industry was carried out. All simulations were carried out in reducing annealing atmosphere of 5% H_2 and N_2 gas mixture commonly applied in steel industry. Processed specimens were characterized for microstructure, texture, tensile properties, and r measurements. Through these simulations it was possible to achieve r values higher than 2.0 in case of IF (Ti) steel and IFHS (TiNb) steel.

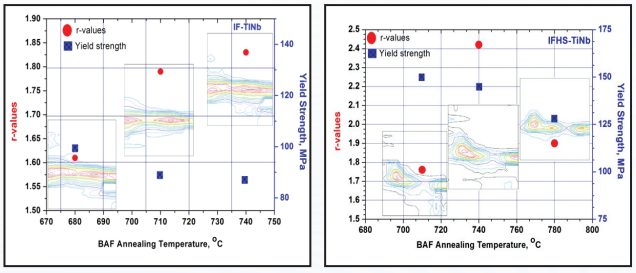


Fig. 15 (a, b): Results of r measurements compiled for two variants of IF (TiNb) steels is shown in the figure.

Mineral Processing

Studies on Characterization and Beneficiation of Low Grade Iron Ore Sample from SMPL

With fast depletion of high grade iron ores, there is a need to exploit low- and lean-grade iron ore resources. Low- and lean-grade ores generally contain high proportion of impurities such as alumina, silica, phosphorous etc. and are finely disseminated. Such ores need elaborate beneficiation for improving iron content for reducing the impurities in the concentrate to be used for iron making. M/S. Sarda Mines Pvt. Ltd. (SMPJ) & M/S. Jindal Steel Pvt Ltd (JSPL) have been interested in developing and exploiting low-grade iron ore reserves from their mines in Barbil area. In this connection they have sponsored a project to CSIR-NML to undertake characterization and bench- and pilot-scale beneficiation studies towards developing process flow-sheet for producing concentrate for iron making.

Characterization of the low-grade iron ore received from SMPL indicated that it contains hematite as the main iron-bearing mineral with substantial goethitic material. Washing and scrubbing with a top size of 30 mm could eliminate major impurities in slime fraction. The beneficiation studies at coarser and fine size fraction were carried out using air pulsated jig. The results obtained showed encouraging enrichment of iron content. In order to enhance recovery of iron, the rejects from the circuit were processed by grinding to liberation size followed by de-sliming and wet high intensity magnetic separation. The work is in progress.

Development of Pilot-Scale Pelletising Technology for Indian Goethitic/ Hematite ore with varying degree of fineness

Barsua iron ore slime concentrate was pelletized with different amounts of binders and combination of binders. Dried pellets were indurated at 1300°C in a chamber furnace. Physical tests such as tumbler index (TI), abrasive index (AI) and compressive strength (CS) and metallurgical tests such as reduction index (RI), reduction degradation index (RDI) and thermal degradation index (TDI) of the indurated pellets were carried out.

Pelletisation with cement as a binder

The slime concentrate was pelletized in a disc pelletiser using cement (1 – 6%) as a binder. Dried pellets were indurated at 1300°C in a chamber furnace. Physical and metallurgical tests were carried out and it was observed that 2% cement was sufficient for producing suitable pellets for iron making with CS more than 200 kgf, TI more than 90% and AI less than 5% whereas RI, RDI and TDI were also proper. Pellets with 1% cement had low TI (85.8%) and slightly high AI (9.7%) whereas more than 2% cement had very high RDI.

Pelletisation with combination of Limestone and Lime as binder

Pelletisation was carried out with different amounts of limestone and lime as binders and these pellets were indurated at 1300°C in a chamber furnace. Physical and metallurgical tests of the indurated pellets indicated that the combination of 2% limestone and 1-2% lime produced suitable pellets for metallurgical purpose whereas pellets produced with 1% limestone and 1% lime showed slightly low RI.

Pelletisation with dolomite and bentonite as binder

Pelletisation was also carried out with different amounts of dolomite and bentonite as binders and these pellets were indurated at 1300°C in a chamber furnace. Tests on the indurated pellets showed that no suitable pellets could be produced with these binders. Dolomite caused closure of gas passages resulting in low RI.

Online Implementation of Iron Ore Alumina Detection Technology at Noamundi Mines of Tata Steel

In mineral industries, compositional analysis of ores plays an important role at different stages of extraction process, from mining, beneficiation to blending and product despatch. Standard industry practice is to collect samples, prepare and analyse either through conventional wet- chemical methods or through instrumental analysis using XRF or ICP. The entire process of sampling, preparation of final pulp for chemical analysis of any bulk material including iron ore is a time consuming (4-6 hours) and cumbersome process. The time-lag between collection of samples and receipt of chemical analysis handicaps plant operators in effective decision making and process optimization. Commercially available cross-belt analysers are capital intensive and their performance in iron ore applications particularly in terms of alumina determination is not adequately established. Hence, need was felt to develop a relatively capital inexpensive, reliable non-invasive method for a faster and accurate determination of iron ore composition, in terms of alumina content, for real time application.

Under this project, a Microwave assisted IR Tata Steel thermography based fast, low cost, simple and non-invasive technique was developed to detect alumina content in iron ores. In the first phase of the project, it was found that two major sources of error arise during experiments and were attributed to human intervention. First was the inconsistency in the time lapse between the end of the microwave heating and the thermal image capturing. The second was the variability in the selection

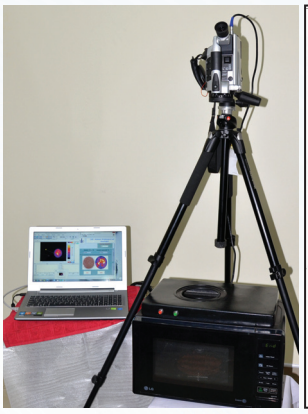


Fig. 1a: complete set up of IR camera

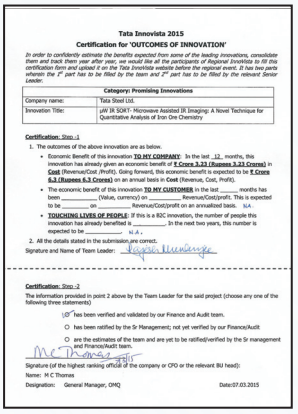


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Fig. 1b: Certificate for Outcomes of Innovation

of the area of the sample that should be used to measure the average temperature of the sample. To eliminate these, in this project, a special microwave with automatic roof opening was designed and fabricated. The IR camera focused from the top of the microwave ensured instant capturing of the image and display of the temperature of a preselected area (Fig. 1). After implementing the automated system, correlation factor for the detection of alumina content by the developed technique with respect to the conventional chemical analysis increased significantly. This project implemented at Tata Steel's Noamundi mines has already yielded on economic benefit of Rs. 3.25 Crocres and is expected to give a benefit of Rs. 6.3 Crores annually.

Beneficiation of barite by column flotation

M/s Oren Hydrocarbons Pvt. Ltd., Chennai approached NML Madras Centre to work out the feasibility of flotation column and also to establish conceptual flotation flow-sheet to improve the specific gravity of low-grade barite sample of Mangampet.

The parameters such as mesh of grind, collector dosage, % solids, slurry feed rate, air rate and wash water rate were studied. Since the volume of gangue minerals (silica and silicate minerals ~ 15%) is comparatively less than barite, reverse flotation strategy was adopted. The gangue minerals were separated by flotation using biodegradable cationic collector. The liberation analysis indicated that barite was liberated from gangue minerals below the grain size of 100 microns. Cationic collector SOKEM 524C with a dosage of 0.4-0.5 kg/t was required to obtain barite concentrates with a specific gravity of above 4.2. The barite recovery slightly improved to 70% in alkaline pH of 8.0-9.0. Low froth depth (below 70 cm) was observed to yield better recovery compared to deep froth depth. Based on the study, the conceptual flow-sheet for the production of the barite concentrates with a specific gravity of 4.2 and above was arrived at.

Studies on the brightness improvement of marble fines by reverse flotation and column Flotation

Imerys Minerals India Pvt. Ltd., Amritsar, Punjab, manufactures and supplies calcium carbonate slurry for paper filling and coating. Their operations mainly consist of size reduction of good quality marble chips down to 2 µm in stages in attrition mills to obtain calcium carbonate slurry of high brightness, generally +90.

The objective of the project was to improve the brightness by flotation. Reverse flotation tests were conducted on flotation column (Fig. 2) by using SOKEM proprietary reagents. It was observed that there was only a marginal improvement in the brightness. Mineral characterization of the sample indicated the presence of pyrite, magnetite, quartz, feldspar apart from calcite. The ROM sample was crushed to three fractions (-30+50#, -50+100#, -100#). The three fractions were subjected to magnetic separation individually by permroll magnetic separator of 20000 gauss. This yielded an improvement of 3 units in brightness from 80% to 83%. Conceptual flow-sheet is being developed which includes size classification, magnetic separation followed by flotation to achieve the desired increased in brightness of 4-5 units.

Fig. 2 : CSIR-NML Column

Evaluation of flotation reagents

CSIR-NML Madras Centre carries out performance evaluation of the flotation reagents developed by M/S. Somu Organo Chem (P) Ltd., Bengaluru at the laboratory and conducts plant trials on the potential reagents. Reagent Sokem 524C was evaluated for reverse flotation of barite (M/S. Oren Hydrocarbons, Chennai), Sokem 705C & 705D for graphite flotation (M/S. TAMIN, Tamil Nadu), Sokem 522C & 524C for laterite separation (M/S. Maheswari Minerals, Hyderabad), and reagents Sokem 590C & Sokem 3 were evaluated for coal flotation (M/S. McNally Sayaji Engg. Ltd., Bengaluru), glycol based frothers for talc flotation (M/S. Golcha Industries, Rajasthan) and reagent Sokem 522C-O for reverse flotation of iron ore tailings (M/S. JSW Steel, Karnataka). Out of the above, Sokem 524C would be used at a commercial scale by M/S. Oren Hydrocarbons in their barite beneficiation plant. Plant trials of Sokem 705C were undertaken for graphite flotation in November, '14 at Sivaganga graphite beneficiation plant of M/S. TAMIN, Tamil Nadu.

Pilot-Scale Spiral Concentration of LD Slag

Presently LD-slag is neither used in steel making nor in iron making. In the present study, the effectiveness of 7-turn coarse spiral followed by 8-turn fine spiral concentration was evaluated to process fine (0.5 mm) LD slag for lowering phosphorus content to the desired level for its utilization in iron ore sintering. The effect of different operating parameters on the performance of spiral has been studied through optimization experiments at different feed flow rates 18-22.2 Kg/min and splitter positions for different feed pulp densities ranging from 18-25%. The results indicated that under optimized conditions, the concentrate product yield with low phosphorous content of about 0.76% is achievable, which is significantly less than what is actually required by the industry (< 0.90%) with a yield of 31%, and this can be effectively utilized for iron ore sintering.

Characterization and Processing of lean-grade goethitic iron ore sample from Ethiopia

About 500 million tonnes of iron ore resources are located in Shire-Mentebteb region of Ethiopia. The deposit is a lean grade goethitic ore and it is to be concentrated to a level suitable for utilization through blending with high grade concentrate for iron and steel making. Detailed characterisation and beneficiation studies on these iron ore samples were carried out. The objective of the study was to develop a process flow-sheet for beneficiation of the low-grade iron ore assaying 33.17% Fe to produce a concentrate with 51% Fe.

Mineralogical studies (Fig. 3 & 4) of the ore revealed that goethite was the main iron-bearing mineral although its abundance is less compared to the gangue minerals. Major gangue minerals were quartz and clay. Clay, which forms the main matrix, contains finely dispersed goethite, quartz and occasionally hematite. From the texture of the ore it was inferred that while the minerals like oolitic/ pisolitic goethite, quartz will be liberated at a relatively coarser size, the finely dispersed goethite and clay will be liberated at extremely fine sizes below 63 µm. The lean grade, complex mineralogy and goethitic nature of the ore posed a challenging task in meeting the objective set by the sponsor.

Bench-scale beneficiation of the sample using different beneficiation techniques were carried out. The sample responded better to magnetic separation than gravity separation. Studies were also extended to processing by froth flotation. However, due to the complexity of the ore the conventional techniques did not respond. The concentrate assaying more than 48% Fe could not be achieved. In view of the failure of conventional techniques, an alternate process involving reduction roasting was carried out using coal as reductant followed by wet low intensity magnetic separation (LIMS). The concentrate assaying 51.5% Fe with 60% iron recovery was recovered from magnetic separation of the roasted sample. For a concentrate with 49% Fe it would be possible to get 73.2% recovery of iron values. Recycling of the middlings is expected to increase the overall recovery. Based on these studies, pilot scale flow-sheet has been developed for concentration of the lean grade iron ore from Shire-Mentebteb, Ethiopia adopting hydrocycloning, and multistage wet high intensity magnetic separation under different conditions.

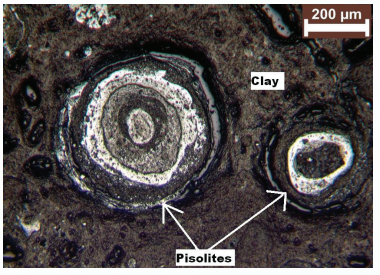


Fig. 3 : Pisolites with alternate concentric rings occurring in a clayey matrix

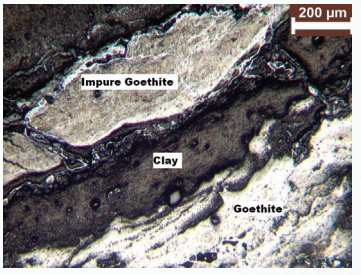


Fig. 4 : An association of impure goethite, Fe-rich clay and silica

Resource, Energy & Environment

Potash Recovery from Feldspar with Simultaneous Recovery of Valuable By-products

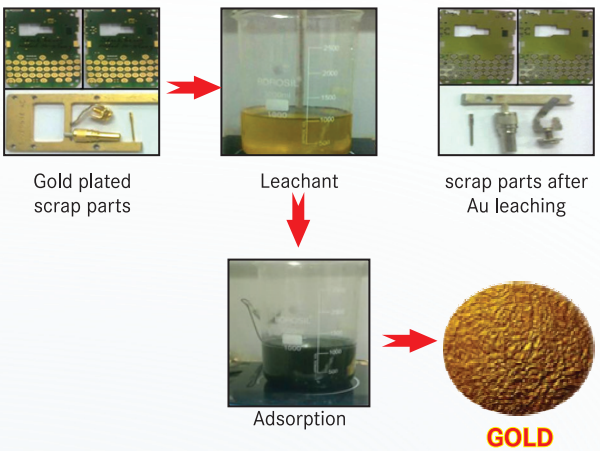
India neither has any high grade primary potash reserve nor produces any potassium-based fertilizer. The entire potash requirement of our country is met through imports. India has reasonably good amount of low grade surface deposit of potash in the form of feldspar with average potash content of about 10-12%. However, direct application of feldspar in the fields is not suitable as the potasium is bound chemically with aluminium and silicon, which cannot be absorbed by plant crops. Potash from such minerals need to be recovered as potash salt for agricultural and other use. No process was earlier available for recovery of potash value from feldspar.

Under a sponsored project from FCI, Aravali Gypsum and Minerals India Limited, Rajasthan, we developed an interesting process for recovery of potash from feldspar ($K_2O.Al_2O_3.6SiO_2$) containing about 11% K_2O. The process recovers potash by volatilization and also produces metallurgical grade Fe-Si. The process also recovers high purity nano-size silica powder suitable for various applications. The process produces an intermediate product containing potash, which can be treated suitably to produce a variety of high value potash salt/compound. The process is under evaluation at 10 kg scale. Such a process and concept for recovery of multiple products along with high value potash compounds directly from feldspar is being developed for the first time in the country.

Recovery of Gold from Mobile Phone PCBs and the Scrap Parts of Telecommunications and Medical Equipments

Gold can act as a high efficient conductor that carries low voltage currents and remains free from corrosion. Therefore, electronic components such as connectors, switches, relay contacts, soldered joints, connecting wires, connection strips made of gold or coated with this metal which makes them highly reliable. Mobile phone PCBs and medical equipments with significant amounts of gold are getting replaced at a faster rate, thus adding up to the generation of E- waste. Therefore, efficient recycling of these scrap is required for both resource conservation and environmental protection.

In order to recover gold from mobile phone PCBs and scrap parts of telecommunication and medical equipment supplied by ADV Metal Combine Pvt Ltd., New Delhi and M/s. Eco Recycling Limited, Mumbai, respectively, the scrap was dismantled and characterized to know the composition and phases of different metallic and non-metallic constituents. At first, the gold plated components were leached in suitable lixiviants such as cyanide, thiourea, thiosulfate, aqua-regia, etc. depending on the composition of the scrap. Different process parameters viz. time, temperature, concentration, pulp density were studied and optimized for the dissolution of gold from the scrap parts. The leach liquor generated was then treated by adsorption and fusion process to recover gold in pure form at lab scale. A complete process flow-sheet was proposed for the recovery of gold from the leach liquor generated from scrap mobile phone PCBs as well as medical and telecommunication equipment.



Process flow-sheet for recovery of gold

Recovery of rare metals from effluents and leach liquor of Waste Electrical and Electronic Equipments using SX/IX

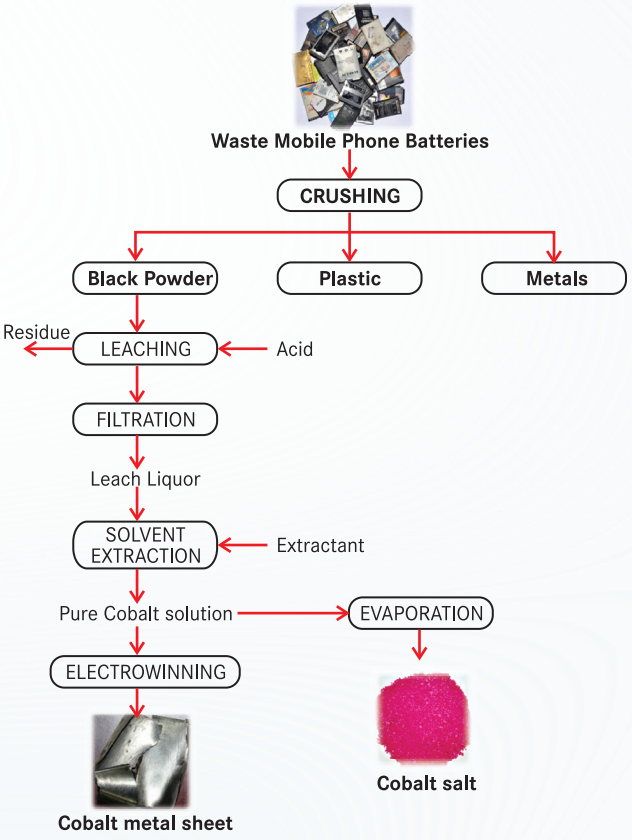
Modern technological advancement in the field of electrical and electronic industries has generated huge amount of electronic waste after its end of life. During production of these electrical equipment, liquid effluents are generated during the etching, chemical and mechanical polishing of Printed Circuit Boards (PCB) to get smooth surface. As a result, solid waste and liquid effluents containing valuable metallic and non-metallic constituents are produced. Recovery of these metals viz. Au, Ag, Pt, Pd, Pb, Cu, Ni, Zn, Cr, Sn etc. not only conserve the limited natural resources but also reduce the environmental pollution. In view of above, a feasible process of leaching was developed to leach out metals from waste PCBs followed by solvent extraction process. Moreover, industrial effluents were also used to extract metals.

Waste PCBs under study contained 15-18% Cu, 0.5-1% Ni, 1-2 % Fe, 4-5% Pb, 7-9% Sn. In order to recover metal values from waste PCBs, leaching process under optimized condition was carried out after crushing and mechanically beneficiating the PCBs. Systematic scientific studies for the recovery of nitric acid and copper from leach liquor of PCBs using various extractant were conducted. Various process parameters such as pH, extractant concentration, time, phase ratio, loading capacity, etc. have been studied, optimized and complete extraction of acid was achieved followed by selective extraction of copper. An alternative method, using mechanical pre-treatment followed by sulfuric acid leaching and solvent extraction of acid as well as different metals to get pure solution was also developed.

Development of processes for recovery of cobalt from discarded Li-ion batteries of mobile phones

Lithium Ion Battreies (LIBs) are widely used in mobile phones which become obsolete after their life span. These discarded batteries contain a lot of valuables as well as toxic metals and materials that can be recovered. An effective method to recover valuable metals from waste LIBs has been developed.

In order to recover cobalt from the LIBs, the sample (supplied by M/S. Adv Metal Combine Pvt. Ltd., New Delhi) was dismantled, beneficiated and characterized to know the composition and phases of different metallic and non-metallic constituents. At first, the concentrate was leached in suitable lixiviants depending on the composition of the concentrate. The leach liquor generated from the crushed LIBs under the optimized condition was used to separate impurities following precipitation, solvent extraction, ion exchange processes using precipitating agents/organic extractant/resin depending on the concentration and composition of the solution. The purified solution containing cobalt in sulfate medium was further utilized for the recovery of cobalt as salt or metal using crystallization/electro winning process at bench scale. The process was transferred to a company and validated.



Process flow-sheet for recovery of Cobalt from mobile phone batteries

Characterization of copper refinery deselenized anode slime

Copper refineries in India produce about 250 tons of anode slime annually containing base metals (Cu, Ni), strategic metals (Se, Te) and Platinum Group Metals (PGMs) along with other minor elements. The conventional steps for processing of anode slime include decopperization, deselenization followed by dore smelting for PGM recovery. Realizing the importance of the physico-chemical properties of anode slime during extraction of valuable metals, CSIR-NML pursued a project on detailed characterization of the deselenized slime samples. Deselenized anode slime samples were examined using various mineralogical techniques wherein each method provided complementary information about the material that helped in illustrating the association of different metals. The chemical analyses of slime samples were carried out by ICP-OES and XRF (standard less), which showed the presence of about 20-24% Ag, ~1.0 % Au, ~0.01% Pt, ~0.02% Pd, 1-2.5% Te, 10-15% Pb and 21-25% Ba. Phase identification by XRD and spot analyses by SEM-EDS and EPMA confirmed the presence of Ag mostly in oxide and sulphate form. Tellurium was found in the form of alloy with Ag, Au, Pt, Sb, Pb and in oxide form with Bi (Figures). Having completed the study of the association of different metals and analyzing their phases; work on recovery of Te from the slime sample is in progress.

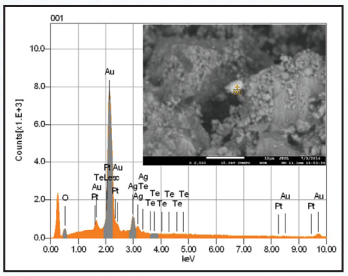


Fig. 1. Typical EMPA image with spot EDS shows presence of various elements in deselenized anode slime

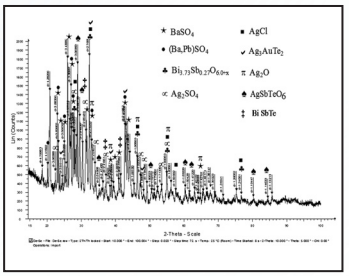


Fig. 2. Typical XRD pattern of deselenized anode slime showing complexity of the material

Tailoring of geopolymer properties by mechanical activation of fly ash

This project is a bilateral collaborative project under Indo-Hungarian Cooperation in Science & Technology. Our partner from Hungary is Institute of Raw Material Preparation and Environmental process Engineering, University of Miskolc, Hungary. The objective of the project was to gain scientific understanding of tailoring of fly ash based geopolymer by controlling the reactivity through mechanical activation. Two fly ashes, one of Indian origin and one of Hungarian origin were used in the study. It was observed that the Class F fly ash of Indian origin is more reactive than brown coal fly ash of Hungarian origin. However, both the fly ashes have shown good property after mechanical activation. FEM studies of geopolymers have been carried out. The main morphological feature observed in the fractured surface was presence of reacted cenosphere with reaction product on the surface, dense gel phase and porous gel phase. EDX analysis confirmed that in dense gel phase, the ratio of Si/Al is 1.8-2.3 whereas in porous gel phase, the ratio is between 0.4 to 1.1. The porous phase was rich in Na. Further, un-reacted quartz grains were also observed. The elemental mapping has shown that Si, Al and H association represent the formation of Zeolite 1.

In the bilateral exchange, two visits were made by Hungarian scientists and one visit by CSIR-NML scientist. The second visit of Indian scientist will be made after March 2015 to close this project and pave the way for future collaboration. In addition, a mini symposium has been planned by inviting some of the eminent scientists of Europe working in this area.

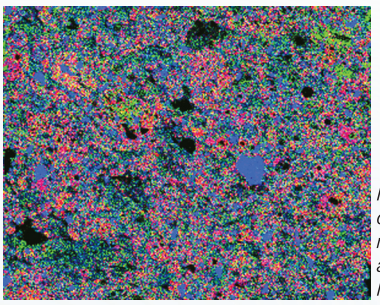


Fig. 3 :Elemental mapping of geopolymer from mechanically activated fly ash (Si = Blue, Al = Red, Na = Green)

Mill Scale-Iron Ore Slime Briquettes for Use in Iron/Steel Making

Slimes generated during iron ore washing and mill scale from the steel making processes are two by-products having significant iron content. High alumina content and fine nature of slimes prevent it from being used in blast furnace while the size distribution of mill scale makes it difficult for agglomeration without grinding. This project sponsored by Tata Steel attempts a synergic use of these two byproducts, whose characteristics supplement each other in making agglomerates suitable for iron extraction.

Since iron extraction is aimed at, self reducing briquettes of mill scale and slime with sufficient amount of Jhama coal have been planned. The work elements included (1) characterization of mill scale and slime, (2) optimization of iron ore slime-mill scale briquetting at bench scale, optimization of continuous briquetting and preparation of ~15 tons of mill scale-slime-Jhama coal self reducing briquette for trials at TAYO mini blast furnace. After optimization, briquettes have been produced at large scale for testing in mini blast furnace. A heap of green briquettes produced is shown in Fig.4 below. Briquettes, after necessary curing, are now ready for the trials.

Fig. 4 : Green briquettes of mill scale-slime-jhama coal mix

Surface Engineering

Corrosion and corrosion fatigue behavior of strategic Aluminium alloys

This project aims to study the general and localized corrosion such as pitting, crevice, intergranular, exfoliation behavior of some strategic aluminum alloys. Emphasis was to produce S-N curve (fatigue data) for AA2219 and AA 5086 aluminum alloys in air and 3.5% NaCl solutions at ambient temperature. The effect of notch on the fatigue limit will also be unveiled. The stress corrosion cracking will be studied to find out the threshold stress intensity for these alloys. Some of the experiments carried out indicated that the highest corrosion rate (~4.0182 mils per year) was for 2219 T8511 and the least for 6061 T6 (0.0075 mpy). Large numbers of pits (~2.567 x 10^4 pits/m^2) with significant depths (as high as 532 m) were found on 2219 T8511 as compared to that of 6061 T6 and 6082 T651. Alloy 6061 T6 suffered from intergranular corrosion unlike alloy 6082 T651 and 2219 T851, the latter two suffered from pitting corrosion. The pitting potential studied by anodic polarization experiments (Fig.1) of various aluminum alloys in 3.5% NaCl solution was as follows: 6061T6>6082T657>2219T8511>2219T87.

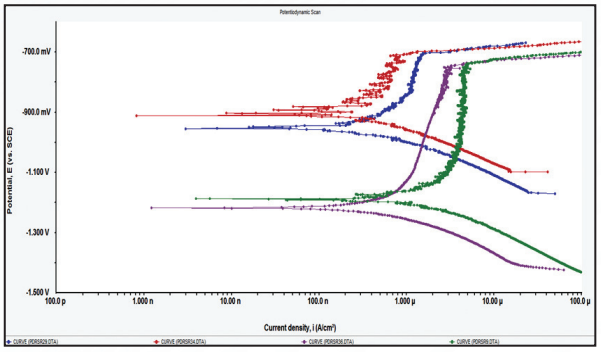


Fig. 1: Anodic polarization behaviour of aluminium alloys in 3.5% NaCl solution

Development of chemical cleaning solvent and corrosion inhibitors for Superheater and Reheater tubes

Cleaning of the hard oxide scales formed in the steam side of superheater and reheater tubes is necessary to optimize the boiler performance and for safety. The primary objective of the project was to identity suitable solvent and inhibitor for chemical cleaning of Superheater and Reheater tubes of boilers operated by NTPC. It was found that two layers of oxides develop on the inner side of the tubes due to interaction of steam with the SH and RH tube materials at high temperature during extended periods of boiler operation. The inner oxide layer has a composition of $FeCr_2O_3$ (Fe-Cr spinel oxide) and it adheres very strongly to the tube material. The outer oxide layer closest to the tube bore centre and in contact with steam inside the tube consists mainly porous magnetite (Fe_3O_4). The magnetite layer generally delaminate from the Fe-Cr spinel layer forming flakes and exfoliates and could block the SH tubes at the bends.

The project objective of identification of suitable chemical cleaning solvent with suitable corrosion inhibitor to clean the scale of SH and RH tubes with a corrosion rate of <0.25 mg/cm^2/h was successfully achieved. The hard oxide scale could be successfully cleaned using a mixture of organic acids and other additives. Cleaning solvent comprising of 4% glycolic acid, 1% formic acid, 5% phosphoric acid, 1% thiourea and 0.25 % ammonium bifluoride was found to be the most appropriate solvent. The operating condition was

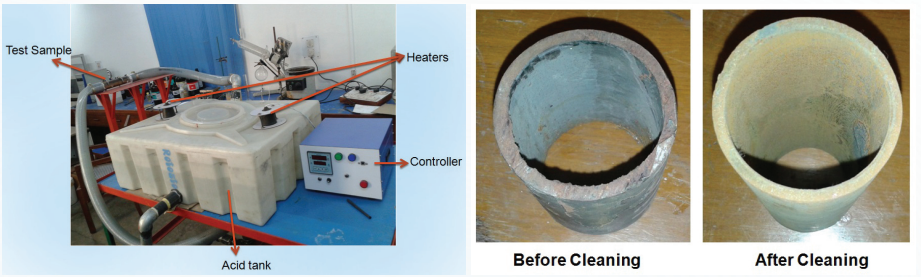


Fig. 2a Test rig fabricated at CSIR-NML to simulate chemical cleaning process for SH and RH tubes. 2b Photograph of Superheater tubes showing complete cleaning of oxide scale.

circulation of the cleaning solvent at 70 ^{0}C for 6 hours. The corrosion rate during the above cleaning process was 8.27 mg/cm^{2}/h which is very high. The corrosion rate was reduced to below 0.25 mg/cm^{2}/h using suitable corrosion inhibitors. Three corrosion inhibitors were identified for the purpose. Two of them are commercially available whereas CSIR-NML has formulated a new corrosion inhibitor. The inhibitor formulated by NML is a mixture of dodecyl pyridinium bromide (DPB, 0.5%) and Octanoylamido Triazole (OAT, 0.1%). A test rig was fabricated at CSIR-NML to simulate the chemical cleaning process of SH and RH tubes (Fig. 2). Personnel from NTPC-NETRA visited CSIR-NML during 11-13 March 2015 to oversee the chemical cleaning process using the test rig fabricated at CSIR-NML. They also examined the corrosion inhibition efficiency of the identified corrosion inhibitors using coupons brought with them.

Development of Technologies for Hot Dip Galvanizing/ Galvannealing of Advanced High Strength Steels for Automotive Applications

Advanced high strength (AHS) steels have great importance on the manufacture of lightweight automobiles. These AHS steels need protections against corrosion while maintaining the structural integrity. Therefore, galvanizability of these AHS grade steels in continuous galvanizing process is important. Selective oxidation of the various alloying elements (Mn, Si, etc) during continuous galvanizing process leads to poor reactive wetting between the liquid zinc and the surface of AHS steels. The migration of alloying elements to the surface and sub-surface, and formation of oxides more stable than iron oxides that cannot be reduced under standard industrial annealing atmospheres is a major scientific challenge. In industrial annealing furnace, the presence of O_2 and H_2O within the controlled H_2–N_2 atmosphere cannot be avoided and the formation of undesirable oxides will disturb the wetting and degrade the quality of coatings. In addition, it is also desired to optimize the surface morphology of the coated surface by thermal cycle process to obtain an ideal surface for subsequent processing for automotive applications. Hot Dip Process Simulator (HDPS), which provides the atmosphere of continuous galvanizing plant are being used to simulate the industrial process and optimize the parameters that can easily be implemented in industries. In this project, galvanizing and galvannealing simulation studies on AHS steels will be carried out using an HDPS to optimise the selection of alloying elements, annealing conditions and to develop understanding of interface reactions during wetting by Zn. These simulation studies will provide guidelines to achieve good surface quality and desired product performance while making the product development process more efficient and economical. The main objective of the project include: Development of Technology for Galvanized and Galvannealed coatings (Fig. 3) of Zn–Al, Al-Si and Zn–Al–Mg alloys on AHS steels (strength of 600-1000 MPa) such as Dual Phase, TRIP and other multi-phase steels for automotive applications using Hot Dip Process Simulator (HDPS) and thorough understanding of the mechanism of interface layer formation during hot dip galvanizing of steels.

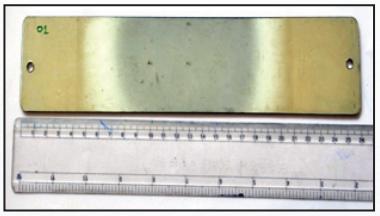


Fig. 3a

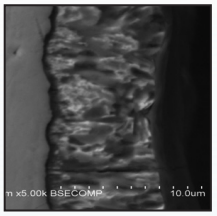


Fig. 3b

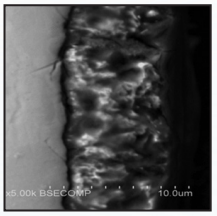


Fig. 3c

Fig. 3 : Images showing the morphology of the surface and interfaces of galvannealed samples

Very High Power Microwave Tubes : Design and Development Capabilities (MTDDC)

The objective of this project is to develop ultrathin TiN film (5-10 nm) on 70-180 mm diameter alumina disc for RF window for MW Tubes to be developed by CEERI-Pilani. The secondary emission coefficient must be within 0.9-1.2 and there has to be good adherence at high temperatures up to 500°C.

TiN coatings was developed on 2" diameter alumina to be used for RF window. 4 Samples with 10, 15, 20, 50 and 100 nm thickness TiN coating have been sent to CEERI Pilani the nodal Lab of the network project. It was observed that the film thickness and the substrate temperature have significant effect on microstructure, phase and mechanical properties of TiN thin films deposited by magnetron sputtering. The interface between the substrate and the film was sharp with very little inter diffusion. XPS analysis showed the presence of TiN as well as some Ti-O-N and/or TiO_2. The Nano-indentation results showed that hardness and modulus increased when thickness of film decreased, due to decrease in grain size (Fig. 4a) . The surface topograhy is shown in Fig. 4b. The average hardness varied from 22 GPa to 42 GPa and average modulus varied from 300 GPa to 527 GPa. The grain sizes of films decreased with thickness, and it varied in the range of 20-60 nm. A very high hardness for thinner films of TiN (42 GPa) was obtained on steel, Si and alumina substrate. The hardness, modulus, grain size could be tailored with choice of deposition parameters, which can be used for RF windows.

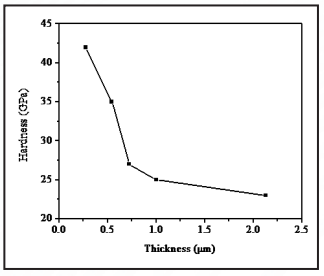


Fig. 4a : hardness variation with thickness of TiN

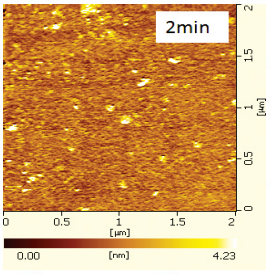


Fig. 4b : AFM topographic picture of 15 nm thick TiN film

Multilayer protective and reflective coating for Solar Thermal Applications

Reflective multilayer coatings of Ni and Ag on elctropolished aluminium sample was developed and 94% spectral reflectance has been achieved in 400-800 nm wavelengths reproducibly. The coated materials were further protected by composite coatings of silica and silica with 5-10% TiO_2. The decrease in reflectivity due to protective coatings was found to be within 1-2 %. The multilayer coatings were able to successfully withstand more than 500 hrs in accelerated humidity and UV exposure weathering test. The maximum decrease in reflectivity in exposed samples was 85% whereas uncoated and unprotected Al showed severe decrease of reflectivity from 82% to 42% within 12 hrs of exposure. The multi-layers also withstood accelerated salt spray test for more than 100 hrs where reflectivity decreased to 85% maximum (Fig. 5). Thus, these multilayer coatings can be employed for solar thermal application. Further optimization is under progress.

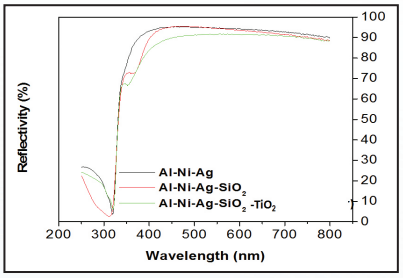


Fig. 5 : Reflectance with multilayer coatings after 100 hrs of weathering test

Studies on impact of air pollution on corrosion of metallic and non-metallic materials

The panels exposed at different locations of the country are being monitored and data retrieved. The laboratory results showed that the salt spray environment was the most aggressive in comparison to moist SO_2 and UV radiation weathering tests, for all the studied metals and alloys. The laboratory investigations revealed that for copper-based materials (copper, brass, bronze), the slowest rate of corrosion was for bronze followed by copper and brass (as shown in Fig.6); There was a decrease in corrosion rate with passage of time for all the metals/alloys. The highest decrease in corrosion rate vis-à-vis the previous exposure was observed for bronze followed by copper and brass. Amongst the various climatic environments, Mumbai was observed to show the highest corrosion rate for a majority of the metals studied followed by Chennai > Jamshedpur > New Delhi >Kolkata > Lucknow> Palampur(as shown in Fig1). The high rate of corrosion at Mumbai may be attributed to high rain fall, pollution level, wind velocity and salinity/humidity at this location. Characterization of corrosion products of weathering steel exposed at different locations indicated that lepidocrocite phase (an unstable and non protective oxide of iron) formed on the samples exposed at Mumbai (showing highest corrosion rate) whereas at Lucknow (showing slowest corrosion rate), maghemite (γ-Fe2O3, an oxide of iron which is most protective and stable) and lepidocrocite are formed; Aluminium was found to be the least affected material due to pollution at different locations followed by bronze< brass<copper < galvanized coating < galvannealed coating< weathering steel < plain carbon steel; Non metallic materials exposed at different locations exhibit weight loss as well as weight gain. Jorhat was found the most corrosive towards non metallic materials.

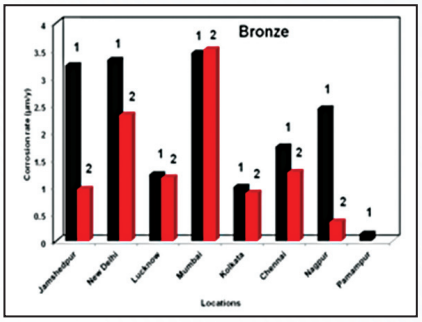


Fig. 6 : Corrosion rate of bronze exposed at various locations of the country. The numbers 1 and 2 indicated on the top of the bars of the figure indicate the corrosion rates for the 1st and 2nd year

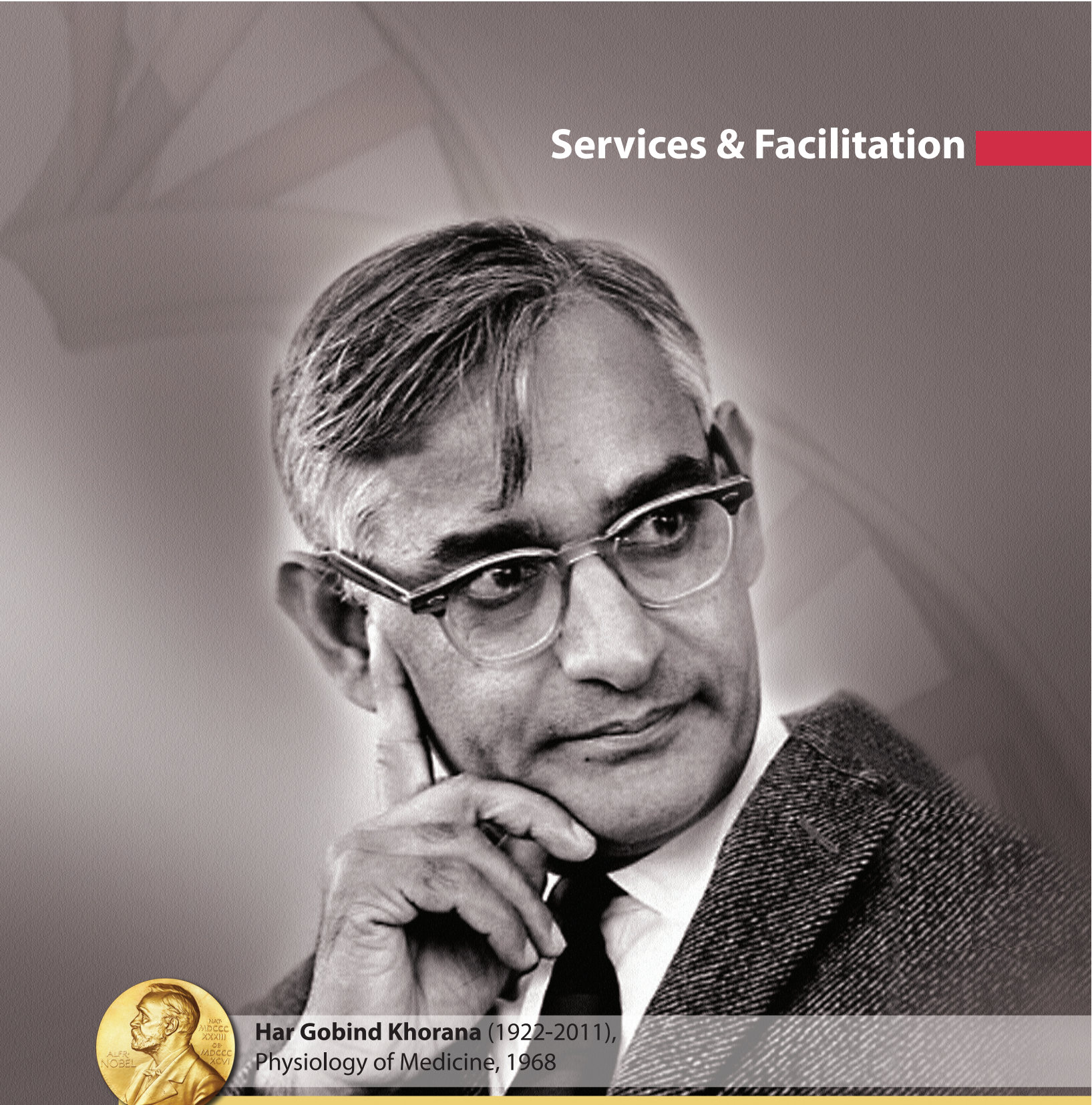
Highlights of Column Flotation Developments at CSIR- NML- Madras Centre

Exploratory Column flotation test work for improving brightness of low grade marble powder at the site of **M/S. IMERYS Minerals India Pvt. Ltd.**, Amritsar

Performance evaluation of air spargers developed by **M/S. Tata Steel**, using CSIR-NML pilot flotation column at Jamadoba Coal Preparation Plant, Dhanbad .

150 tpd NML Flotation Column installation is in progress at **M/S. VV Minerals**, Srikakulam, AP for beneficiation of sillimanite.

1000 tpd capacity barite beneficiation plant incorporating NML Flotation Column technology is being installed for **M/S. Oren Hydrocarbons Pvt. Ltd.**, Chennai. This is the second barite beneficiation plant using NML column technology.



Har Gobind Khorana (1922-2011),
Physiology of Medicine, 1968

He was an Indian-American biochemist who shared the Nobel Prize for Physiology or Medicine with Marshall W. Nirenberg and Robert W. Holley for research that helped to show how the order of nucleotides in nucleic acids, which carry the genetic code of the cell, control the cell's synthesis of proteins. Khorana and Nirenberg were also awarded the Louisa Gross Horwitz Prize from Columbia University in the same year. He was born in Raipur, British India (today Tehsil Kabirwala Punjab Pakistan) and became a naturalized citizen of the United States in 1966 and subsequently received the National Medal of Science. He served as MIT's Alfred P. Sloan Professor of Biology and Chemistry, Emeritus and was a member of the Board of Scientific Governors at The Scripps Research Institute, American Medical Research Institute.

Engineering Division

1. Introduction :

The Engineering Division caters and co-ordinates the engineering needs, both R&D and infrastructural, of the laboratory. Majority of the needs are non-repetitive in nature though some are routine ones. The facilities of this division include civil engineering unit, electrical engineering unit, central workshop, drafting unit.

Major categories of the activities performed by the Division are as following:

1. Design and Development of prototypes
2. Project Engineering
3. Engineering Consultancy
4. Infrastructural Development
5. R&D in Welding Technology
6. Up-keeping of residential premises
7. In-house maintenance and support
8. Workshop facilities

2. Design and Development

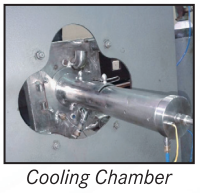
2.1 Fuel efficient Coke based Brass melting furnaces for artisans :

An eco-friendly and energy efficient coke based brass melting furnace has been designed and developed for artisans engaged in manufacturing brass artifacts. This furnace is capable of melting upto 10 kgs of brass per batch using 20% less coke than the existing one and also maintains a pollution free environment. This furnace has been field tested at various places. The Technology has been transferred to Technical Training Institute, Balasore, Odhisa in 2014 and to MIDCO, Moradabad in 2013.

2.2 Set-up of Annealing Simulator for real size tensile specimen :

This in-house designed equipment has been successfully commissioned this year. Main highlights of the equipment are controlled atmosphere furnace which can heat upto 1200 ºC. Fully automatic and programmable movement of annealing chamber into the furnace and controlled rate of cooling of tensile specimen in H_2-N_2 environment are special features of this simulator. In addition to above, this unit was augmented with high rate of cooling of specimen in H_2-N_2 environment in 2014-15.

Annealing simulator for real size flat tensile specimen



Cooling Chamber

3. Other engineering support Activities rendered

3.1 Central workshop

1. Last year (2014-15), more than 300 job requests were received in central workshop from various divisions of the laboratory. These requests included various fitting, machining, fabrication & specimen machining jobs from various types of materials. All these jobs were completed in time to the satisfaction of indentors.
2. Major Facilities Available

   CNC Lathe, Universal Milling, Shaper, Radial drill, Pillar Drill, Double column band saw, Shearing c/c, Pipe bending m/c, TIG/MIG welding, Plasma arc welding.

3.2 Infrasructure Management:

1. The infrastructure management team has successfully completed more than 3000 maintenance jobs related to civil, electrical, air-conditioning work from various residents /scientist while maintaining time schedules in the previous year (2014-15).

3. Infrastructure Development

3.1 Construction of new shed for development of zero waste technology for dry beneficiation of thermal coal in LSTF pilot plant.

3.2 Extension of erstwhile HMSS plant to join with the rotary kiln at LSTF Area.

3.3 New sampling room for processing of ores & minerals in LSTF Area.

3.4 Renovation of Canteen at CSIR-NML.

3.5 Renovation of Coal Characterization Laboratory at LSTF pilot plant.

Construction of new shed for development of zero waste technology for dry beneficiation of thermal coal in LSTF pilot plant.

Extension of erstwhile HMSS plant to join with the rotary kiln at LSTF Area

New sampling room for processing of ores & minerals in LSTF Area.

Coal Characterization Laboratory at LSTF Area

Renovation of Canteen at CSIR-NML

Renovation of Dining Hall and associated areas in Executive Center in Agrico Campus Area

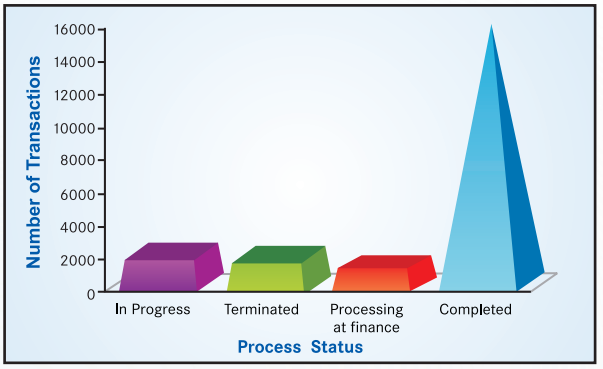
Administration

Administration provides the support system to R&D and has aligned itself positively to realize the Vision of CSIR-NML as well as enable the system to meet the goals and targets set. Right from the recruitment of the staff to their sustained care through facilitation of their academic, career related needs and vital needs like housing and health, administration forms the nerve line in the following way:

- Formulate and implement the policies concerning administrative procedure for smooth functioning of the institute.
- Provide advice to the functional bodies (Committees groups) within the organization.
- Keep liaison with CSIR Headquarters on matters related to administration.
- Provide healthy working conditions and atmosphere to Institute by correct interpretation of rules and regulations.
- Advice Director, Advisor Management, Head HRG on the matters of administrative nature.
- Seek instruction of the Director on the matters for implementation.

CSIR NML being identified a Nodal Lab. to implement ERP in CSIR Lab/Instt., the administration has undergone major shift in terms of work culture and in going paperless. It has evolved a faster delivery system with CSIR-Enterprise Transformation initiative undertaken by CSIR to focus on building electronic workplaces and re-engineering processes for augmented service delivery by implementing the integrated ERP system through ICT interventions. It has become possible due to the inculcation of an improved work culture and decentralized leadership at all levels.

Process -Transactions (ERP) as on 18 March 2015



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 CSIR guidelines. This division provides a central accounting and financial information to Director and CSIR through the management information system.

Following are the major activities of the Finance & Accounts Division

- 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
- To ensure adequate cash flow
- Implementation of ERP system in Finance & Accounts Division to establish a procedurally correct and accurate system with cost effectiveness.
- Managing the budget and expenditure of ACSIR in CSIR-NML
- To provide appropriate financial information relating to different heads of accounts and projects to Director of the Lab and decision maker in order that informed judgments and decisions are made.
- To prepare financial documents like Revised Budget Estimates and Budget Estimates, Receipts and Payments account and Balance Sheet of the organization on a given date for submission to CSIR and decision makers including submission to CAG-Audit for certification of accounts
- Preparation and Submission of utilization certificate to sponsors for all the projects sponsored by them
- Pre Audit of all the bills before making final payment to avoid any irregularity
- 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 remittance of service tax, income tax and other remittances within schedule date to appropriate authority
- To monitor cash management including transfer of funds from CSIR and other sponsors and a reconciliation of bank statement with our cash book

Performance

1. 100% utilization of Budget Grant allocated by CSIR- Rs 5806.530 lakhs
2. Utilization from Laboratory Reserve- Rs 961.398 lakhs
3. Settlement of outstanding CAG Audit Paras – 4 out of 6.
4. Generation of EBR by investment of surplus funds- Rs 413.549 lakhs
5. Settlement of outstanding advances of O.B. amounting to - Rs 1180.315 lakhs
6. Generation of Lab Reserve - Rs 830.746 lakhs.
7. Bank reconciliation of the Cash Book completed up to 31st March, 2015
8. All Pension cases (22 nos superannuation pension + 2 nos Voluntary retirement + 11 nos family pension cases) have been settled. 25 cases of restoration of pension and 7 cases of additional quantum of pension have also been settled.
9. GPF Account as on 31-03-2015 has been closed and GPF statement posted in intranet.
10. Remittance of service tax / income tax and submission of returns to appropriate authority has been completed
11. CENVAT credit amounting to Rs 23.988 lakhs availed during the financial year.

Accounts of AcSIR has been maintained

Stores & Purchase

The division is mainly responsible for procurement of capital equipments, spares & consumable items, AMC of equipments, ARC for chemicals etc. including imports. It is also responsible for maintaining a minimum inventory of some essential consumable items. Different committees like Technical & Purchase Committee, Purchase Committee, Equipment Prioritization Committee and Standing Disposal Committee help the Stores & Purchase Division in arriving at suitable decisions as per the CSIR Purchase Rules of Goods & Services, 2008.

- **The major procurements for which orders have been placed during 2014-15 :**

(1) Iwatani Surtec HDP Simulator AV-MF
(2) FGX Dry Coal Separator System
(3) AKA-Flow Dry Separation Unit
(4) Inductive Coupled Plasma Spectrometer
(5) Consultancy Services for "Preparation of Detailed Project Report (DPR) for R&D Project including setting of Pilot Plant for Cold Rolled Grain Orientation (GRGO) Steel".
(6) Various orders have been placed pertaining to renovation of NML-canteen.
(7) Apart from above, orders for many other minor equipments, accessories and spares, office equipments, chemicals, ARC for supply of specials gases etc. were placed.

- **Major scientific equipments installed and commissioned during 2014-15 :**

(1) Computer Controlled Long Range Infrared Camera
(2) Thermo-Gravimetric Analyzer
(3) Simultaneous TG-DTA Analyzer with all Accessories
(4) Automatic Isoperibol Calorimeter with Combustion Vessel.
(5) Portable Sensing Device

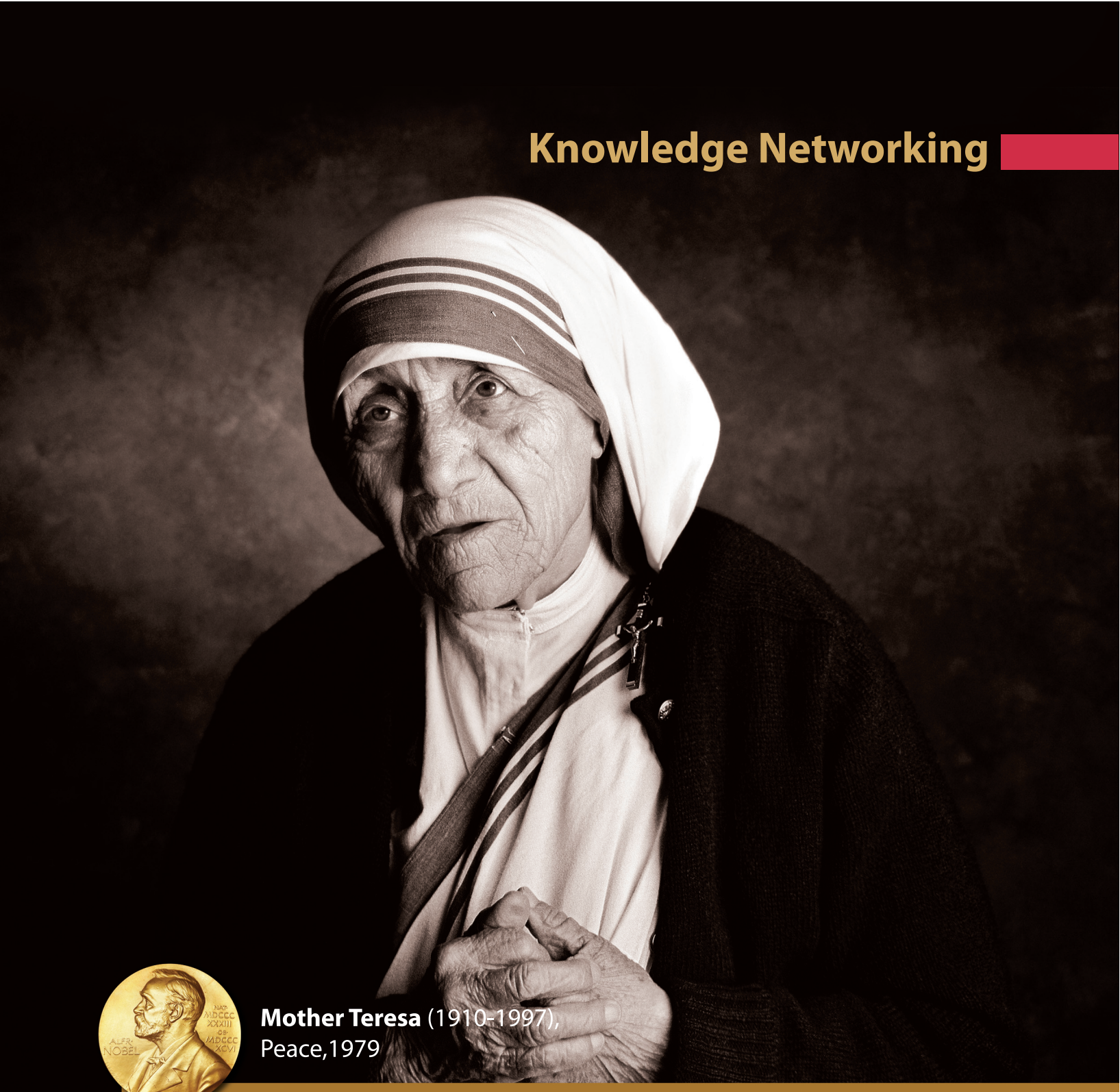
- **Major scientific equipments for which procurement process has been initiated during the year 2014-15 :**

(1) Magnetron Sputtering System for Deposition of Metallic and Ceramic Coatings
(2) Pusher Type Muffle Furnace
(3) Digital Image Correlation (DIC) System
(4) Scanning Electrochemical Workstation with SCEM, SVET, LEIS and SKP Facilities.
(5) Salt Spray Chamber
(6) Fusion Bead Preparation Machine
(7) Rotary Type Roasting Furnace
(8) Potentiostat /Galvanostat

The Stores & Purchase Division has taken up the challenging task of the implementation of the ERP package for Stores & Purchase with an objective of automation of process and a paperless office. It is co-ordinating with the CSIR team in ensuring a speedy implementation of Enterprise Resource Planning solution.

Following procedures are presently being done through ERP :

(1) Raising of indents
(2) Entry of data pertaining to items for procurement under specific category & sub-category
(3) Procurement through Local Purchases under without Quotation (cash).
(4) Purchase Orders are being generated through ERP under Local Purchase (credit) and Local Purchase Committee (LPC).
(5) Daily Receipt of items are being done under Stores Receipt Voucher (SRV) and Cash Purchase Register (CPR) and workflow is working successfully.
(6) Online bills submission are being done against SRV and CPR for payments to the suppliers.
(7) Payments are also being done through FVC Mode in ERP.



Mother Teresa (1910-1997),
Peace,1979

She was a Roman Catholic religious sister and missionary who lived most of her life in India. She was born in today's Macedonia, with her family being of Albanian descent originating in Kosovo. Mother Teresa founded the Missionaries of Charity, a Roman Catholic religious congregation, which in 2012 consisted of over 4,500 sisters and is active in 133 countries. They run hospices and homes for people with HIV/AIDS, leprosy and tuberculosis; soup kitchens; dispensaries and mobile clinics; children's and family counselling programmes; orphanages; and schools. Members must adhere to the vows of chastity, poverty and obedience as well as a fourth vow, to give "wholehearted free service to the poorest of the poor“. Mother Teresa was the recipient of numerous honours including the Nobel Peace Prize. In 2003, she was beatified as "Blessed Teresa of Calcutta“.

National Knowledge Network (NKN) and CSIR Enterprise Transformation Activities

NKN

CSIR-NML is linked to the National Knowledge Network (NKN) grid with a bandwidth of 100MBPs. In addition to providing high bandwidth for lab-wide Internet access, the National Grid computing network (grid GARUDA of C-DAC, Bangalore and CSIR High Performance Computing (HPC) at C-MMACS, Bangalore are also utilized as and when required. This is mainly to address high-end computational materials modeling problems (e.g Multi-scale modeling & analysis, Monte Carlo and Cellular Automata simulations etc. at meso-scale). NKN can also be used to access the supercomputing infrastructure with the state of art supercomputing facility at CSIR C-MMACS (Mathematical Modeling & Computer Simulation), Bangalore.

ICT Enterprise Transformation initiative

CSIR-Enterprise Transformation (ERP) is an organizational transformation initiative undertaken at CSIR to focus on building electronic workplaces and re-engineering processes for augmented service delivery. Various ERP modules have been implemented successfully to a large extent at CSIR-NML. On-line utilization of the ERP package has been extensively made for all functional modules like Human Resource Processes, Research and Development, Materials management, Finance management, Engineering, Infrastructure & Facility Management etc. Some of the achievements of ERP implementation efforts are enumerated below which enabled CSIR-NML as the leading laboratory in the arena of ERP implementation

Human resource

All the prerequisite data entry has been completed for e-service books of all employees and has been made fully functional. Most of the employee self service functionalities like GPF, children education allowance, leave, loans & advances, medical and telephone reimbursement, monthly pay bill of employees etc. are made fully operational as on-line processes. Some of the crucial associated functions such as tour proposal processing, adjustment bill submissions; LTC etc. has been also made operational. E-File system, with a built–in workflow structure has successfully replaced the existing time consuming manual processing system. This has eventually facilitated a faster and efficient way of processing files with least manual interventions.

R&D Planning

Information on the ongoing and completed projects have been processed through ERP package. Employee role mapping activities have been completed and all employees are mapped with projects. Budget allocation to all notional projects has been made to facilitate the ERP work flow seamlessly. The necessary inputs/documents of ongoing projects have been uploaded in the ERP system. The project receipts for the respective financial years are being processed in CVR.

Infrastructure and Engineering Services

Revised version of Materials Master Module (i.e. Stores & Purchase Module) has been deployed successfully. Under this version, a new set of category & sub-category of items have been introduced for entering and mapping items in the laboratory. Purchase indents are being raised as per the new version of category & sub-category. If required, manual purchase order could also be generated. Online submission of FVC for payments has been also successfully implemented. Stores Module for PIR entry has been functioning flawlessly and inconsistencies have been removed. DRR entry for generating SRV etc. under the ERP functionality has been tested. With regard to Engineering and Service module, passed Works and Services bill, Security deposit bill, Earnest Money bill and Service Tax Reimbursement Bill for Financial Year 2013-2014 have been raised on-line in the prescribed FVC Bill Format through the ERP work flow process. The on-line requests for works from the staff members can also be registered through the ERP system.

Finance and Accounts

All the past transactions through FVC has been completed under the ERP system. All the bills are being processed online through ERP nodule except IR bills, CENVAT Credit etc.

E-learning

The e-learning portal has been made functional. This portal provides a technology platform for exchange of knowledge resources and storing the knowledge in digital format.

Information and Communication Technology Unit (ICTU)

The ICT Unit Manpower

In recent years, IT system has become an integral part of any organization. It has provided optimal resource utilization, flexible work environment, converged communications and means to interact closely. Now, it is very easy to keep track of the frontier of knowledge base and cutting edge technologies developed in any part of the globe through internet.

The Information and Communication Technology Unit (ICT unit) is a part of evolution of NML's IT facilities takes care of management of IT resources in the lab and time-to-time up gradation with the latest technology which covers System Administration, Web Design, Development and Hosting, Mail Systems Management, Threat Management on Networks and other IT related activity. This unit also provides IT related counselling and advice to the Lab employees.

The ICT division is well equipped with computational facilities in terms of hardware and software. IT team Consisting scientists and technologists is actively involved to support the R&D activities performed at lab level by providing rugged IT infrastructure and seamless Internet facility.

The ICT unit is actively involved to provide seamless and uninterrupted IT services to R&D activities by carrying out following lab wide activities:

- System management (Email & Servers etc), maintenance and administration
- Internet connectivity and Bandwidth management
- Network Infrastructure (LAN, WiFi) maintenance
- Video Conferencing and Skype activities
- Design, development of web based applications, hosting and publishing
- VPN and Inter-site connectivity
- Biometric and Surveillance
- Telecommunication and Teleconferencing
- Audio-Visual facility

Knowledge Management

IP Analytics services

CSIR-National Metallurgical Laboratory started providing IP search and analysis services to its clients in the area of minerals, metals and materials. The Laboratory offers patent analytic services that enable clients to take an eagle's eye view of the current and future trends of their respective technologies and develop their ideas around such technologies. During 2014-15, several IP landscapes are drawn and Analytical reports are prepared for the client as well as for internal research projects. The analytical reports of CSIR-NML were intended to provide its clients with insights, which aid them to strategize and plan their business approach in a better manner.

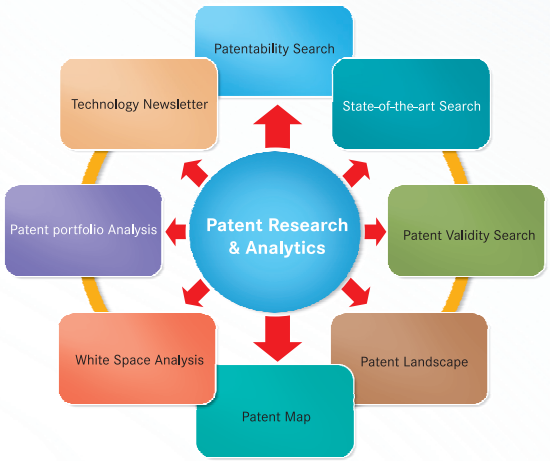
IP Analytics is the systematic evaluation and visualization of IP data to identify technological trends in order to ensure appropriate implementation, protection and monetization of inventions. CSIR-NML has in-depth expertise in IP information and research to assist its clients in specific areas of patent research. With vast experience in the area of patinformatics/patent analytics, CSIR-NML provides various services, viz, IP search and Analysis, Evaluation of Freedom-to-Operate Space, Patent Landscaping, Patent portfolio Analysis, Patent Mapping, Patent Citation Analysis, White Space Mapping and Competitive Intelligence by utilizing patent and non-patent literature databases - Open Access as well as commercial software and databases. The laboratory has commercial database resources such as Thomson Reuters Web of Knowledge, Questel QPAT, etc. and Text Mining software like VantagePoint. CSIR-NML's patent analysts are highly proficient in the technical analysis of patents particularly in the areas of Minerals, Metals and Materials.

The laboratory also provides specialized competitive intelligence services like Competitor Tracking/Profiling, Comparative Technology Evaluation, Market Assessment Studies, Strategic Grouping/Collaboration, Patent SWOT Analysis, Patent Claim Analysis and Market Segmentation Analysis on demand from the clients.

Patent Research Analytics Services

Patent search and Analytical services was provided to our clients by a dedicated team, using cutting edge tools and database resources of the Laboratory. The analysis of patent portfolios of the client was carried out to compare client's patent profile to that of a similar company to identify competitive strengths and weaknesses and the client was provided an in-depth qualitative analysis of the strengths, weaknesses, and relative values of the individual patents in the patent portfolio. The following business and research intelligence reports were brought out: (i) Patentability, State-of-art, patent validity and patent landscape and patent map, (ii) Patinformatics and Scientometrics analysis of the area of invention and (iiii) White Space

Mapping in technological areas identified by client. Apart from the above, a monthly news letter was brought out updating the monthly patenting status of the global players, News, patenting status in India, etc. The diagram shows the services provides to client during 2014-15



Information Systems and Database management

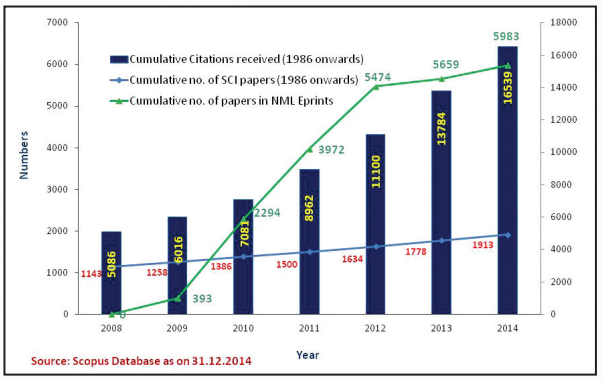
A number of web based information systems and related databases are developed and maintained in-house at CSIR-NML for the efficient overall functioning of the laboratory. These information systems and databases provide input for managerial decision making while supporting numerous key activities of the laboratory e.g. Project Information Management and Monitoring, Documents and Reports Management, Employee Profile Management, Human Resource (Competence and Man days Involvement) Management. Some of these information systems have been consequently winning awards and recognitions from reputed national and international Government and private bodies e.g. Skoch Merit Certificate 2012 and 2014, Skoch Digital Inclusion Award 2012 and E-World Best Jury Award for Innovative Initiatives in Governance 2011.

Fig. Real time reporting in key functional areas of laboratory

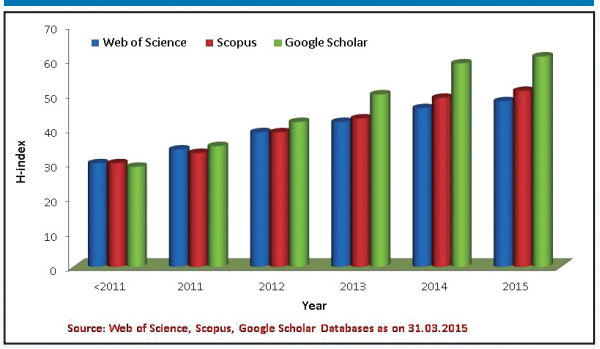
SCI Publications and Citations

135 SCI papers were published from CSIR-NML during the calendar year 2014. These papers are regularly uploaded in Laboratory's Institutional Repository. The cumulative citations for the SCI publications (1986 onwards) from CSIR-NML has increased from 13784 (in 2013) to 16539 (in 2014) registering an increase of about 20% growth. The average citation per paper is 8.64 against 7.75 in the last year. 57 articles have received more than 50 citations/paper (source: Scopus) as on Dec 31, 2014.

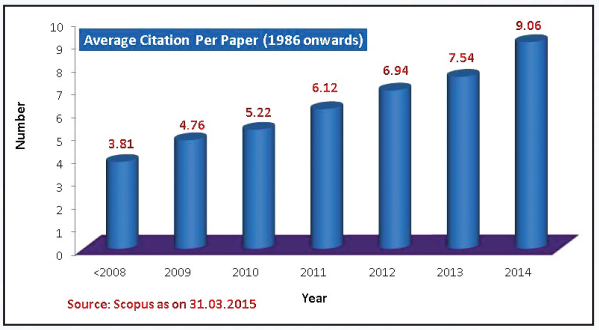
SCI Publications and impact of IR in Citation values



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



H-Index & Avg Citation/Paper

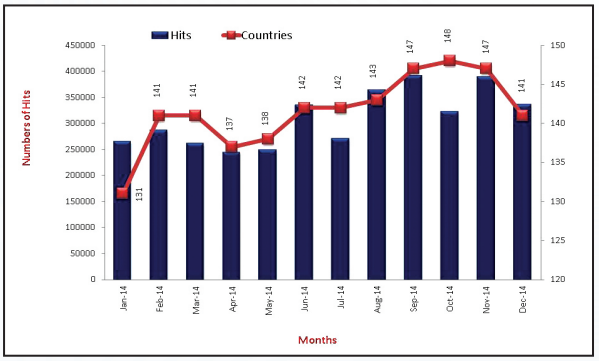


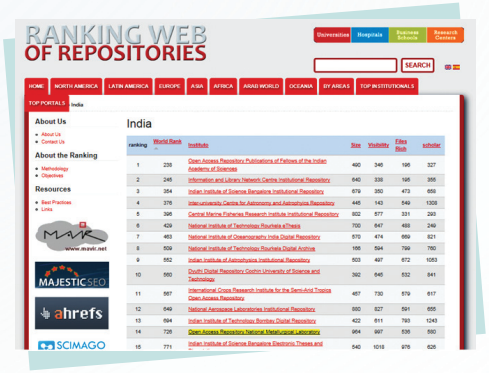
Institutional Repository

The NML Institutional repository (http://eprints.nmlindia.org) has maintained its global visibility and popularity with average hits of over 0.35 million per month and a cumulative total of over 11.66 million hits since inception (2009). The researchers from 182 countries have accessed NML repository. During last two months 148 countries (highest users in a month) have accessed the database. Among the global users, the top twenty countries in decreasing order were: United States, India, Germany, China, South Africa, Russia, Canada, Australia, Turkey, UK, Iran, France, Malaysia, Korea, Ukraine, Brazil, Hong Kong, Netherlands, Japan and Italy.

Country-wise access of NML Eprints site

NML Eprints in terms of hits/downloads
as on Dec 31, 2014





NML Eprints ranking (14th) among worlds web repositories (35 nos.) as on 18th March 2015

Transparency Portal

The CSIR-NML Transparency portal (http://library.nmlindia.org/tp/index.htm) containing all information pertaining to staff pay & allowances, immovable property, foreign and local travel, Honorarium, project details, expenditure pattern, local purchase data, works and services, CAG report, Research publication, Citations, Patents, Technology transfer etc. has been updated periodically. This caters to the information needs of a citizen due to its global accessibility. It can be mentioned here that CSIR-NML launched transparency portal in May 2012.

Information under RTI Act

During the reporting period, 11 applications were received and all of them were responded to within the time schedule. So far no appeal was referred to Central Information Commissioner (CIC) for review. The data regarding RTI has also been uploaded in laboratory's Transparency portal.

Information Products

- CSIR-NML Annual Report 2013-14
- Director's Desk-Aug 11, 2014 and February 6, 2015
- Journal of Metallurgy and Materials Science, Vol. 56 (1-4), 2014. ISSN 0974-1267 (Online) (http://www/indianjournals.com) and ISSN 0972-4257 (Print)
- NML Record Book 2015 and Monthly Calendar
- Brochure, Information Folder

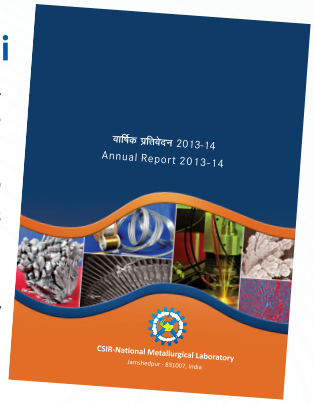
Hindi Cell

Official Language Implementation

CSIR-NML 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, annual competitions and divisional inspections for enhancement of Hindi use in the divisional activities.

Publications in Hindi

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



Promotional Activities for Hindi Implementation

- Four inspections were conducted by Hindi Officer covering various divisions for identifying the areas of Hindi implementation and enhancing the use of Hindi in divisional activities.
- Incentive Scheme for working in Hindi has been introduced and employees are actively participating in the scheme. Seven Employees namely Shri Parmarth Suman, Dr. Anjani Kumar Sahu, Shri Ambar Tirki, Shri Akhilesh Kumar Nigam, Md. Nayeem Ansari, Shri Sudhir Kumar and Shri C.R. Chakraborty were awarded 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.

Hindi Competition

"Hindi Competitions" were organized from **8th to 12th September, 2014** for NML Employees. On this occasion, a total of 5 Hindi competitions were organized for NML Staff and Officers. The competitions included : Essay writing, Noting/Drafting, Hindi dictation and Self-written poetry recitation etc. All the winners were felicitated with prizes and certificates on the occasion of Hindi day celebration on 12th September, 2014.

Activities of Hindi Implementation for TOLIC, Jamshedpur

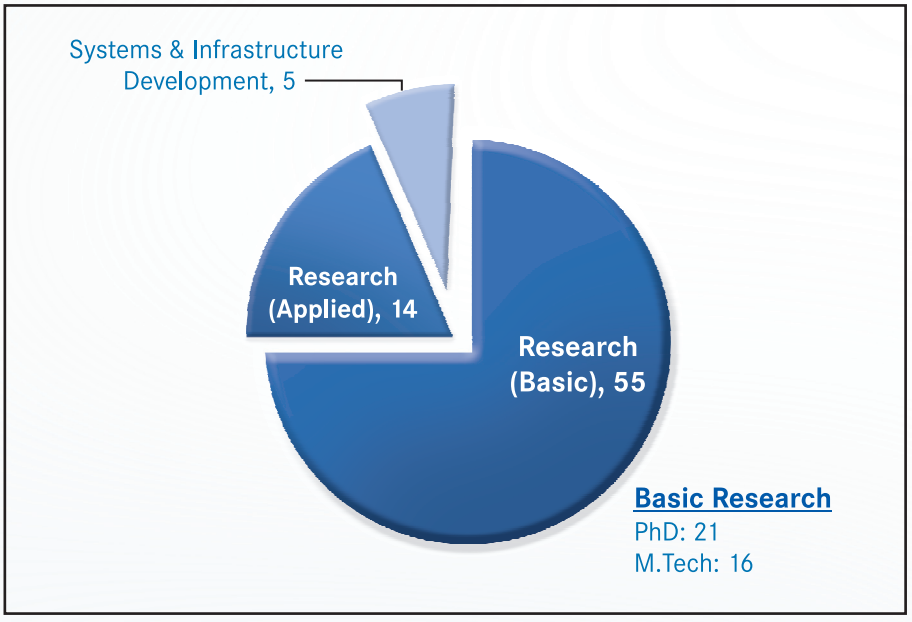
- CSIR-NML is the Secretariat of TOLIC, Jamshedpur. It has 65 Members from all the Central Govt. offices located at Jamshedpur and adjacent. Only the Heads of these offices are members. Dr. S. Srikanth, Director CSIR-NML is Chairman of this committee. Under his chairmanship this committee is playing vital role for enhancement of Hindi use in these offices. TOLIC, Jamshedpur has been adjudged 'First' for commendable performance in implementing the Official Language policy of the Union during the reporting year. CSIR-NML bagged first prize for its efforts in implementation official language by ministry of Home Affairs , Govt. of India.
- Ms. Nita Choudhary, (IAS), Secretary, Department of Official Language, Ministry of Home Affairs, Govt. of India visited CSIR-NML on 7th October, 2014 to conduct a meeting with Town Official Language Implementation Committee, Jamshedpur in CSIR-NML Lecture Hall. More than eighty Senior Officials from different Government organisations participated in this meeting. She was overwhelmed with the inspiring work done by TOLIC Jamshedpur for the benefit of school and college students of Jamshedpur. She suggested TOLIC Jamshedpur to do more programmes for students, teachers as well as guardians. She assured to put this exemplary deed of TOLIC Jamshedpur on Govt. of India site which can be seen on www.rajbhasha.gov.in

In-house Project Support Group (i-PSG)

In-house Project Support Group (i-PSG) at CSIR-NML supports not only 'research projects' but also 'knowledge management' and 'system and infrastructure development' projects directed towards improvement in performance, relevance and impact of research undertaken.

Forty projects were in progress during the year. In addition to the patents filed, the sponsored projects generated and the conference proceedings presented from work done in i-PSG projects, some of the significant publications from the i-PSG projects in the calendar year 2014 are the following :

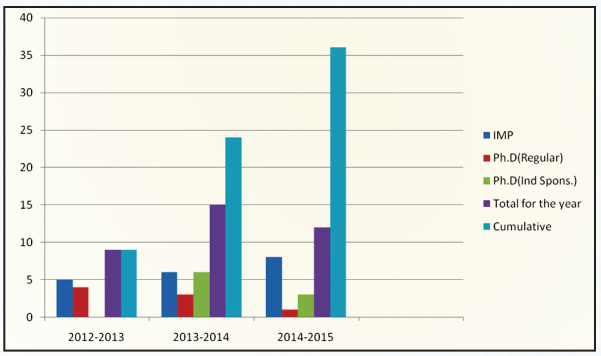
- Extraction of lithium from primary and secondary sources by pre-treatment, leaching and separation: A comprehensive review, published in Hydrometallurgy, 150 (2014), pp.192-208.
- Microstructural characteristics and mechanical properties of carbon nanotube reinforced Aluminum alloy composites produced by ball milling published in Materials and Design, Volume 64, 2014, Pages 542-549.
- Colloidal graphite/graphene nanostructures using collagen showing enhanced thermal conductivity" published in Int. J. Nanomedicine 2014; 9: 1287–98
- Parametric control on giant magnetoimpedance (GMI) behaviour of CoFeSiBCr amorphous wires for prospective sensor applications published in Sensors and Actuators A, 220 (2014) 382 - 387.



AcSIR Academy of Scientific & Innovative Research
Set up by an Act of Parliament, An Institute of National Importance

Academy of Council of Scientific & Innovative Research-NML

Under the banner of Academy of Scientific and Innovative Research (AcSIR), CSIR-NML has initiated Ph.D. / Integrated M.Tech-Ph.D programs in the emerging and trans-disciplinary areas of Materials and Metallurgical Engineering, broadly involving mineral processing, primary and secondary extraction processes from ores, secondary resources and wastes, energy efficient and environmentally friendly processes, advanced materials for functional applications, structural materials and alloys, automotive, nuclear, power, energy efficient materials and coatings, waste utilization, nondestructive evaluation, mechanical behavior of materials, surface engineering of various advanced alloys and materials, corrosion and prevention, metal forming, thermo-mechanical behavior, grain boundary engineering, iron and steel making, energy & environment in metallurgical industries etc. Direct Ph.D. course at CSIR-NML was started from January 2012 session while Integrated M. Tech-Ph.D (IMP) course was initiated from August 2012 session. In the year 2014-15, 8 new students were admitted to IMP course while 05 students, including 3 industry sponsored students, have joined AcSIR-NML for their doctoral studies, taking the total student strength to 36 (IMP: 14 students and Ph D: 22 students). 2012-13 batch of IMP students of AcSIR-NML have been awarded M. Tech degrees during the 4th convocation of AcSIR in November 2014. The first PhD from AcSIR NML under the Engineering cluster was awarded to Dr. Ganesh Chalavadi.



Total Students: 36

impression

... I greatly appreciate receiving CSIR-NML Annual Report for the year 2013-2014. It is impressive in contents and elegant as a product. I wish the lab the very best.

With my best wishes and personal regards

Dr. BALDEV RAJ,
FTWAS, FNAE, FNA, FASc, FNASc.HM,IIM,HF,BIns.NDT
President-Research, PSG Institutions
President, Indian National Academy of Engineering
President, International Institute of Welding,
President Elect, International Council of Academies of
Engineering & Technological Sciences
Chairman, Board of Governors, Indian Institute of Technology, Gandhinagar
Hon.Member,International Committee on NDT
Hon.Fellow, International Medical Sciences Academy
Member, German National Academy of Sciences

PSG Institutions
PSG College of Technology Campus
Tamil Nadu, India
18/06/14

Congratulations to you and team for hosting the Foundation Day yesterday with near-perfection... I like your approach of treating a celebration as an act of introspection and reaffirmation of NML 's commitment to its mission...

Best regards,

Rajendra P. Goel,
(Pensioner)
27/11/15

Recognitions & Resources

Subrahmanyan Chandrasekhar (1910-1995),
Physics, 1983

He was an Indian American astrophysicist born in Lahore who, with William A. Fowler, was awarded the 1983 Nobel Prize for Physics for his mathematical theory of black holes, which was a key discovery that led to the currently accepted theory on the later evolutionary stages of massive stars. The Chandrasekhar limit is named after him. He worked in the areas like stellar structure, theory of white dwarfs, stellar dynamics, theory of radiative transfer, quantum theory of the hydrogen anion, hydrodynamic and hydromagnetic stability, equilibrium and the stability of ellipsoidal figures of equilibrium, general relativity, mathematical theory of black holes and theory of colliding gravitational waves. He became a naturalized citizen of the United States in 1953

National/International Awards & Recognitions

Most Significant CSIR Technology of the Five Year Plan Period for the technology "Development and commercialization of column flotation technology for the beneficiation of low-grade mineral deposits".

Dr. G Bhaskar Raju,
Chief Scientist

Dr. S Prabhakar,
Chief Scientist

Dr. S Subba Rao,
Chief Scientist

Dr. TV Vijayakumar,
Principal Scientist

Ms. N Vasumathi,
Scientist

Tata Innovista 2015 Award

- For the TATA-NML collaborative project “Graphene from Natural Source" under “The Leading Edge - Proven Technologies”. Team : Dr. Ranjan Kuamr Sahu, Senior Scientist, and Mr. YN Singhbabu.
- Regional Award for the TATA-NML collaborative project “Microwave - IR Sort; for compositional analysis of Iron Ore" under “Promising Innovation Category”. Team : Dr. Sarmistha Palit Sagar, Principal Scientist, and Dr. Arpita Ghosh, Scientist.

TATA INNOVISTA
Celebrating Innovation

Fellow of Royal Society of Chemistry (FRSC)

Dr. Trilochan Mishra,
Principal Scientist

Meritorious Contribution in Research and Education conferred by NACE International, India Section

Dr. Indranil Chattoraj,
Chief Scientist

National NDE award for System Innovation and Development 2014

Dr. Ashis Kumar Panda,
Sr. Scientist

Fellow of Indian Institute of Metal 2014

Mr. Indu Bhusan Mishra,
Chief Scientist

H.S. Pareek Award of the Geological Society of India for the year 2014.

Dr Bibhuranjan Nayak,
Principal Scientist

- Young Scientist Award 2013 of the Biotech Research Society, India
- Young Metallurgist Award for 2014
- Felicitation by the Jamshedpur Chapter of the IIM

Dr. Abhilash, Scientist

Raman Research fellowship 2014-2015

Dr. Ashis Kumar Panda,
Sr. Scientist

Skoch Order-of-Merit awards 2014
for the project **"Inquest"**
- An e-reporting system.

Ms. Beena Kumari,
Scientist

Dr. Indranil Chattoraj,
Chief Scientist

Dr. Sital Kumar Pal,
Principal Scientist

Dr. Anuradha Madhukar,
Sr. Scientist

Mr. Ashish Upadhyay
Technical Oficer

CSIR-NML Foundation Day Awards

P. Ramachandra Rao
- Best Employee Award 2013-14

Mr. AK Pandey,
Section Officer
(Non-Technical Category)

Mr. C Srinivasa Rao,
Technician II

Mr. Ashish Upadhyay,
Technical Officer
(Technical Category)

Dr. BR Nijhawan Award
for the Best Technical Paper

for the paper "Biomimetic nanocomposites of carboxymethyl cellulose-hyroxyapatite : Novel three dimensional load bearing bone grafts, Published in Colloids and Surfaces B : Biointerfaces, 115 (2014), pp. 182-190"

Dr. Subhadra Garai,
Scientist

Dr. Arvind Sinha,
Sr. Principal Scientist

Prof. VA Altekar Award
for the Best Technology

for the technology " Development of process technology for beneficiation of dumped low grade iron ore fines for iron and steel making"

Mr. RK Singh,
Scientist

Dr. RK Rath,
Sr. Scientist

Ms. Sunati Mohanty,
Scientist

Dr. Mamta Sharma,
Scientist

Dr. Ratnakar Singh,
Chief Scientist

Prof. Shilowbhadra Banerjee Award for Best In-house Project

for the project "Development of novel corrosion inhibitors for copper and its alloys"

Dr. A K Mohanty,
Sr. Scientist

Dr. S Chakraborty,
Principal Scientist

Dr. S Kant Tiwari,
Sr. Principal Scientist

Dr. Trilochan Mishra,
Principal Scientist

Dr. J K Sircar,
Chief Scientist

Awards at the 18th International Conference on Non-ferrous Minerals and Metals-2014 held at Nagpur

First Prize in Oral Paper Presentation for paper entitled "Recovery of metals from spent nickel-cadmium (Ni-Cd) battery by leaching electrowinning process", presented by Dr.N.S.Randhawa; and co-authored by Payal M. Yelne, Kalptaru Gharami, D.C. Sau and Manoj Kumar.

Dr. Navneet Singh Randhawa,
Technical Officer

Dr. Deepak Chandra Sau,
Scientist

Dr. Manoj Kumar,
Sr. Scientist

Best Poster Presentation award for paper entitled "Recovery of light rare earth metals from waste fluorescent powder", presented by Himanshu.R.Verma; and co-authored by Pratima Meshram, S.K.Sahu, B.D.Pandey and T.R.Mankhand

Ms. Pratima Meshram,
Scientist

Dr. Sushanta Kumar Sahu,
Sr. Scientist

Dr. Bansi Dhar Pandey,
Chief Scientist

Best Paper Award in the area of Institutional Repository

The paper entitled, "Benefit of Institutional Repository and its Global Impact" authored by A.K. Sahu, N.G. Goswami and B.K. Choudhury has been awarded in one day Seminar on "Role of a Librarian in the Changed Global Scenario" organised by Society for Documentation & Information Science in association with The Institution of Engineers (India) Jamshedpur Local Centre and Jharkhand Information and Library Association, Ranchi.

Town Official Language Implementation Committee (TOLIC) Awards

First Prize for Best Implementation of the policy of the union regarding Official language HINDI (2013-14)

TOLIC Jamshedpur, headquartered at CSIR-NML was awarded among 13 states at National Level. Central Home Ministry conferred the award on 13th Feb 2015 at Gangtok.

First Prize in Hindi Poem Writing Competition 2014-15

Mr. Parmarth Suman,
Asstt. (G) Gr.II

Garden of the Year- 2015

CSIR-NML participated in the Annual flower show and won the total 26 nos. of prizes in different categories in the 26th Annual Flower show organised by Tata Steel, JUSCO and Horticultural Society, Jamshedpur during December 25-28, 2014, held at Gopal Maidan, Bistupur. On behalf of CSIR-NML, the prizes were received by Mr. Sanatan Naiya, Sr. Technician(II) from the Chief Guest, Mr. Ashish Mathur, Managing Director, JUSCO on 28th December,2014 during Prize distribution Ceremony

Editorial Board Membership

Dr. Srinivasan Srikanth,
Director NML

- Transactions of The Indian Institute of Metals
- Bulletin of Materials Science
- Science and Culture

Dr. Sarmistha Palit Sagar,
Principal Scientist

- Journal of the Korean Society for NondestructiveTesting

Dr. Bansi Dhar Pandey
Chief Scientist

- Hydrometallurgy
- Metals and Materials International

Dr. Ashok Kumar Mohanty,
Sr. Scientist

- Journal of Nanoscience Letters
- World Journal of Analytical Chemistry

Dr. Trilochan Mishra,
Principal Scientist

- International Journal of Materials and Chemistry (SAP, USA)
- American Journal of Physical Chemistry (Science publisher, USA)

Dr. Abhilash,
Scientist

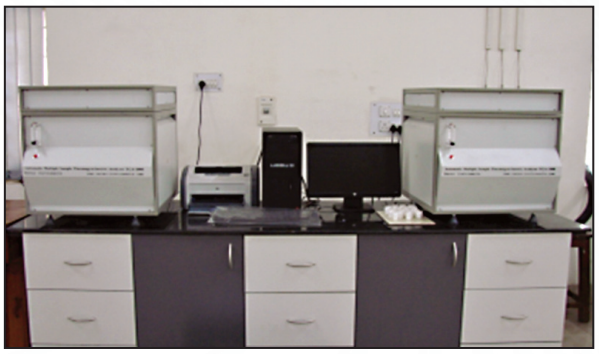
- CIBTech Journal of Microbiology
- Scientific Journal of Environmental Sciences

International Agreements/Collaborations

Facilities Created

Proximate analyser (TGA 1000 Navas) (Multiple Sample Thermogravimetric Analyzer)

It is used for proximate analysis of coal. The instrument determines the moisture, ash, volatile matter and loss on ignition content of coal by measuring the weight loss at different temperature at controlled environment. 19 samples can be analyzed simultaneously in selectable nitrogen, oxygen and air atmosphere



Simultaneous TG- DTA Analyzer

Model : STA 7300,

Make : Hitachi,

Range of Temperature : RT-1300 0C,

Atmosphere : static air, flowing Ar, N2, O2.

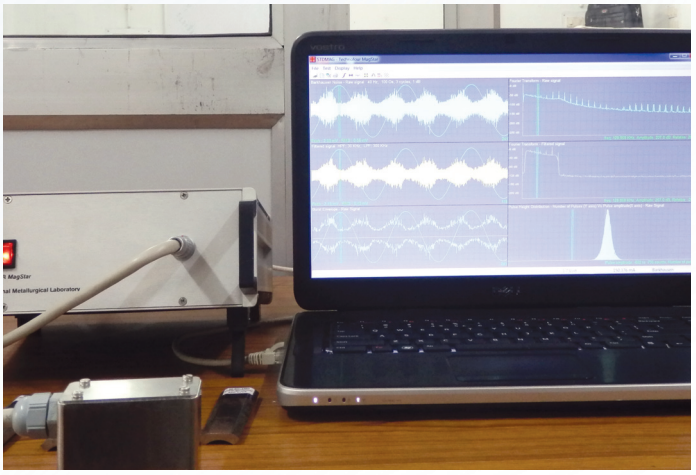
Simultaneous TG/DTA improves ease of operation, sensitivity and analytical accuracy of conventional standalone systems. If flexibility and high performance is needed in various applications, the new DTG-60/60H combines them all: Basic functions required by simultaneous thermogravimetry/differential thermal analysis (TG/DTA) measurements are improved. Atmosphere control is programmable. As in DSC, the TA-60WS provides advanced acquisition, analysis and report functions which ensure comfortable simultaneous measurements

Computer Controlled Long range Infrared Camera

The Computer controlled uncooled long range infrared camera is a state - of - the - art thermography system designed for precise, quick and non - contact measurement of the surface temperature of objects. This Infrared Camera has been designed for universal application and can be used both as a mobile and as a stationary device for measuring and storing temperature values. Typical fields of application of the thermography system are amongst other things: Material inspections, Quality Control & Process monitoring, Predictive maintenance, Gas Leak detection, Thermographic inspection of electrical and mechanical systems and aggregates & Quality assessment of ores and minerals

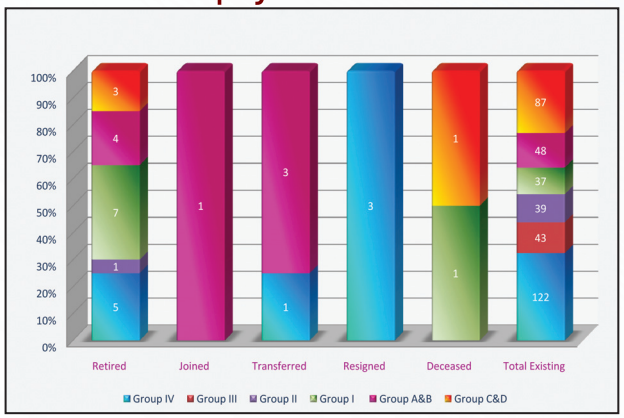
Portable magnetic sensing device (Magstar) with laptop

It is jointly developed by M/S. Technofour, Pune and CSIR-NML (Model: MagStar). The system is cable of measuring magnetic hysteresis loop (MHL) and magnetic barkhausen emission (MBE) separately using a single magnetizing probe with selection-clicks to relevant softwares. The device is portable and light weight. The instrument can be used for (a) evaluation of microstructural changes during heat-treatment/ageing (b) determination of ferrite volume fraction (c) evaluation of ferromagnetic phases and its correlation with mechanical properties (e.g. hardness) and (d) residual stress analysis. The equipment can be used for onsite evaluation of power plant steels.

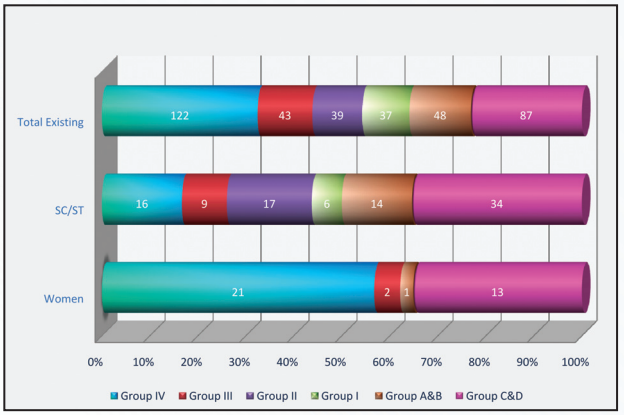


Human Resource Profile

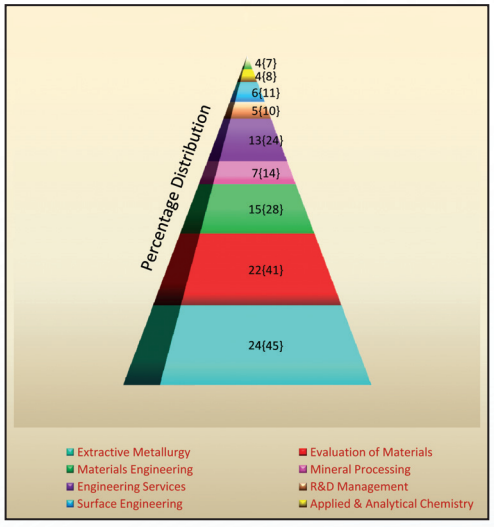
Employee Profile



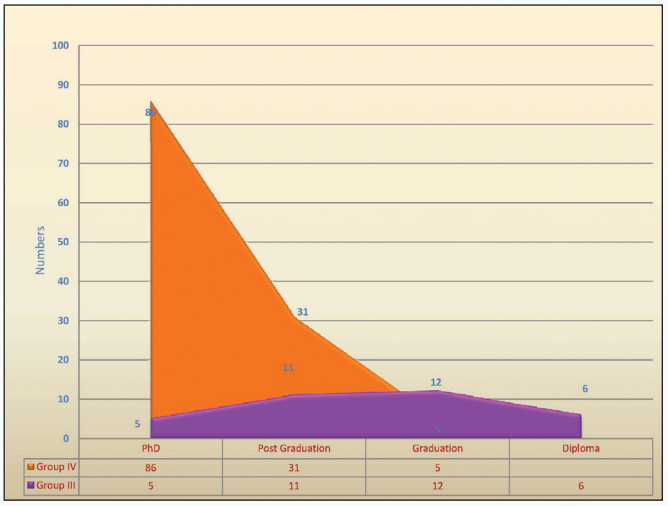
Profile of Women & Disprivileged sections of society



Manpower in Core Areas



Qualification of Scientists and Technical Officers



Employees News

Employees Superannuated

Mr. Desa Singh,
Lab. Assistant
31-05-2014

Mr. AK Shaw,
Lab. Assistant
31-07-2014

Mr. Jharkhande Singh,
Lab. Assistant
31-07-2014

Dr. S Prakesh,
Chief Scientist
31-08-2014

Shri SN Dhar,
Lab. Assistant
30-09-2014

Dr. RP Bhagat,
Chief Scientist
31-10-2014

Dr. Narayan Parida,
Chief Scientist
31-10-2014

Shri NV Rao,
Lab. Assistant
31-10-2014

Mr. Biswanath Shaw,
Security Guard
10-31-2014

Mr. PC Shekhar Deo,
Lab. Assistant
30-11-2014

Mr. MK Das Biswas,
Asst(S&P)
30-11-2014

Mr. J Sharma,
MTS
30-11-2014

Mr. PN Swamy,
Sr. Steno
31-12-2014

Mr. A Bagchi,
SO(F&A),
31-12-2014

Mr. B Giri,
MTS
31-01-2015

Mr. Bhagwat Prasad,
Asst.(S&P) Gr.I
31-01-2015

Mr. SS Singh,
Technician(2)
28-02-2015

Mrs. Kiron Devi,
Multi Tasking Staff
28-02-2015

Dr. RK Jana,
Chief Scientist
28-02-2015

Dr. BD Pandey,
Chief Scientist,
31-03-2015

Employees Transferred from CSIR-NML

Mrs. Ranu Verma,
Assistant (G) Gr.I
Transferred to IMMT
Bhubaneswar
on 16-04- 2014

Dr. Anuradha Madhukar,
Senior Scientist
Transferred to CSIR
Headquarters, New Delhi
on 25-04-2014

Mr. Vinod Kumar,
Administrative Officer
Transferred to CSIR-
Headquarters, New Delhi
on 27-06-2014

Mr. RK Saha,
SO(G)
Transferred to
CGCRI Kolkata
on 16-01-2015

Employees Transferred to CSIR-NML

Mr. Dheeraj,
Finance and
Accounts Officer,
Transferred from
CSIR-CBRI, Roorkee
on 02-02-2015

Employees Resigned

Dr. D Mandal,
Scientist
on 02-09-2014

Mr. Arpan Das,
Scientist
on 04-12- 2014

Dr. A Das,
Principal Scientist
on 16-01-2015

Deceased Employee

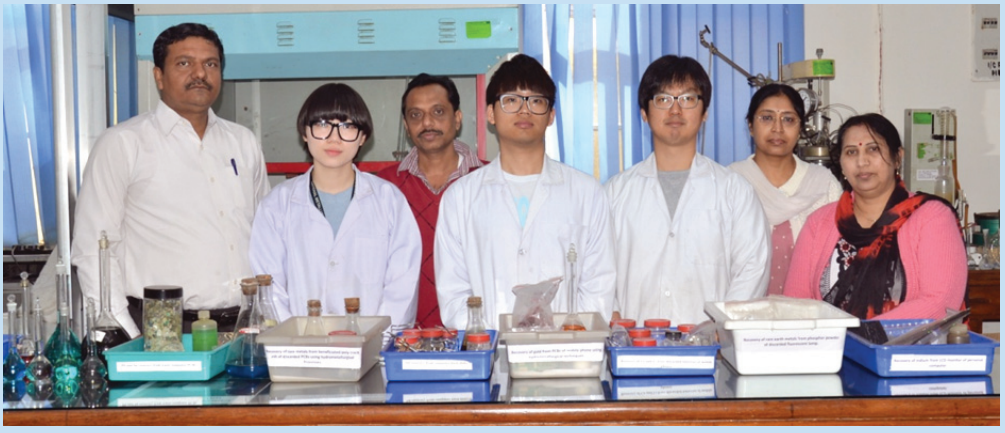
Mr. Kishan Mukhi,
Multi Tasking Staff
on 16-04-2014

Mr. Pratap Singh,
Laboratory Assistant,
on 23-11-2014

Trainings Organized

Korean Internship Programme (Jan – Feb 2015)

The fifth batch of interns from South Korea comprising of three students were provided internship for a period of two months at CSIR-National Metallurgical Laboratory, India under KEMREP program of South Korea and MoU between Korea Maritime University and CSIR-NML. The training program establishes a framework to provide an opportunity for students to apply educational, leadership and communication concepts and theories in practical context. Under this program, students from Korea Maritime & Ocean University and Kangwon National University Korea visited CSIR-NML, Jamshedpur for their internship. This KEMREP program enhances the exchange of scientific knowledge and communication between two countries, which is helpful for the betterment and future development in different research areas. They were provided training in the areas of hydrometallurgy, analytical chemistry and recycling.



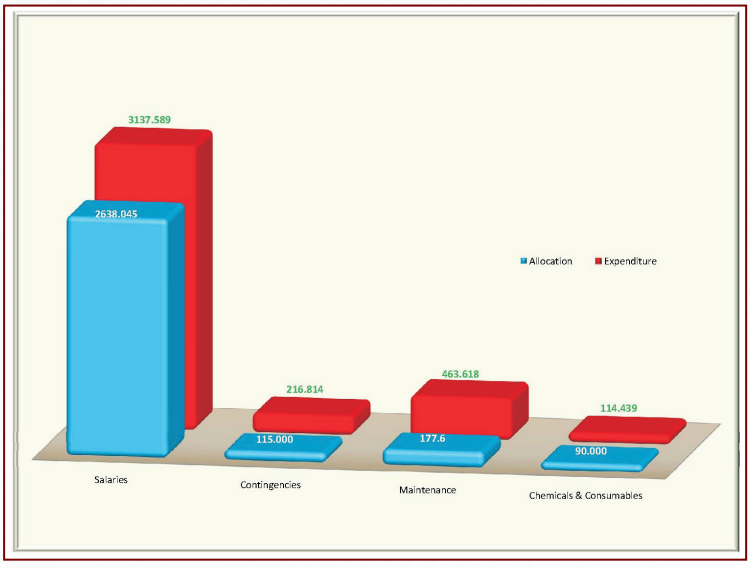
Korean Interns Mr. YoungJim KIM, Mr. Hyeongjun Gwon and Ms. Hyeon-ji Jo with CSIR-NML supervisors and co-ordinator

ISO QMS Internal Auditor's Training (25-26 Mar 2015)

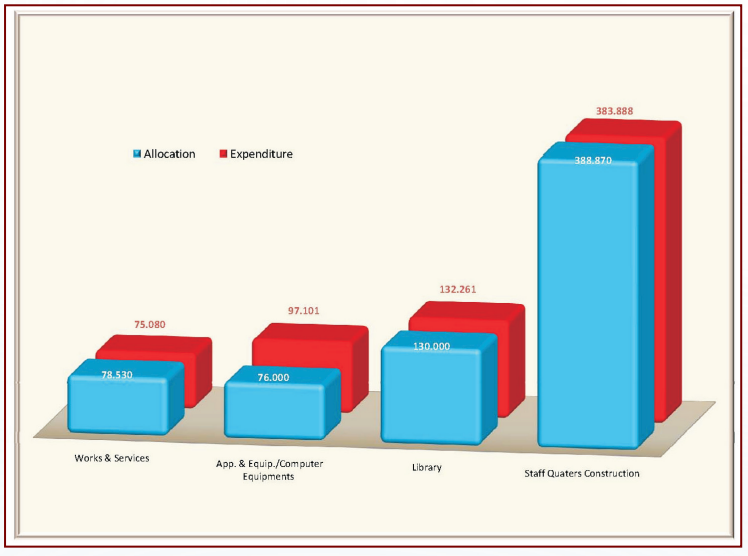
The aim of the course was to train a group of CSIR-NML staff members as "Internal Quality Auditors". A batch of 24 participants from CSIR-NML attended this training. Mr. Jayanta Chakraborty, Trainer, Bureau Veritas Certification (India) Pvt. Ltd. conducted the training program and covered the essentials of ISO 9001 standards and auditing through role play and other mock drills.

Budget 2014-2015

Allocation and Expenditure (Capital [Rs In Lakhs])



Allocation and Expenditure (Recurring [Rs In Lakhs])



Star Clients

CSIR-NML's Fortune 1000 Clients

General Electric	Boeing
Reliance Industries	Oil & Natural Gas Corporation Ltd.
Indian Oil Corporation	National Thermal Power Limited
	Steel Authority of India Limited
	Bharat Heavy Electrical Limited
DLF	Natinal Mineral Development Corporation (NMDC) Ltd.
GAIL (India) Limited	Larsen & Tourbo Co. Ltd.

CSIR - NML's ET 500 Clients

NHPC Ltd.	Hindustan Zinc Ltd.	Jindal Steel & Power
Essar Steel	Tata Motors	JSW Steel
Bharat Petroleum Corporation limited	Texmaco Ltd.	Usha Martin Ltd.
Mahindra Ugine Steel Company	Sterlite Industries	CESC Ltd.
Neyvelli Lignite Corporation Ltd.	Mcnally Bharat Engineering Co.	National Aluminium Co. Ltd.

Interactions & Reviews

Amartya Sen (born 1933)
Economic Sciences, 1998

Amartya Sen is Thomas W. Lamont University Professor, and Professor of Economics and Philosophy, at Harvard University and was until 2004 the Master of Trinity College, Cambridge. He is also Senior Fellow at the Harvard Society of Fellows. Earlier on he was Professor of Economics at Jadavpur University Calcutta, the Delhi School of Economics, and the London School of Economics, and Drummond Professor of Political Economy at Oxford University.

His research has ranged over social choice theory, economic theory, ethics and political philosophy, welfare economics, theory of measurement, decision theory, development economics, public health, and gender studies.

Amartya Sen's books have been translated into more than thirty languages, and include Choice of Techniques (1960), Growth Economics (1970), Collective Choice and Social Welfare (1970), Choice, Welfare and Measurement (1982), Commodities and Capabilities (1987), The Standard of Living (1987), Development as Freedom (1999), Identity and Violence: The Illusion of Destiny (2006), The Idea of Justice (2009), and (jointly with Jean Dreze) An Uncertain Glory: India and Its Contradictions (2013).

Amartya Sen's awards include Bharat Ratna (India); Commandeur de la Legion d'Honneur (France); the National Humanities Medal (USA); Ordem do Merito Cientifico (Brazil); Honorary Companion of Honour (UK); Aztec Eagle (Mexico); Edinburgh Medal (UK); the George Marshall Award (USA); the Eisenhauer Medal (USA); and the Nobel Prize in Economics.

Distinguished Visitors

Dr. Gaurav Mohanty,
EMPA, Switzerland
Elevated temperature nanomechanics : understanding nanoindentation creep in fcc metals and micropillar strain rate jump tests in nanocrystalline nickel
21 Apr 2014

Mr. Michael Laracy,
Tata Fellow, MIT, USA
Use of Boiler ash for geopolymer brick.
12 Sep 2014

Mr. Hitesh Mamgain,
Product Specialist, WITEC, Germany
Hybrid Microscopy: Combining near field optical microscopy with spectroscopic techniques such as Raman, PL & IR PL and with SEM.
22 Mar 2014

Ms. Snigdha Ghosh,
Target Corporation of India, Bangalore
Modelling of LD converter
10 Oct 2014

Dr. Sanket Sarkar,
GE Global Research Bangalore
Microstructure Based Creep Modeling in Superalloys.
12 Jun 2014

Prof. HS Ray,
Adjunct Professor, B E College, Shibpur, Howrah
Dreams & Connectivity
28 Oct 2014

Dr. Krishnendu Mukherjee,
Researcher, Section of Materials, Science and Characterisation, Depart.
MICRESS formalism and its application on modelling of heat treatment of DP.
26 Jun 2014

Dr. KN Udupa,
Head Chemistry, Scientific Services, Tata Steel, Jamshedpur
Uncertainty Measurement: ILCT & PT - Importance in NABL.
29 Oct 2014

Dr. Thomas Poinot,
Post Doctoral Associate, MIT, USA
Activities of Tata Centre at Massachusetts Institute of Technology, A Glimpse.
12 sep 2014

Mr. Vrettos Stelliou,
Area Manager, Nanomegas
Precession Electron Diffraction Applications in TEM: from crystal structure determination to orientation imaging and strain mapping at nm scale
12 Nov 2014

Distinguished Visitors

Mr. KN Gupta,
Retired Chief Scientist, CSIR-NML, Jamshedpur

Some Unique Places in Canada.

18 Nov 2014

Dr. Somnath Bhattacharyya,
TIFR Mumbai

Spectroscopy without spectrometer; using different modes of TEM images to determine chemical composition

28 Nov 2014

Mr. Frederic Theys,
International Sales Manager at Presi, France

Developments and Innovations in Metallography

03 Dec 2014

Dr. Thomas Poinot,
Post Doctoral Associate, Tata Centre at Massachusetts Institute of Technology

Activities of Tata Centre at Massachusetts Institute of Technology, A Glimpse

08 Dec 2014

Prof. Michael Free,
Department of Metallurgical Engineering, The University of Utah, USA

Modeling and Validating Electrodeposition for Commercial Applications.

19 Jan 2015

Prof. S Mukherjee,
FCIPT Division, Institute for Plasma Research, Gandhinagar, India

Environment Friendly Plasma Technologies: Developments at Institute for Plasma Research

02 Feb 2015

Dr. Suman Guha,
Post Doctoral Fellow, University of Cambridge, UK

Finite element studies on size effect using a higher order strain gradient plasticity theory.

17 Mar 2015

Special Events

Workshop on Remaining life assessment (RLA-2014) (02 Apr - 03 Apr 2014)

The workshop RLA-2014 provided a platform for discussing RLA of different components based on NDT at sites and destructive laboratory tests and above all the use of NMLMAT database in RLA studies. A large number of plant engineers, consultants, R&D material scientists and authorities dealing with regulations participated in the workshop.

Eighth School on Analytical Chemistry (SAC-8) (14 Apr- 21 Apr 2014)

An eight day program "School of Analytical Chemistry¨ was organized in association with the Association of Environmental Analytical chemistry (AEACI) and Bhabha Atomic Research Centre (BARC), Mumbai. The program provided a platform for sharing the subject knowledge amongst the 70 odd research scholars, academicians, scientists, and chemists from different Universities and Government Laboratories. The participants were given hands on training in 7 different modules of experimental work by using highly sophisticated equipments like ICP-MS, ICP-OES, XRF, DRS and AAS. Dr. Srinivasan Srikanth, Director CSIR-NML inaugurated the program. Dr. BN Jagatap, Director Chemistry Group, BARC, Dr. T Mukerjee, Former Director and President, Association of Environmental Analytical Chemistry, Dr. AVR Reddy, Head Analytical Chemistry Division, BARC, Mumbai also participated in the program. Mr. D. Acharya, Chairman cum Managing Director, Uranium Corporation India Ltd. (UCIL) Jaduguda graced the valedictory session of the program as the chairman and chief guest.

Memorandum of Understanding (MoU) signed with M/S. Technical Training Institute, Balasore, Odisha, on "Energy Efficient Coke based Brass and Bell Metal Melting Furnace" (09 May 2014)

National Technology Day Celebrations (11 May 2014)

Prof. Srikumar Banerjee, Homi Bhabha Chair Professor, BARC, Mumbai and Chancellor, Central University of Kashmir, Srinagar graced the occasion as the chief guest. He gave a lecture based on nuclear energy and also released the annual report of CSIR-NML.

Blood Donation Camp (26 June 2014)

The camp was organized by CSIR-NML Staff Club.

Telecast of "EUREKA" Programme : An interview with Dr. S Srikanth, Director, CSIR- NML on "Rajya Sabha" Television Channel (28 June 2014)

"Eureka", the Rajya Sabha TV channel program telecast. interviews of leading scientists and showcases scientific contributions of individuals and institutions on every Saturday and Sunday. The program is produced in collaboration with CSIR-NISCAIR. An interview of Dr. Srinivasan Srikanth, Director, CSIR-NML was telecast on 28 June 2014 at 10.00 am.

Visit of Ethiopian High power Delegation (05 Aug 2014)

A high power delegation comprising of Ethiopian Minister of State of Industries, His Excellency Mr. TH Tessema along with the WD Shumete, Director General of their Metal Industry Development Institute and three of their directors, Mr. DA Woldemichael, Mr. MD Asires, and Mr. EA Mihretu of the same institute visited CSIR-NML. These delegates were highly interested in collaborating with CSIR in the areas of human resource training, Identification of thrust areas for industrial development, assistance in facility planning and strategy development for R&D.

Workshop on Basics and Importance of Communication Skills (07 Aug 2014)

The workshop was organized by Indian Society for Training & Development, Jamshedpur Chapter. Mr. Ranjit Ram and Mrs. Nandita Sinha, Members, Jamshedpur Chapter conducted the program.

Interaction with Dr. G Radhakrishan, Project Leader, ERP, CSIR (07 Aug 2014)

Dr. G Radhakrishnan, Project Leader, ERP visited CSIR-NML. All the technical and administrative staff of CSIR-NML interacted with him with respect to ERP.

ISO Certification Audit (05 - 07 Aug 2014)

Mr. Prosenjit Mitra, Auditor TUV-SUD South Asia Pvt. Ltd and his team audited CSIR-NML.

66th Research Council Meeting (11 Aug 2014)

Following members were present during the meeting: Dr. HM Nerurkar, Chairman, Former Managing Director, Tata Steel Ltd., Jamshedpur, Dr. Amol A Gokhale, Director, Defense Metallurgical Engineering, Dr. Pradip, Group Leader, Materials and Minerals, Processing Technology, Tata Research Development & Design Centre, Dr. SN Ojha, Professor, Dept. of Metallurgical Engineering, Institute of Technology, Banaras Hindu University, Varanasi, Mr. Kamal Dasgupta, Acting Director, CSIR-CGCRI, Kolkata and Dr. Srinivasan Srikanth, Director NML.

Hindi Week Celebrations (08 Sep - 12 Sep 2014)

The chief guest of the inauguration program was Prof. Bal Mukund Painalli head, indi department Kolhan University and the chief guest of the concluding program was Dr. RR Rakesh, Principal, Cooperative college, Jamshedpur . He talked about the evolution of Hindi as a National and Official language. Several essay writing and poetry competitions were organized during this week and the winners were awarded with citations and cash prizes.

Independence Day Celebrations (15 Aug 2014)

Independence day was celebrated in CSIR-NML on 15 Aug 2014. Dr. Srinivasan Srikanth, Director CSIR-NML hoisted the national flag. A football match and children' cultural program was also organized on this occasion.

72nd CSIR Foundation Day Celebrations (26 Sep 2014)

The chief guest of the function was Dr. Krishnaswamy Kasturirangan, President, National Academy of Sciences (NASI) and former member of Indian Planning Commission. Other dignitaries present on the dais were Dr. MK Mishra, Vice Chancellor, BIT Meshra, Ranchi, Dr. Srinivasan Srikanth, Director, CSIR-NML and Mr. SR Hembram, Controller of Administration. Dr. Kasturirangan delivered the foundation day lecture on the overview of future space programs and prospects of Indian Space Mission. More than 200 school children from the schools in and around Jamshedpur attended the program. An essay competition was also organized within the laboratory on this occasion.

Swacha Bharat Mission (02 Oct 2014)

All employees of CSIR-NML took the oath and participated in several cleanliness programs during the day.

NARAKAS Meeting (07 Oct 2014)

Mrs. Neeta Choudhary, IAS, Secretary, Official Language, Ministry of Home Affairs, Govt. of India headed the meeting. She praised CSIR-NML on the use of Hindi language as the official language and outlined that Hindi can be a powerful tool for reaching our society for solving their burning issues.

One Day Seminar On "Role of a Librarian in the Changed Global Scenario" (13 Oct 2014)

The seminar was organized by The Institution of Engineers (India) Jamshedpur Local Centre in association with Society for Documentation and Information Science, Jamshedpur & Jharkhand Information & Library Association, Rachi.

A Five Days School on Characterization and Conservation of Archeological Objectives (13th Oct - 17th Oct 2014)

It was jointly organized by INAE & CSIR-NML. 42 participants from 20 states of the country representing 22 organizations participated in the deliberations.

Memorandum of Understanding (MoU) signed with M/S. Tata Pigments, Jamshedpur on "Production of Ferrite and Pigment Grade Monodispersed Nano Iron Oxide"(15 Oct 2014)

Vigilance Awareness Week (27th Oct - 1st Nov 2014)

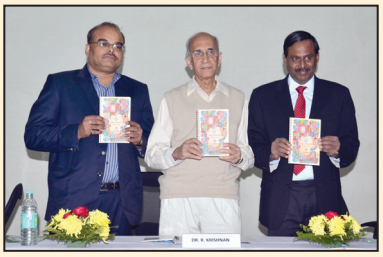
Mr. RK Mishra, Additional commissioner, Central Excise and Service Taxes, Jamshedpur graced the occasion as the chief guest and delivered a lecture on vigilance.

5th Prof. P. Ramachandra Rao Memorial Inter School Quiz (24th Nov 2014)

The quiz master of the program was Mr. VV Ramanan Mrs. Sudha Rao graced the occasion as the chief guest. Kerala Samajam Model School, Jamshedpur became the winner and Loyola School, Jamshedpur became the runners up in the quiz.

65th CSIR-NML Foundation Day Celebration (26th Nov 2014)

Dr. R. Krishnan, Former Director, Gas Turbine Research Establishment, Bengaluru & Naval Chemical and Metallurgical Laboratory, Mumbai; former Chief Controller R&D, DRDO, New Delhi graced the occasion as the chief guest. He delivered the first Dr. Nijhawan Memorial Lecture and presented awards of different categories to CSIR-NML staff and meritorious children of CSIR-NML staff.



International Conference on "Processing of Lean Grade and Urban Ores (IC-LGO 2015)" (20 Jan-22 Jan 2015)

The theme of the conference was "Waste Management" i.e. to develop suitable technologies for the utilization of various lean grade ores, fines, dumped ores, slime, mine water, urban ore viz. industrial solid/ liquid wastes, E-waste, municipal waste etc. through energy efficient and environment friendly processes. The broad areas covered in the conference were Mineral Processing, Recycling and Energy & Environment. Prof. Kwadwo Osseo-Asare, Dept. of Materials Science and Engineering and Energy and Mineral Engg., Pennsylvania State University, USA, and Dr. R. N. Patra, Chairman and Managing Director of Indian Rare Earths Ltd., graced the conference as the Chief Guest and Guest of honor respectively. About 260 delegates (33 abroad and 227 Indian) participated in the conference. Many eminent personalities from all over the world like Prof. Michael Free, Jochen Petersen, David Dreisinger, Takashi Nakamura from USA, South Africa, Canada, Japan, respectively as well as Industries, Academic Institutions and R & D Organizations in India participated in the deliberations. IC-LGO 2015 has covered 130 technical papers in which 15 Plenary, 27 Keynote and Invited lectures, 67 oral and 21 posters.

Republic Day Celebration (26 Jan 2015)

Republic day was celebrated in CSIR-NML and CSIR-NML Residential complexes. The national flag was hoisted by Director, NML. The staff with their family members participated in the celebrations.

School of Advanced Coal Characterization (27 Jan -31 Jan 2015)

A four days seminar was organized having participation of more than 50 delegates (researchers and engineers) from the power plants and the metallurgical coke making plants of the country, including Tata Steel, JSW Steel, NTPC, CMPDIL, Coal India and CSIR-IMMT. Expert faculty members from reputed organizations of India and abroad like ISM, Dhanbad, BHU, Varanasi and University of Alberta, Canada delivered classroom lectures during the seminar. The topics covered included coal carbonization, petrography, washability, coke making and advanced coal characterisation including Factsage modelling. The workshop also included hands on demonstration of the coal characterization facilities at CSIR-NML and QEMSCAN demonstration and CCT lab visit at Tata Steel.

Memorandum of Understanding (MoU) signed with M/S. Wolfram Metchem (P) Ltd., Kolkata on "Tungsten Metal Powder Production from Carbide Scrap" (29 Jan 2015)

67th Research Council Meeting on (13 Feb 2015)

The following members were present in the meeting: Mr. HM Nerurkar (Chairman), Former Managing Director, Tata Steel Limited, Dr. Pradip, Group Leader Materials and Minerals Processing Technology, Tata Research Development & Design Centre, Dr. Amol A Gokhale, Director, Defense Metallurgical Engineering, Indian Institute of Technology (BHU), Dr. Biswajit Basu, Joint Executive President, Aditya Birla Science & Technology Centre, Dr. S Srikanth, Director, CSIR-NML, Dr. R. Mohanty, Scientist, CSIR, Dr. SK Pal, Secretary. The special invitees present were : Mr. Anand Sen, Tata Steel, Dr. T Venugopalan, Tata Steel, Dr. Sanjay Chandra, Tata Steel, Mr. DP Deshpande, Tata Sponge

International Women's Day (09 Mar 2015)

A panel discussion entitled "Role of a woman in a man's life" was organized on this occasion. The moderator of the discussion was Ms. Sushmita Ghosh, TQM Officer of JUSCO and the panelists were: Dr. Srinivasan Srikanth, Director, CSIR-NML, Mr. Kumar Rahul, Section Officer, Administration, Mr. Ammasi, Ph. D. Student AcSIR, CSIR-NML, Dr. Shrikant Nair, Dentist and Mr. Pratim Bannerjee, Engineer and Rotarian.

4th Prof. P Ramachandra Rao Memorial Lecture (23 Mar 2015)

The lecture was delivered by Dr. G Malakondaiah Formerly Director, Defense Metallurgical Laboratory, DRDO, Hyderabad & Chief Controller, R&D (HR & M), DRDO, New Delhi on “Sustained Steel Research : A Case Study of DMR-1700 Steel”. Prof. S N Ojha, Dept. of Metallurgical Engineering, IIT, BHU, Varanasi chaired the function.

NASI Workshop on Women Empowerment in Science & Technology (WEST-2014) (25 Sep - 26 Sep 2014)

WEST 2014 was a two days workshop having the themes “Scientific Writing (Day 1)” and “Meet the Mentors (Day 2)”. The number of registered delegated in the workshop was 120 and it consisted of women students, research scholars, faculties and researchers from different universities, academic institutions and industries all over Jharkhand. The chief guests and speakers of the function were Dr. Krishnaswamy Kasturirangan, President, National Academy of Sciences (NASI) and former member of Indian Planning Commission, Prof. Krishna Mishra, IIT Allahabad and Dr. Neeraj Kumar, Executive Secretary of National Academy of Scientist (NASI), Allahabad Chapter and Prof. Veena Tondon, Department of Zoology, NEHU, Shillong and General Secretary , NASI .

International Deputations

Mr. Krishna Guguloth, Scientist was deputed to Italy to attend the "3rd International European Creep Collaborative Committee (ECCC) Creep & Fracture 2014" during 05th May-07th May 2014.	
Dr. S Prabhakar, Chief Scientist, visited USA during 08th Aug-24th Aug 2014 to attend "ASISC-Annual Meeting" at Michigan Technological University, USA. As part of the progam he visited Cliffs Iron Ore Mines at Michigan. He also delivered a talk at M/S. Arcelor Mittal Global R&D, Chicago.	
Dr. Amitava Mitra, Chief Scientist was deputed to Spain under the fellowship "Mobility grants for guest researchers at Campus Iberus" within the campus of International Excellence Programme promoted by Spanish Ministry of Education at Public University of Navarra, Pamplona, Spain during 01st Sep 2014 to 30th Nov 2014.	
Dr. Jitendra Kumar Sahu, Principal Scientist deputed to Germany to participate in "International Forum for Material Testing (IFMT) 23rd TestXpo" during 12th Oct - 17th Oct 2014.	
Dr. Abhilash, Scientist was deputed to China to attend 6th International Conference on Hydrometallurgy "ICHM-2014¨ during 16th Oct - 19th Oct 2014.	
Ms. Pratima Meshram, Scientist was deputed to China to attend 6th International Conference on Hydrometallurgy "ICHM-2014¨ during 16th Oct - 19th Oct 2014.	
Dr. Sarmistha Palit Sagar was deputed to South Korea to participate in the Workshop on "Current and Future Trend of Non Linear Ultrasonic Techniques for NDE¨ during 21st Oct -24th Oct 2014.	
Dr. Ashok Kumar Ray was deputed to USA for attending the "Second World Congress on Petrochemistry and Chemical Engineering¨ during 27th Oct - 29th Oct 2014.	
Dr. Ashis Kumar Panda, Senior Scientist was deputed to Japan for availing the "Raman Research Fellowship" at National Institute of Material Science, Tsukuba, Japan during 30th Mar 2015 to 29th July 2015.	

National Deputations

- Mr. Randhir Kumar Singh, SRF, Mr. Kaustav Barat, SRF, Mr. Anindya Das, SRF, and Mr. Rajeev Kumar Gupta, SRF were deputed for attending the Workshop on "Remaining Life Assessment RLA-2014"organized by CSIR-NML, Jamshedpur during 02nd Apr - 03rd Apr 2014.
- Dr. Bansi Dhar Pandey, Chief Scientist, Dr. Jhumki Hait, Senior Scientist, Ms. Pratima Meshram, Scientist, and Dr. Abhilash, Scientist were deputed to Ghatsila for attending one day Seminar on "Latest Advancements in Copper Smelting & Refining¨ organized by IIM, Ghatsila Chapter & ICC, Ghatsila 05th Apr 2014.
- Dr. Maitree Bhattacharya, Senior Scientist was deputed to attend the 3rd International Conference on "Recycling and Reuse of Materials (polymers, wood, leather, glass, metals, ceramics, semi conductors, water etc) and their products (ICRM-2014)" organized by MG University, Kerala during 11th Apr- 13th Apr 2014.
- Dr. Shantanu V Madge, Principal Scientist, was deputed to Ghaziabad for attending "Induction Training Programme for newly recruited Scientists¨ organized by CSIR-HRDC, Ghaziabad during 20th Apr- 29th Apr 2014.
- Dr. Sushanta Kumar Sahu, Senior Scientist and Ms. Aarti Kumari, Trainee Scientist were deputed to Mumbai for attending "National Conference on Rare Earth Processing and Utilization" organized By Rare Earth Association of India, Mumbai during 02nd May - 03rd May 2014.
- Mr. Anuj Pradhan, Finance and Accounts Officer and Dr. Gopi Kishore Mandal, Senior Scientist were deputed to Ghaziabad to participate in "4th Module of Leadership Development Programme" organized by CSIR-HRDC, Ghaziabad during 19th May- 23rd May 2014.
- Mr. Ranjit Sandilya, Assistant(G)(I) and Mr. Upendra Upadhyay, Assistant(Stores and Purchase) were deputed to Ghaziabad to attend "Induction Training for Assistants Selected under CASE - 2013", organized by CSIR-HRDC, Ghaziabad during 23rd June 2014 to 25th July 2014.
- Dr. Bansi Dhar Pandey, Chief Scientist, Dr. Abhilash, Scientist, Ms. Pratima Meshram, Scientist, Dr. Vinod Kumar, Sr. Technical Officer and Mr. Navneet Singh Randhawa, Technical Assistant were deputed to Nagpur to attend 18th International Conference on "Non-Ferrous Minerals & Metals-2014" organized by Corporate Monitor with IBAAS, VNLIT, JNARD&DC & AI circle at Nagpur during 11th July - 12th July 2014.
- Mr. Nimai Halder, Technical Assistant was deputed to Ghaziabad to attend the "Orientation Training Programme for Technical Group III Personnel", organized by CSIR-HRDC, Ghaziabad during 14th July - 18th July 2014.
- Mr. A Ammasi, Trainee Scientist and Ms. Mamta Kumari, Trainee Scientist were deputed to Jamshedpur to participate in the "Workshop on Agglomeration of Iron Ore Fines 2014" by IIM Jamshedpur Chapter and Tata Steel held at SNTI, Jamshedpur during 21st Aug - 22nd Aug 2014.
- Dr. Manoj Kumar, Senior Scientist was deputed to New Delhi to attend "Financial Management in Scientific Organizations (One Week)" by IIPA, New Delhi during 25th Aug 2014 to 29th Sep 2014.
- Md. Murtuja Hussain, Scientist was deputed to Bangalore to attend International Conference on "Friction based Processes (ICFP-2014)" organized by IISC, Bangalore during 03rd Sep- 05th Sep 2014.
- Dr. Deepak Chandra Sau, Scientist was deputed to Rourkela to attend a short term course on "Fluidized Bed Technology for Waste Management Design, Modeling and Simulation" organized by NIT, Rourkela during 07th Sep- 13th Sep 2014.
- Mr. Pankaj Kumar, Technical Assistant was deputed to New Delhi to attend the "5th Capacity Building Programme for Technical Assistants", organized by Indian Institute of Public Administration, New Delhi during 08th Sep - 19th Sep 2014.
- Dr. Mamata Sharma, Scientist, Ms. Rupa Das Biswas, Technical Officer and Dr. S. Chakravarty, Principal Scientist were deputed to Kolkata to participate in the 66th Annual Meeting and Symposium of the "International Committee for Coal and Organic Petrology (ICCP-2014)", organized by CSIR-CIMFR, Dhanbad and held at Science City, Kolkata during 20th Sep - 25th Sep 2014.
- Dr. Abhilash, Scientist was deputed to New Delhi to attend international conference and XI convention of the Biotech Research Society, India on "Emerging Trends in Biotechnology (ICETB-2014)" organized by School of Environmental Sciences, JNU, New Delhi and BRSI, held at New Delhi during 06th Nov - 09th Nov 2014.

- Dr. Sarmistha Palit Sagar, Principal Scientist and Dr. Jagannath Pal, Principal Scientist were deputed to Ghaziabad to attend second CSIR advanced leadership development programme" organized by CSIR-HRDC, Ghaziabad during 17th Nov- 21st Nov 2014.
- Dr. Sanjay Agarwal, Scientist, Dr. Gopi Kishore Mandal, Sr. Scientist and Dr. Satadal Ghorai, Senior Scientist were deputed to Jamshedpur to participate in the "Thermo-Calc software" Workshop, organized by Tata Steel and Bhanu Scientific Systems Pvt. Ltd., Hyderabad, held at Tata Steel, Jamshedpur during 18th Nov-21st Nov 2014.
- Dr. Abhilash, Scientist was deputed to Vishakapatnam to attend Seminar "IBAAS 2014", organized by IBAAS, JNARDDC and CHALIECO, China, held at Vishakapatnam during 27th Nov- 29th Nov 2014.
- Dr. Ashish Kumar Panda, Senior Scientist was deputed to Pune to attend "Non-Destructive Evaluation Conference (NDE-2014)" organized by ISNT, Pune Chapter during 03rd Dec - 07th Dec 2014.
- Mr. Tarun Kumar Das , Scientist, Mr. Avijit Kumar Metya, Scientist and Ms. Minati Kumari Sahu, PA-III were deputed to Pune to attend "Non-Destructive Evaluation Conference (NDE-2014)"organized by ISNT, Pune Chapter during 04th Dec - 06th Dec 2014.
- Mr. Parikshit Mahato, CSIR-SRF was deputed to Kolkata to attend "EMCA-2014" organized by NIT-Durgapur & CSIR-CGCRI, Kolkata during 04th Dec-06th Dec 2014.
- Dr. Mita Tarafder, Senior Principal Scientist was deputed to Kolkata to attend "INFOCOM 2014 Entrepreneurship Program" organized by ABP Pvt. Ltd. Kolkata on 06th Dec 2015.
- Ms. Sailaja Sharma, CSIR-JRF and Mr. Randhir Kumar Singh, SRF were deputed to Chennai to attend "International Symposium for Research Scholars (ISRS-2014)", organized by IIT, Madras during 11th Dec- 13th Dec 2014.
- Mr. Shashikant Choudhary, Senior Technical Officer and Mr. Sudip Kundu, Scientist were deputed to Guwahati to participate in "3rd National Knowledge Network (NKN) Annual Workshop 2014", organized by IIT, Guwahati during 15th Dec - 17th Dec 2014.
- Dr. MM Humane was deputed to Nagpur to attend "18th NASAS (Eighteen National Seminar on Aerospace Structure)", organized by VNIT Nagpur, ARDB, New Delhi and Maintenance Command, IAF, Nagpur during 15th Dec - 17th Dec 2014.
- Mr. Biraj Kr Sahu, Trainee Scientist and Mr. Snehashish Tripathi , Trainee Scientist were deputed to Bombay to attend Conference on "Microstructure Texture and Image Analysis Research" organized by IIT Bombay during 15th Dec - 17th Dec 2014.
- Mr. Avinash Kumar Chandan, Trainee Scientist, Ms. Rashmi Singla, Trainee Scientist, Mr. Bhawesh Bhandari, Trainee Scientist, Ms. Leena Patil, JRF, Mr. Chandra Veer Singh, Trainee Scientist, Mr. Shivendra Sinha, Trainee Scientist and Mr. Gaurav Kumar Bansal, Trainee Scientist were deputed to Ghaziabad to attend "Research Orientation Programme" organized by CSIR-HRDC, Ghaziabad during 26th Dec 2014 to 01st Jan 2015.
- Dr. Rajat Kumar Roy, Scientist was deputed to Vijayawada to attend International Conference on "Signal processing and communication engineering systems (SPACES-2015)" organized by KL University, Vaddeswaram, Vijayawada, India during 02nd Jan - 03rd Jan 2015.
- Mr. Amit Prakash, Technical Officer was deputed to Kolkata to attend Second International conference on "Advances in mechanical engineering and its interdisciplinary areas(ICAMEI-2015)" ,organized by college of Engineering & Management, Kolaghat & IEI, Kolkata during 02nd Jan - 04th Jan 2015.
- Dr. Sanjay Prasad, Senior Scientist, Dr. Vinod Kumar, Senior Technical Officer(2), Dr. M Malathi , Scientist, Ms. Pratima Meshram, Scientist , Mr. Indu Bhusan Mishra, Chief Scientist, Mrs. Rupa Das Biswas, Technical Officer(A), Ms. Swati Pramanik , Project Assistant (II), Mr. Manish K. Sinha, JOC and Mr. Thomas C Alex , Principal Scientist were deputed to attend International Conference on "Processing of Lean Grade and Urban Ores"(IC-LGO 2015) at CSIR-NML, Jamshedpur during 20th Jan- 22nd Jan 2015.
- Dr. Mainak Ghosh, Senior Scientist and Mr. Rajneesh Kumar, Scientist were deputed to attend "National Welding Seminar 2014-15" organized by Indian Institute of welding & Tata Steel during 22nd Jan - 24th Jan 2015.

- Mr. Rachit Ghosh, Senior Technical Officer(2) was deputed to Dhanbad to participate in the National workshop on "Challenges and Opportunities for Management of Water Supplies in Rural Areas (COMWRA 2015)" organized by KRC, Dept. of Environmental Science & Engineering, Ism, Dhanbad during 23rd Jan- 24th Jan 2015.
- Mr. SR Hembram, Controller of Administration was deputed to Ghaziabad to attend a training on "Implementation of Rajbhasa " at HRDC, Ghaziabad during 28th Jan - 31st Jan 2015.
- Dr. Suprabha Nayar, Principal Scientist and Ms. Lubna Sheikh, SRF were deputed to attend "78th Annual Session of Indian Ceramic Society at SNTI, Jamshedpur during 02nd Feb - 03rd Feb 2015.
- Dr. Vinod Kumar, Senior Technical Officer and Dr. Ari Vidyadhar, Senior Scientist were deputed to attend Workshop on "Advance Characterization techniques for Mineral Matters" organized by Tata Steel R&D Division, Jamshedpur on 06th Feb -2015.
- Dr. Abhilash, Scientist was deputed to Pune to attend National Conference on "Microbiology- DMRIHW 2015" during 20th Feb 2015 to 21stFeb 2015.
- Mr. TC Alex, Principal Scientist was deputed to Kolkata to attend "Management and Utilization of Wastes from Metal Processing and Thermal Power Stations" organized by CGCRI, Kolkata during 13th Feb - 14th Feb 2015.
- Md. Murtuja Hussain, Scientist and Mr. V Rajinikant, Scientist, Mr. B Mahato, Technical officer, Mr. Sumanta Bagui, Scientist were deputed to Jamshedpur to attend "TEM course by Prof. N Prabhu" organized by Tata Steel during 21st Feb - 24th Feb 2015.
- Dr. Vinod Kumar, Senior Technical Officer (3) and Dr. Ari Vidyadhar, Senior Scientist were deputed to Jamshedpur to attend Workshop on "Advanced Characterized Techniques for Mineral Matters" on 06th Feb 2015.
- Mr. Jyoti Kumar, Technician (1) was deputed to attend Seminar organized by Town Official Language Implementation Committee organized by at Hindustan Petrolium Corporation Ltd., Jamshedpur on 11th Feb 2015.
- Mr. Sudip Kundu, Scientist was deputed to Kolkata to attend the International conference on "Applications and Innovations in Mobile Computing (AIMoC)" 2015 organized by Jadavpur University, Kolkata during 12th Feb - 14th Feb 2015.
- Dr. Vinod Kumar, Senior Technical Officer (3) was deputed to Dhanbad to attend the Professional Development Program on "Agglomeration Techniques" organized by Executive Development Centre, Indian School of Mines, Dhanbad during 16th Feb - 20th Feb 2015.
- Mr. Prabir Kumar Roy, Senior Technical Officer (2) was deputed to Jamshedpur to attend "The Significance of Uncertainity Measurement during Mechanical Testing of Metals and Materials" organized by M/s. Tinius Olser Ltd., UK and M/s. Aimil Ltd. at Hotel Center Point, Jamshedpur on 18th Feb 2015.
- Ms. Sailaja Sharma, SRF was deputed to attend TEM Course training program in Tata Steel, Jamshedpur during 21st Feb - 24th Feb 2015.
- Dr. Rajendra Kumar Rath, Senior Scientist, Dr. Vinod Kumar, Senior Technical Officer (3), Mr. DP Sahoo, Senior Technician (2), Dr. Shobhana Dey, Principal Scientist, Ms. Pratima Meshram, Scientist, Dr. Abhilash, Scientist, Dr. B Nayak, Principal Scientist and Dr. Manoj Kumar Mohanta, Principal Scientist were deputed to Vishakhapatnam to participate in International Seminar on "Mineral Processing Technology (MPT- 2014)" at Andhra University, IIME Vishakhapatnam during 12th Mar - 14th Mar 2015.
- Dr. Ratnakar Singh, Chief Scientist was deputed to Vishakhapatnam for participating and chairing technical session in "Mineral Processing Technology 2014 (MPT-2014)" and attending Executive Council and GB Meetings as an EC member at Indian Institute of Mineral Engineering & Andhra University, Vishakhapatnam during 12th Mar - 14th Mar 2015.
- Dr. DC Sau, Scientist was deputed to Kolkata for attending training course on 'COMSOL' software at Comsol Multiphysics Pvt. Ltd., Kolkata during 25th Mar - 28th Mar 2015.

Excerpts From Audit Report and Action Required

Reference : Inspection report on the Audit of Accounts of National Metallurgical Laboratory, Jamshedpur, A Unit of Council of Scientific and Industrial Research under Ministry of Science and Technology, Government of India, for the year 2010-11 (Transactions)

Item no. *(as per Audit Report)*	Item	Details	Action Required
Part I.			
5.a	Outstanding / meritorious achievements of NML	1. CSIR Business Development & Marketing award - 2010 2. CSIR Tecnofest 2010: Gold awards - i. Theme pavilion on Mining, Minerals & Materials; ii Theme pavilion on Water	
5.b	Outstanding objections from previous years	Please see Table I	Please see Table I
Part II. Section A			
Para -1	Non-commisioning of equipment even after payment of Rs 144.32 lakh in November 2011	Procurement of equipment ' Instrumented Mirror Image multi - spiral Washer system for Mineral Benefication'	Action is being taken for installation and full utillization of the equipment. The case is currently referred to CSIR for guidance.
Part II. Section B			
Para -1	Non -finalisation of technology transfer fee	Transfer of know how to BHEL in June 2011 in a non disclosure agreement. Technology transfer terms couldn't be finalised with BHEL and upscaling not yet done.	Replies send to audit vide our letter No. NML/ Accts/CAG-Audit/(7)/2014-15 dated. 21/01/2015. **Response of audit is awaited.**
Para -2	Non-commercialization of technology transferred to industry.	Transfer of technology to M/s Technofour , Pune and royalty thereof.	-do-
Para -3	Know-how developed at a cost of Rs.237 lakh - scale up wanting	The first phase of the project completed on 30th November 2012 and the report submitted on Feb 2013. Potential end users identified .Second phase of the project initiated since 11 Aug 2014 and project ongoing.	-do-
Para -4	Unserviceable/Surplus/Obsolete store items awaiting disposal.	NML has explored agencies for E-Auction terms and have finalised with M/s MSTC Ltd. in consultation with others sister Labs.	-do-
Part III			
TAN	NIL		
Part IV			
Recommendations	NIL		

Inspection Report for the Year	Para reference		Observation	Remarks
2003-04 (Trans)	Part-II, Sec-B	Para-2	Loss of Rs 10.66 lakh due to non-recovery of rent at market rate	Para is dropped
2003-04 (Trans)	Part-II, Sec-B	Para-2	Non-completion of the work of modernization of "Extrusion Pres" and consequent non-utilization thereof for about 5 years	-Do-
	Part-II, Sec-B	Para-12	Theft case	Further development is awaited; Para stands.
2005-06 (Trans)	Part-II, Sec-B	Para-2	Unproductive expenditure of Rs.170.00 lakh	Para is dropped
2006-07 (Trans)	Part-II, Sec-A	Para-1	Infructuous expenditure of Rs 20.49 lakh besides blockage of Rs 121.80 lakhs	Position will be communicated separately, para stands.
2007-08 (Cert	Part-II, Sec-B	Para-2	Asset Register - observation thereon	Para is dropped
2007-08 (Trans)	Part-II, Sec-B	Para-1	Technology developed at a cost of Rs. 19.10 lakh could not be popularized to end users due to lack of imparting training.	-Do-
	Part-II, Sec-B	Para-4	Non-recovery of licence fee at revised rate	-Do-
2008-09 (Trans)	Part-II, Sec-B	Para-2	Non-achievement of objectives	-Do-
	Part-II, Sec-B	Para-3	In-house projects-observation thereon (B) Projects kept-in-abeyance (D) Non-conduction of scaling up of the technology	-Do-
	Part-II, Sec-B	Para-10	Non-disposal of condemned vehicles	Para is uploaded and dropped from this IR
	Part-II, Sec-B	Para-11	Stores and stock - observation thereon (A) Stores materials found short during physical verification (B) Non-disposal of unserviceable store material/spare parts of vehicles	-Do-
	Part-II, Sec-B	Para-12	Theft case - observation thereon	Para is dropped
	TAN - 2		Library books and journals-observation thereon (A) Non-receipt of journals (B) Missing library documents (C) Books/journals awaiting write-off sanction	TAN is dropped
2009-10 (Trans)	Part-II, Sec-B	Para-1	Blockage of Rs.33.95 lakh	Para is updated and dropped from the IR
	Part-II, Sec-B	Para-2	Blockage of fund of Rs.20.93 lakh due to non-utilization of equipment	Para is dropped
	Part-II, Sec-B	Para-3	Less recovery of income Tax of Rs.243112.00	-Do-
	Part-II, Sec-B	Para-4	Contractual royalty/premia not received against the transferred technologies	-Do-
	Part-II, Sec-B	Para-5	Non-submission of Final Report of completed projects	-Do-
	Part-II, Sec-B	Para-6	Outstanding Advances	Para is updated and dropped from the IR
	TAN-1		Non-furnishing of fidelity bond by the persons handling stores	TAN is dropped

impression

...We are very thankful to NML Jamshedpur for their continued timely technical support and being part of our critical technical decisions. We hope to continue this excellent business relation with NML Jamshedpur.

With warm regards,

PJM Rao,
Deputy General Manager (Inspection and Advisory Services),
BPCL Mumbai
24/07/14

...We appreciate the efforts that have been made during the study and active collaboration that NML, Jamshedpur had with MRPL. We have mutually benefitted from the same...

Yours truly,

P. sujith,
Dy. General Manager (Inspection)
23/07/2014

Venkatraman Ramakrishnan (born 1952),
Chemistry, 2009

Venkatraman "Venki" Ramakrishnan is an Indian-born American and British structural biologist, who shared the 2009 Nobel Prize in Chemistry with Thomas A. Steitz and Ada E. Yonath, "for studies of the structure and function of the ribosome". He currently works at the MRC Laboratory of Molecular Biology in Cambridge, England. Ramakrishnan was born in Chidambaram in Cuddalore district of Tamil Nadu, India to C. V. Ramakrishnan and R. Rajalakshmi. In 1999. Ramakrishnan is a Fellow of the Royal Society, a member of EMBO and the U.S. National Academy of Sciences and a Fellow of Trinity College, Cambridge. He was awarded the 2007 Louis-Jeantet Prize for Medicine, the 2008 Heatley Medal of the British Biochemical Society and the 2009 Rolf-Sammet Professorship at the Goethe University Frankfurt. He received India's second highest civilian honor, the Padma Vibhushan, in 2010.

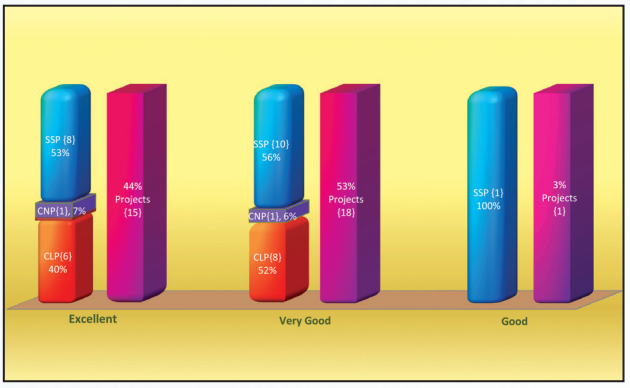
Ramakrishnan was knighted in the 2012 New Year Honours for services to Molecular Biology.

Ramakrishnan was included as one of 25 Greatest Global Living Indians by NDTV Channel, India on 14 December 2013.

Customer Feedback

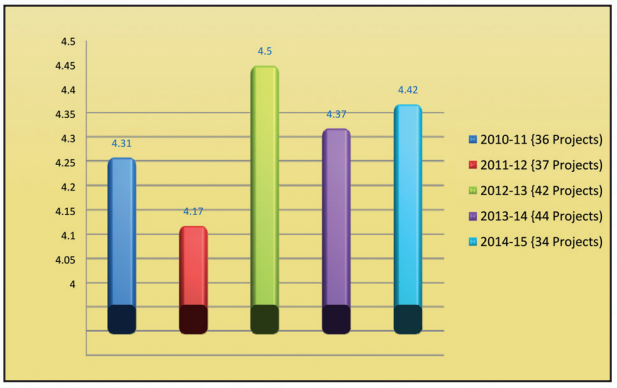
Customer Satisfaction Evaluation Summary

(Received in 2014-15: For 34 Nos. of Projects)



Sponsored Projects (SSP), Consultancy Projects (CNP), Collaborative Projects (CLP)

Average Customer Satisfaction Evaluation (CSE) Index Max. 5



Comments from our Collaborators and Sponsors

M/S. Gontermann Peipers (India) Ltd.

The team and their leader have extensive knowledge of the measurements carried out.[SSP 0830]

M/S. Tata Steel Ltd.

This team is quite competent and flexible as well as having friendly approach. [CLP 0111]

M/S. Sasan Power Limited, Coal Division

I believe in highest level of integrity, independence, impartiality and accuracy that is what I got from your lab. [SSP 0829]

M/S. McNally Bharat Engineering Company Limited

NML has one of the most well equipped labs. for mineral processing, moreover they have a highly motivated and competent group in-charge of this lab.[SSP 0843]

Korea Institute of Geoscience and Mineral Resources (KIGAM)

KIGAM would like to do joint collaboration with NML in future.[SSP 0708]

M/S. Tata Steel, Technology Group (Global Wires and Longs),

There are many areas of work where CSIR-NML can jointly work for improvement. [CNP 0161]

M/S. West Bengal Power Development Corporation, Birbhum

Good infrastructure and well equipped lab in respect of coal analysis.[SSP 0937]

M/S. Essar Steel India Limited

Good quality of work.[SSP 0887]

Intellectual Property Created

PATENT APPLICATIONS FILED BY CSIR-NML

An improved suction casting assembly for the preparation of bulk metallic glass (2851DEL2014).

A Process for Recovery of potash from fledspar with simultaneous Recovery of ferro-Silicon (3006DEL2014).

Development of Biomimetic novel three dimensional metal fibre reinforced polymer hydroxyapatite nanocomposite for different load bearing bone graft application (3438DEL2014).

An improved process for the prolysis of depopulated printed circuit boards (PCBs) of e-waste (2465DEL2014).

A Process for preparation of magnesium-aluminum alloy directly from its halide salt (3007DEL2014).

An improved process for recovery of lead and zinc from zinc leached residue (0205NF2014/IN).

DeoxyCalc- A computer programme for the prediction of deoxitants and deoxidation product's stability during steelmaking .

Process for the preparation of ductile Cu-based bulk metallic glass (0243NF2014/IN).

Iron cobalt Based High Induction soft magnetic amorphous alloys (0242NF2014/IN).

An improved method to produce cold bonded briquettes from iron ore (0288NF2014/IN).

An improved process for the reduction of chromite ore (0289NF2014/IN).

An improved process for preparation of cold bonded carbon composite pellets for utilization of iron ore micro -fines and carbon bearing fines (0302NF2014/IN).

A process for the electrothermic production of magnesium metal (0301NF2014/IN).

The connector condenser design of the electrothermic production of magnesium (0315NF2014/IN).

An improved giant magneto impedence sensor device for structural integrity assessment of engineering components (0316NF2014).

An improved process for preparation of iron oxide pellets using sodium lignosulphonate containing wastes and copper smelting slag replacing bentonite (0317NF2014/IN).

A novel processing scheme for multi stage multi product dry beneficiation of coal using air fluidization on an inclined deck (3485DEL2014).

Auxillary cold chamber for an improved annealing simulator device (0028NF2015).

PATENT APPLICATIONS JOINTLY FILED BY CSIR-NML AND COLLABORATOR

A Process for the production of Grapheneo xide based anti-corrosion coating of metals by solution method (0093NF2014/IN)	Jointly filed with M/s. Tata Steel
A process for the preparation of paving blocks using AOD Slag and IFS slag using geopolymerisation (0114NF2014/IN)	Jointly filed with M/s. Shyam Ferro Alloy Ltd
An improved process for the conversion of hematite powder into magnetite using CNG (compressed natural gas) (0115NF2014/IN)	Jointly filed with M/s. Tata Steel
A method of generating recyclable products from primary steelmaking slag (356KOL2014)	Jointly filed with M/s. Tata Steel
An improved process for the conversion of Hematite Powder into magnetite using COG (coke oven gas) (559KOL2014)	Jointly filed with M/s. Tata Steel
An improved process to produce block/bricks using high iron ash generated in sponge iron plants through geopolymerization (0204NF2014/IN)	Jointly filled with M/s. Tata sponge Iron Ltd., Orissa
A process for compositional analysis of iron ores (854/KOL/2014)	Jointly filed with M/s. Tata Steel
A process for production of directly reduced iron in tunnel kiln (0318NF2014/IN)	Jointly filed with M/s. Tata Steel
Corrosion resistive graphene oxide based coating of metals using seedlac and vegetable oil (0457/2014/IN)	Jointly filed with M/s. Tata Steel
An improved Giant Magneto-Impedance (GMI) based Sensing Device for the detection of carburisation in austenitic stainless steel (0458/2014/IN)	Jointly filed with M/s. Indian Oil Corporation Ltd.

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Software for online detection of alumina in Iron ore.

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Ongoing & Completed R&D Projects

CLP 0089	Optimization of strength in V/N induced micro alloyed steel by varying vanadium content with fixed Nitrogen level
CLP 0105	Development of API X80 linepipe steel (2nd Phase)
CLP 0113	High Strain Rate Deformation Behaviour of Automotive Grade Sheet Steels
CLP 0117	Creep damage assessment of high temperature headers and pipeline using multi parameter non-destructive examinations.
CLP 0121	Scale-up studies for fluidized bed conversion of hematite powder into magnetite suitable for application in heavy media separation
CLP 0124	Development of delivery standard of Hot rolled sheets based on Ultrasonic velocity mapping
CLP 0125	Torison properties of cold drawn pearlitic steel: role of residual stress, microstructure and crystallographic texture
CLP 0127	Recovery of Chrome Value from Chromite ore.
CLP 0128	Effect of pellet properties on partial replacement of bentonite by designated organic binder
CLP 0130	Studies on feasibilty of cleaning fine coal (-1.0 mm) using controlled air fluidization in air table
CLP 0131	Studies on recovery of carbon values from West Bokaro Coal Washery rejects (middling & tailings)
CLP 0132	Effect of varying ratio of ore type on properties of iron ore pellet
CLP 0133	Studies on improving reducibility of iron ore pellet
CLP 0134	Study on pellet quality by varying flux composition
CLP 0135	Technology modification of iron ore slime briquetting for cement binder replacement
CLP 0136	Mill scale-iron ore slime briquettes for use in iron/steel making
CLP 0137	Assistance in setting up of Commercial Plant for producing Briquettes from Iron Ore Slime
CLP 0138	Perfecting the technology of paving blocks from LD slag using cement binder
CLP 0139	Scaling up of process developed for utilisation of LD slag as flux
CLP 0140	Scale-up studies for biochemical upgradation of Joda Iron ore slimes
CLP 0141	Bio-chemical dephosphorisation of LD slag
CLP 0142	Extraction of rare earths (in pure/mixed oxides) from blast furnace slag
CLP 0143	Use of mill scale as heavy media separation in cyclone
CLP 0144	Study on viscosity and liquidus temperature of blast furnace slag at different basicity and temperature regime
CLP 0145	Study of Heat Transfer during Production of DRI-Simulating Tunnel Kiln Conditions
CLP 0146	Studies on Smelting Reduction of Sintered Chromite Ore Pellets in SAF
CLP 0147	Online Implementation of Alumina Detection Technology at Noamundi Mines of Tata Steel
CLP 0148	Development of Online Temperature Monitoring System for Mould in Billet Caster using FBG Sensors
CLP 0149	Development of "High stretch flangeable (HER) grade steels without 'Ca' - treatment at HSM"
CLP 0150	Optimization of YS/UTS ratio in Nb+Ti Micro-alloyed hot rolled steels through precipitation characterization
CLP 0152	Effect of alloying elements on phosphating
CLP 0153	Nickel coated Rebar for Cryogenic Application
CLP 0154	Evaluation of fatigue/fracture behaviour of wheel materials
CLP 0155	Evaluation of cold work embrittlement in automotive grade steels
CLP 0156	Effect of CAL parameters; temperature, time and cooling rates, on Ferrite+ martensite phase formation in DP steel

CLP 0157	Optimisation of CAL annealing parameters for achieving rbar greater than 2.
CLP 0158	CAL annealing parameters effect of composition / annealing parameter /over aging on Lüder elongation
CLP 0159	Annealing Cycle Optimization for D and EDD grade of Cold Rolled steel
CLP 0160	Beneficiation of coal flotation tailings by column flotation and testing of bubble generation system developed by TATASTEEL
CLP 0161	Production of Calcium Ferrite From Mill Scale and Lime
CNP 0154	Providing Technical Expertise to CARIRI to Study Corrosion Failure Problems of Industries in Trinidad & Tobago
CNP 0162	Patent Research Analytics Services
CNP 0163	Consultancy on marketetable grade iron oxide production from waste iron sludge.
CNP 0164	Consultancy on Optimization of specific Aluminium consumption in the production of ferro titatinum at MINEX Metallurgical Co.
CNP 0165	Training on Product Development including CRGO steel at RINL
CSC 0132	Design and development of novel solvent extraction/hydrometallurgical process for separation and recovery of individual rare earth from selected resources/rare earth and other values from wastes
ESC 0103	Development of novel CSIR Technologies for manufacturing tailored and patient-specific Bio-Ceramic implants and biomedical devices at affordable cost (Bioceram)
ESC 0104	Advanced ceramic materials and composites for energy and structural applications (CERMESA)
ESC 0109	Development of zero waste technology for processing and utilization of thermal coal.
ESC 0503	Development of Magnesium Metal Production Technology (MPT)
GAP 0245	Beneficiation of Iron ore Slime from Barsua and other mines
GAP 0246	Development of pilot scale pelletisation technology for Indian Goethitic/Hematite ore with varying degree of fineness
GAP 0248	Evaluation of mechanical properties of structural materials using miniature test technique
GAP 0249	Quality Evaluation of Coal-Cores explored from different regions of India
GAP 0250	Hydrogen Induced fatigue in high Strength Alluminium Alloy
GAP 0251	Tailoring of geopolymer properties by mechanical activation of fly ash
GAP 0252	Microstructure measurement in un-irradiated Zr-2.5% Nb pressure tube material
GAP 0253	Study on the interface layer formation during hot dip galvanizing of advanced high strength steels for automotive applications
GAP 0255	Investigation of sensitization behaviour of austenitic stainless steel using magnetic techniques
GAP 0256	Production of Low Phosphorous Steel through Induction Furnace Route Using DRI as Major Ferruginous Materials - an Industrial Assessment
GAP 0257	Development of Non-linear Ultrasonic based technique for Multi-axial Fatigue Damage evaluation in SA333Gr6 and SS304LN
GAP 0259	Feasibilitystudies on the Development of a Process for Production of Gadolinium Metal by Fused salt electrolysis
OLP 0141	Monte Carlo simulation of grain growth and recrystallization kinetics during thermomechanical rolling of high strength steel A mathematical model to predict mechanical properties of hot rolled high strength steel strip using an Adaptive Neuro-Fuzzy Inference System (ANFIS) architecture
OLP 0142	Development of sensor using nanostructured magnetic materials and studies on their performance evaluation in SHM. Module 1: Development of high sensitive GMI based magnetic sensing

	devices using low magneto-restrictive rapidly quenched wire(Module - III: Study on the performances of the GMI sensing device and its applications in structural health monitoring (SHM) of engineering components)
OLP 0172	Study of microstructure during phase transformation in Fe-30Mn-Si and Fe-30Mn-Si-3Al by X-ray diffraction(Module I)
OLP 0173	Development of ductile Magnesium based alloys.
OLP 0174	Corrosion and Tribological behavior of surface modified titanium alloys
OLP 0179	Assessment of Creep Damage by Guided Wave Ultrasonic Technique (Module I)
OLP 0182	Friction stir welding of carbon steel
OLP 0184	Improvement of magnetic energy product of hexaferrite permanent magnet(Young Scientist)
OLP 0190	High strain rate deformation of automobile grade steels (Module I)
OLP 0191	Creep-Fatigue Interaction Behaviour of Advanced Ultra Super Critical Boiler Grade Materials: Module I
OLP 0192	Extraction of valuable metals from Lithium ion batteries.
OLP 0193	Synthesis and characterization of water based graphene-ferrofluids (G-FF).
OLP 0197	Alloy Design & Casting of CRGO Steels
OLP 0198	Hot rolling, cold rolling and annealing of grain oriented silicon steel
OLP 0200	Design of an improved suction casting attachment for the preparation of bulk metallic glasses
OLP 0201	Recovery of tellurium from deselenized copper refinery anode slime
OLP 0205	Recrystallization behavior of TWIP steels
OLP 0206	Recovery and recycling of rare earth metals (REMs) from primary/ secondary resources
OLP 0209	Preparation of high pure tungsten powder of desired grade from HAPP alloy scraps
OLP 0210	Development of rapidly solidified high induction alloys for transformer core
OLP 0211	Biomimetic Metal fiber reinforced hydroxyapatite nanocomposite: A novel three dimensional load bearing bone grafts
OLP 0212	Development, demonstration and training of coke/coal based brass melting furnace for rural artisans
OLP 0214	Correlation of stereological parameters with mechanical properties of micro alloyed steels: Module I -Micro structural processing and quantification
OLP 0216	Effect of alkali concentration on the reaction kinetics of fly ash geopolymer
OLP 0217	Localization techniques in Underwater Acoustic Sensor Network - survey and a new thought
OLP 0218	Development of nanocomposite TiSiBC hard & tough coatings by magnetron sputtering and structure property correlation
OLP 0219	Life prediction model for creep-fatigue interaction in P92 grade advanced creep resistant steel
OLP 0221	Improving the high temperature compressive strength of hematite pellet without bentonite using slag bonding agent
OLP 0222	Green separation of rare earth metals using Ionic Liquid as extractant
OLP 0223	Theoretical and Experimental Investigation of Deoxidation Phenomena During Liquid Steel Treatment of Electrical Steel
OLP 0224	Preparation of Magnesium Aluminum alloy through electrochemical co-deposition
OLP 0225	Study of particle in centrifugal and pulsating force field
OLP 0226	Study on the formation of intermetallics during annealing treatment of galvanized steel
OLP 0228	Synthesis and characterization of Biomimetic Sintered Porous 3D Hydroxyapatite as bone Grafts/Scaffolds
OLP 0229	Effect of Thermal Cycling Process on Structure and Tensile Flow Properties of Austenitic Stainless Steel (Module -I)

OLP 0230	Synthesis and characterization of nanomagnetic Hydroxyapatite for wound healing (Module I)
OLP 0231	Development of carbon fibre reinforced polymer hydroxyapatite Nanocomposite for load bearing bone graft applications (Module I).
OLP 0232	Modelling of the Inclusion removal by synthetic Slag - A Multi-phase CFD coupled with DEM approach (Module I)
OLP 0233	Development of bainitic microstructures for component of hydro-turbine generators (Module I)
OLP 0234	Optimisation of Contract Demand for Saving in electricity bill
OLP 0235	Development of a software and database framework for efficient and transparent functioning of NML canteen
OLP 0237	Studies on creep properties of Zr-2.5Nb alloy tubes with different microstructures including texture
OLP 0238	Development of novel alloys for potential coating applications. (Module-1)
OLP 0239	Studies of geopolymer concrete using synergistically fly ash and bottom ash (Module-I).
OLP 0240	Development of bainite -austenite steel for improving abrasive wear resistance
OLP 0241	Nanostructured Fe based amorphous alloy for transformer core application.
OLP 0242	Study of dissolution kinetics of Dolime (CaO.MgO) and Ferrosilicon (FeSi) in Eletrothermal (synthetic) slag and optimize the energy consumption during the ELECTROTHERMAL process/route for Magnesium production
OLP 0243	Enhancing the efficiency of a column flotation process using micro bubbles
OLP 0244	Producing the desired quality hot band for subsequent CRGO processing.
OLP 0245	Design of new alloy chemistry & a novel fabrication route for CRGO hot band production.
OLP 0246	State of damage at Micro, Meso & Macro Length Scale
OLP 0247	NABL accreditation of CSIR-NML CRM activity.
OLP 0248	Computerization of permanent employee recruitment process at CSIR-NML
PSC 0101	Very high power Microwave Tubes: Design and development capabilities (MTDDC)- i) Development of ultrathin TiN coatings on alumina for rf window and ii) Thermal and mechanical characterization of materials for gyroton.
PSC 0111	Measurement Innovation in Science and Technology (MIST)
SSP 0524	Studies on low temperature sensitization and low temperature thermal embrittlement of narrow gap weld joints of austenitic stainless steel
SSP 0640	Studies on impact of air pollution on corrosion of metallic and non-metallic materials
SSP 0708	Rare earth separation and recovery from Korean Monazite/REOs.
SSP 0727	Recovery of rare metals from effluent and leach liquor of WEEE using SX/IX.
SSP 0730	Studies on creep behavior of Zr-2.5Nb alloy
SSP 0743	Characterisation studies on Rubber Tiles
SSP 0747	Failure analysis of boiler water wall tubes.
SSP 0748	Evaluation of Reagents for Flotation
SSP 0749	Estimation of failure of drier in the paper mill at M/s Sevenhills paper mills, Samalkot, Andhra Pradesh
SSP 0750	Characterization of Cement Tiles
SSP 0773	Development of load bearing polymer hydroxyapatite composite
SSP 0778	Development of a process of making fiber reinforced hydroxyapatite nano composite three dimensional structure.
SSP 0799	Metallographic studies and ACRT properties of service exposed tube of SA 213 (P91) grade of Steel
SSP 0811	Development of GMI based Portable non-destructive magnetic Sensing device for detection of carburization quantitatively for health monitoring of carburised structure at Petrochemical / Refinery Industry (GPS)

SSP 0813	RLA of Crude Distillation and Visbreaker Unit Heater
SSP 0816	Environmental friendly aluminium coating to replace cadmium phase-III
SSP 0820	Residual life assessment (RLA) of Hydrogen Reformer and Pig Tail Tube
SSP 0822	Rolling and heat treatment process optimization of various alloy steels
SSP 0823	Coated steel products performance evaluation
SSP 0824	Evaluation of Coal Core Characteristics of different region of Orissa
SSP 0826	Development of processes for making biphasic (Hydroxyapatite+beetaTCP) nanocomposite blocks & transfer of technology
SSP 0827	Material evaluation of center buffer couplers
SSP 0831	Seam overall characteristics of coal core samaleswari and projapara, IB River coalfield, Orissa
SSP 0834	Development of suitable chemical cleaning solvent and suitable inhibitors for RH and SH chemical cleaning
SSP 0838	Studies on beneficiation of low grade iron ore of SMPL.
SSP 0839	Study on Smelting Reduction of chromite ore in 50 kVA EAF
SSP 0840	Studies on characterization and beneficiation of low grade Iron ore sample from shire-Mentebteb,Ethopia
SSP 0844	Evaluation of creep properties of X22CRMOV12-1 20 CRMOVTIB4-10 and X20 CR 13 grade steel
SSP 0849	Evaluation of creep and stress rupture properties of T-91 material
SSP 0851	Enhancement of in process effiency in tech production of FERC and FEMN through Rational Charges Distribution
SSP 0854	Corrosion and corrosion fatigue behavior of strategic Aluminium alloys.
SSP 0855	Dry Separation of cenosphere from fly ash
SSP 0858	Stress Rupture property evaluation and microstructural studies of SS304H steel of coastal Gujarat Power Limited.
SSP 0859	Potash recovery from feldspar with Simultaneous recovery of Ferro Sillicon
SSP 0860	Failure Investigation of Lp Turbine Blade Root Crack
SSP 0863	Failure Analysis of damaged LPCR Blades
SSP 0864	Failure Analysis of economiser Tube
SSP 0866	Study on stress rupture behaviour of Alloy 690 material.
SSP 0867	Development of processes for recovery of cobalt from discarded Li- ion batteries of mobile phone.
SSP 0868	Development of low cost online defect detection system for high end drawn wires
SSP 0869	Microstructural Characterization of Fusion Boundary of Ferrite- Nickel based Alloy in Dissimilar metal Weld
SSP 0870	Recovery of Gold from the scrap parts of telecommunications and Medical Equipments
SSP 0871	creep strain behaviour of 12% Cr Ferritic Steel
SSP 0872	Failure analysis of boiler reheater tubes at Essar Power M.P.Ltd.,
SSP 0873	Failure analysis of boiler tubes of unit #1 &4 , MTPS, DVC
SSP 0875	Consultancy services towards providing scientific /technical expertise to M/s. JSW Steel Ltd., by CSIR-NML
SSP 0876	Failure investigation of Water Wall Tube
SSP 0878	Environmental Friendly Coatings: Corrosion and Erosion Resistance
SSP 0880	Microstructural analysis of LPTR Blades of R- 29 Areo Engine aropos of failure investigation process of accident areo engine no 262581700022.
SSP 0882	Creep fatigue intercation behaviour of Nickel Based Super Alloys SU-718
SSP 0883	Evaluation of creep and stress rupture properties of ASTM A 387Gr.12 steel
SSP 0884	Failure Analysis of Kneader Components
SSP 0885	Assessment of central quality of high carbon cast billets using ultrasonic imaging

SSP 0886	Development of compositionally modulated multilayered alloy (CMMA) of Zn-Mn and Zn-fe Coatings by Electropalting technique.
SSP 0887	Creep rupture property evaluation of ASTM A 387 Gr. 11 steel
SSP 0888	Creep behaviour of X19CrMoNbVN-11-1, 20CrMoVTiB410 and X20Cr13 grade steel
SSP 0889	synthesis of biometric electrospum collagen - Graphene Nanocomposties with varying Graphene contenet
SSP 0890	Failure Investigation of cooling coils in zinc plant from HZL, Rajasthan
SSP 0891	Beneficiation of barite by column flotation
SSP 0892	Studies on the brightness improvement of marble fines by reverse flotation & column Flotation
SSP 0893	Evaluation of Reagents for flotation
SSP 0894	Studies on cement concrete designer floor tiles
SSP 0907	Metallurgical opinion on analysis and evaluation of off grade copper cathode
SSP 0908	Reduction smelting of copper slag
SSP 0909	Development of Aluminum reflectors protective coating for thermal solar application.
SSP 0910	Failure analysis of thimble of 20/90 Bajrang Dragline of Nigahi project.
SSP 0911	Pilot scale spiral concentration of LD slag
SSP 0912	Creep Test SA213 Steel Grade T5, T11,T22 for 5000 hrs
SSP 0913	Training programme of boiler inspectors from Assam.
SSP 0914	Creep testing of samples from Alstom Forge Power Limited.
SSP 0915	Technology transfer of lacquer for copper and silver based alloys to M/s Mahashraya Chemicals Pvt. Ltd. Balasore, Odisha
SSP 0916	Hydometallurgical Replenishment of Red mud for Extarction of rare Earths Elements
SSP 0917	Evaluation of creep rupture properties of ASTM A 387 Gr.22 steel
SSP 0918	Coal Core Characteristics of different region of Orissa.
SSP 0919	Design and development of pulser & receiver and signal analysis software for ultrasonic Flow meter
SSP 0920	Metallurgical Failure Analysis of Boiler Tube.
SSP 0921	Microstructural investigation of LPTR Blades of R-25 Aero engine
SSP 0922	Investigation of hydride and valuable metal concentration in process and waste product samples of Hindustan Copper Limited.
SSP 0923	Opinion on evaluation of of anode slime
SSP 0924	Dephosphorization of High Carbon Ferromanganese Alloy produced at Balaghat Mine, MOIL
SSP 0926	Failure analysis of boiler tubes of unit # 4 & 6, MTPS, DVC
SSP 0927	Evaluation of residual stress in shot peened steel subjected to fatigue using magnetic barkhausen emissions technique
SSP 0928	Creep rupture tests of P11, P12, P22 and P91 grade of steels for IBR requirements.
SSP 0930	Estimation of Moisture in coke using non-invasive thermography technique
SSP 0932	Metallurgical Failure Analysis of Boiler Economiser Tube
SSP 0933	Evaluation of Mozambic coal characterization.
SSP 0934	Remaining life assessment of CAT. cracking unit stripper /fractionator shell plate
SSP 0935	Failure Analysis of Door Nose wheel LH (Pt No. KB 322 L0115-000)
SSP 0936	Measurement of stacking fault energy using XRD and TEM.
SSP 0937	Investigation and Analysis of Clinker-deposit of BKTPP Unit-3 Boiler
SSP 0938	Failure analysis of damaged 1st stage Fan Rator blade of RD-33 Aero Engine
SSP 0939	Seam overall characteristics of talcher coal field , Odisha

SSP 0940	Transfer of technology on production of pigment and ferrite grade nano iron oxide from waste chloride pickle liquor
SSP 0941	Charges towards creep testing of CRMOV for 1000HR
SSP 0942	Melting study of Ferro-chrome slag in 50 kVA EAF
SSP 0943	Chemical analysis of bauxite ore.
SSP 0944	Failure analysis of two failed pinion samples
SSP 0945	Remaining life assessment (RLA) of heater tube (radiant section)
SSP 0946	Feasibility study of iron recovery from the waste generated in KMML
SSP 0947	Smelting of chromite ores and pellets of varying silica for making ferrochrome
SSP 0948	High temperature mechanical deformation and fracture behavior of Nickel based super alloys
SSP 0949	Charges for technology licensing for commercial manufacture of Magstar equipment.
SSP 0950	Use of roasted LD slag as blended cement component
SSP 0951	Environmental friendly coating cadmium & hexa vallent chrome replacement, corrosion resistanct
SSP 0952	Influence of incremental step forming process on subsequent mechanical properties.
SSP 0953	Corrosion evaluation of 05 nos. of steel rebars samples.
SSP 0954	Failure analysis of boiler wall tube leakage
SSP 0955	Licensing of Knowhow for Anti-tarnishing Lacquer to Multicoat Surfaces Pvt. Ltd., Kolkata
SSP 0958	Desktop tool for blend design
SSP 0964	Evaluation of Center Buffer Coupler Parts
SSP 0965	testing and metallurgical Analysis of as received Rail BPL/SUW/1
SSP 0966	Investigation of failed component of turbocooler 7171 of Mig-21 Bison CU-2069
SSP 0968	Root Cause Analysis of Coal Mill Central Pipe Choekage
SSP 0969	Testing of Vibrating Dewatering
SSP 0971	"ASAP -advanced Electromagnetic sensors for assessing property scatter in high value steel"
SSP 0972	Technology Transfer for ZRB2 technology
SSP 0973	Technology Transfer for TIB@ technology
STS 0004	Testing and Analytical services of MEF
TMP 0207	Metallurgical analysis flying incident to MIG-21(T-77)C-1155 on 16 Apr 13
TMP 0217	Failure analysis of damaged 1st stage NGV (nozzle guinite vame) of R -25 Aero Engine.
TMP 0221	Analysis of different process water Analysis & Chemical Dosing
TMP 0223	Fractal Analysis of room temperature impact samples of blades
TMP 0224	Failure Analysis of ruptured steel pipe of IOCL
TMP 0225	Failure Analysis of boiler tubes of unit #3,6 & 7 from MTPS,DVC
TMP 0227	Studies on Beneficiation of Low Grade lime stone chips from Nandini Mines

Targets Planned

Kailash Satyarthi (born 1954),
Peace, 2014

Kailash Satyarthi) is an Indian children's rights advocate and an activist against child labour. He founded the Bachpan Bachao Andolan (lit. Save the Childhood Movement) in 1980 and has acted to protect the rights of more than 83,000 children from 144 countries. It is largely because of Satyarthi's work and activism that the International Labour Organization adopted Convention No. 182 on the worst forms of child labour, which is now a principal guideline for governments around the world.

His work is recognized through various national and international honours and awards including the Nobel Peace Prize of 2014, which he shared with Malala Yousafzai.

Targets Planned for 2015 - 2016

Performance Targets

	Objectives	Planned
1.	ECF	22 Crores
2.	Industrial ECF (a part of ECF)	14 Crores
3.	International ECF (a part of ECF)	2.5 Crores
4.	Expenditure(other than salary & pension & allowances)	15 Crores
5.	Lab Reserve to be generated	9 Crores
6.	Customer Satisfaction Index	4.5
7.	Publications	135
8.	Patents	30
9.	Copyrights	5
10.	Technologies to be Developed	5
11.	Technologies to be Transferred	5
12.	M.Tech/Ph.D students for AcSIR	

Organizational Targets for 2015 - 2016

Major Technological & Scientific targets Planned for 2015-2016

Activity	Targets for 2015-16
Development of zero waste technology for processing and utilization of thermal coal	• Development of flow sheet for coarse coal using dry separator and studies on recovery of combustibles from rejects of coarse coal. • Development of Geopolymer cement from fly ash at pilot scale and its techno-economic analysis. • Dry separation cenosphere-fly ash mixtures • Enrichment and separation of Ge, Se, Te and Ga by mixed salt precipitation from leach solution.
Development of Magnesium Metal Production Technology	1. Technical Targets (2015 – 2016): ▪ Paper: 3 SCI Papers ▪ Patent: 1 Patent 2. Experimental and Pilot Plant: • To improve the power consumption at the running scale by carrying out 2 nos. of campaign in hot condition after tapping the first heat-slag. • To improve the purity of Mg crowns produced in various campaigns by using the raw material in the form of briquettes instead of lumpy raw materials.

	• To develop a flux and a process for the refining of magnesium to a level of more than 99.8% metallic content.
	• To produce a total quantity of 400 kg of high purity magnesium.
	• Continuation of the modeling work with IIT Kharagpur. The followings are the deliverables:
	  ■ Simulation of the thermal profile for the best 10 campaigns.
	  ■ Estimating the magnesium condensation patterns in one cycle with different magnesium generation kinetics.
	  ■ Thermal simulation of the cooling phase after the magnesium production.
	  ■ Developing high efficiency computational resources for the CFD modeling in NML.
	• Improvement in Pilot Plant design to improve the evacuation technique to minimize the dust generation, actual bath temperature measurement device in the process, and intermittent removal of the magnesium produced.
	• Conceptualization of the design of 1 ton Raw Material (~ 125 kg Mg) capacity pilot plant working in semi-continuous mode will be started after consistently producing up to 400kg magnesium at the present pilot scale.

Coal core analysis	One patent, one publication, ECF generation Rs. 2.0 Crore along with R&D project sponsored by Industries
Sustainable technologies for Extraction of rare earths	• Optimization of process for the recovery of rare earths from phosphor powder by precipitation route. • Solvent extraction separation of light rare earths by using Cyanex 572, a novel reagent as extractant.
Incremental Sheet Forming	• Extraction plan for miniature specimens. • Residual stress measurement. • DOE for evaluation of mechanical properties. • Evaluation of tensile/fatigue in Al alloys due to ISF.

Business, Administration & other targets Planned for 2015-2016

Business	• Creation of Innovation centres with industries • Internationalize NML research through collaborations and partnerships
Human Resources	• Recruitments in Group IV (scientist) and Group III (technical) cadres • Training and mentoring of students (undergraduate, postgraduate and PhD-level) • Organization of skill and performance enhancement programmes
Administration	• Implementation of adhar based Biometry • Disposals through e-auction • Up to date service book entry of leave record

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Giving us feedback, keeping in touch :

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

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