Indian Minerals Yearbook 2017

(Part- I : GENERAL REVIEWS)

56th Edition

RESEARCH & DEVELOPMENT

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GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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5 Research & Development

The Science and Technology (S&T) programmes of the Ministry of Mines, Government of India, cover the disciplines of Geology, Exploration, Mining, Beneficiation and Mineral Processing, Rock Mechanics, Ground Control and Non-ferrous Metallurgy and Environmental issues related to Mining and Metallurgy. Standing Scientific Advisory Group (SSAG) in its 47th meeting held on 23.08.2016 at Shastri Bhawan, New Delhi considered and recommended Grant-in-Aid under S&T programme of the Ministry of Mines. The 47th SSAG has approved the projects, and summary of the same is given in Table-1.

During 2016-17, Sixteenth meeting of Project Evaluation and Review Committee (PERC) was held on 06.09.2017 at JNARDDC, Nagpur. As per minutes of said meeting, a total of 116 project proposals were received for the year 2017-18. A two-stage review process was adopted to evaluate the proposal for recommendation to SSAG. The first stage comprised of preliminary screening of the proposals done by a team of experts constituted by Ministry of Mines. Based on the guidelines as adopted in 14th PERC, the experts conducted pre-screening of the proposals. Total 27 proposals covering five areas, namely (i) Geosciences and Exploration (ii) Mining, (iii) Mineral Processing & recovery from waste (iv) Metal Extraction (Metallurgical processes) and (v) Alloys, specialty materials and product were short listed for further review in the second stage. Total 27 project proposals were presented by the respective Principal Investigators (PIs) and evaluated by the committee during the 16th PERC meeting. Furthermore, one proposal of NIMH recommend by Ministry of Mines was also reviewed.

Based on the detailed review and evaluation by committee experts, total 9 project proposals comprising of (i) One from Geosciences and Exploration (ii) Two from Mining (iii) Two from Mineral Processing & recovery from waste (iv) One from Metal Extraction (Metallurgical processes) and (v) Three in the area of Alloys, specialty materials and product are being recommended to SSAG. Out of recommended projects, 5 are from academia with emphasis on novel techniques and methods which can have an application potential in near future, if successful. The rest 4 proposals are from R&D laboratories wherein the emphasis is on quicker development and direct translation to user agency or commercial exploitation. NFTDC's project is related to the area of Urban Li Battery Mining, whereas, JNARDDC is collaborating with IIT Bhubaneswar and VNIT, Nagpur in two projects related to industrial wastes. CEEW has been recommended for one project for conducting periodic assessment of resources index of India – for effective policy decisions on mineral and manufacturing sector of India. The details of recommended project proposals are given in Table -2.

Out of 19 not recommended project proposals, 6 proposals are given another opportunity to resubmit to next PERC with revisions. The detail of projects to be resubmitted with revision to PERC is given in Table-3.

Table-1: Summary of Projects Approved by 47th SSAG as on 23rd Aug. 2016

Title	Institution	Financial Outlay & Duration
1) Geological studies of Archaean greenstone belts of Aravalli craton NW Indian Shield: Implication for crustal evolution & economic Potential.	Aligarh Muslim University, Aligarh	Total Budget ₹ 22.321 lakh, Duration 2 years.
ii) Large scale digital database creation of bauxite & laterite deposits of Mah-arashtra state using geo-information technology.	JNARDDC & MRSTC, Nagpur	Total Budget ₹ 69.5484 lakh, Duration 2 years JNARDDC ₹ 43.8234 lakh MRSTC: ₹ 25.725 lakh.
iii) Development of environment friendly blasting technique.	Indian School of Mines, Dhanbad	Total Budget ₹ 29.04 lakh, Duration 3 years.
iv) Postural risk analysis of Mining equipment operators and its relation to musculoskeletal disorders.	National Institute of Miner's Health, Nagpur	Total Cost ₹ 37.66 lakh, Duration 2 years.
v) Effect of modified seed properties in precipitation of aluminium hydroxide from Bayer liquor.	JNARDDC, Nagpur	Total Budget ₹ 44.99 lakh, Duration: 2 years.
vi) Development of eco-friendly bio-based reagents for mineral flotation.	Institute of Minerals & Materials Technology Bhubaneswar	Total Budget ₹ 24 lakh, Duration 2 years MoM ₹ 12 lakh CSIR Co-Funding ₹ 12 lakh MoM funds to be released in two equal installments of ₹ 6 lakh subject to proof of co-funding by CSIR (IMMT).
vii) Extraction of potash values from silicate rocks.	Indian Institute of Technology, Roorkee	Total Budget ₹ 20.0 lakh, Duration 2 years.
viii) Technology Development (TRL-7) for calico-thermic reduction of RE metal oxides & establishment of pilot plant for extraction and purification of samarium	Non Ferrous Materials Technology Development Centre, Hyderabad	MoM ₹ 186.5 lakh NFDTC: ₹ 150 lakh. Duration: 2 years.

The SSAG in addition to above approved projects not approved/deferred the following projects.

Table -2: Summary of Projects recommended by 16th PERC to SSAG for approval

Category	Project Title	Implementing Institution	Project Cost & Duration	Recommendation
Geosciences and Exploration	Critical Mineral (non-fuel) Resources Index of India – for effective policy decisions on mineral and manufacturing sector of India	Council on Energy, Environment and Water (CEEW), New Delhi	₹ 36.29 lakh, duration = 3 yrs	i. The project envisages to develop critical index in each mineral commodity in order to access potential of mineral. ii. The country needs to have a periodic estimation of methodology of individual commodities for critical mineral resources available for realistic policy decision. iii. The project will develop a website which can be viewed in public domain and utilised by Ministry of Mines with common data for assessment. iv. PI advised to keep GSI and IBM on board during the development of framework so that it can be used by these organisations as and when required.
Mining Related	Development of a novel underground mining method for exploitation of Chromite deposits from friable ore body and host rocks of Sukinda Valley, Odisha	Department of Mining Engineering, IIT, Kharagpur, West Bengal	₹ 68.46 Lakhs, duration = 3 yrs	i. OMC support letter noted by PERC. ii. The mining/exploration of friable rock mass of horizon are a challenging issue. iii. The project aims in the development of a methodology to address the challenge which is important for conservation of deposits in the country. iv. Odisha Mining Corporation (OMC) has given a letter of support and provided site facility.
-do-	Processed Sea sand for construction and other purposes	Civil Engineering Department, Saveetha Engineering College, Thandalam, Chennai	₹ 51.62 Lakh, duration = 3 yrs	i. Budget should be rationalised to ₹ 40 Lakhs and duration to 2 years. ii. Usage of offshore sand for construction is a challenging task for the country in near future. iii. The proposal aims for development of suitable technique and use of processed sea sand for construction for cement concrete.
Mineral Processing & recovery from waste	Estimation of Morphodynamicity and its remedial action using Red mud based concrete at coastal zone of Eastern Odisha	1. Jawaharlal Nehru Aluminium Research Development & Design Centre, Nagpur and 2. IIT, Bhubaneswar, Odisha	₹143.41Lakh, duration = 3 yrs	i. The projects should be taken up in two parts. The initial feasibility study in Part-A is recommended with a seed money of ₹ 30 Lakhs (JNARDDC and IIT, Bhubaneswar - ₹ 15 Lakhs each) for a period of 6 months. ii. Based on the results obtained in Part-A, the full scale project may be considered in Part-B iii. The focus of the project should be more on field study.
-do-	Nano Processing of Industrial Rejects for Use as Additives in Mix-designs for Improved Pozzolanic Reaction Efficiency	1. Jawaharlal Nehru Aluminium Research Development and Design Centre, Nagpur and 2. Visvesvaraya National Institute of Technology, Nagpur, Maharashtra	₹ 49.77 Lakh, (JNARDDC - ₹ 37.69 lakh & VNIT- ₹ 12.07 lakh) duration = 2 yrs	i. The PI has proposed to use a cost-effective way for preparation of nanoparticles/nano-composites using industrial wastes as precursors rather than expensive chemicals. ii. The outcome of the R&D work may lead to overall reduction of construction cost by means of reduced use of binder (cement) which shall be substituted by the

Concld. (Table-2)

Category	Project Title	Institution	Project Cost & Duration	Recommendation
				above nano-materials which will be cheaper and efficient to improve binding properties. iii. PI is advised to submit a consent letter from Industry with regards to utilisation of the R&D outcome for economic and efficient building and construction work, etc.
Metal Extraction (Metallurgical processes)	Urban Li Battery Mining: Physio-Chemical Separation of Used Li ion Batteries for Recovery of Li, Co, Ni active materials and Cu, Al metals	Nonferrous Materials Technology Development Centre, Hyderabad, Telangana	₹ 94.82 Lakh (MoM- ₹ 83.82 lakh & Central Electronics Ltd and NFTDC to support Rs 11 lakh), duration = 2 yrs	i. Project is well conceived and it addresses the issue of Li resource for LiB manufacturing. ii. The deliverable is at pilot plant (TRL-7) level and on successful completion technology can be transferred to a large no. of SMEs & MSMEs. iii. Framework for regulatory mechanism for institutionalising collection and recovery to be examined.
Alloys, specialty materials and products	Development of Metal-Graphene Alloys	Department of Materials Engineering, Indian Institute of Science, Bengaluru, Karnataka	₹ 21.60 Lakh, duration = 3 yrs	i. Application to be made very specific, particularly for graphene conductive electrode materials ii. One dedicated JRF to be taken for the project. iii. Institute overheads should be as per SSAG norms i.e. of 1% of capital and 5% of non-capital. iv. Duration to be reduced to 2 years only. v. Budget to be rationalised within ₹ 20 lakhs.
-do-	Fabrication of Advanced Ceramic Nanocoatings for Automotive Applications	1. Christ University, Faculty of Engineering (Kengeri Campus), Kanminike, Kumbalgodu Bengaluru, Karnataka and 2. Jawaharlal Nehru Aluminium Research Development and Design Centre, Nagpur, Maharashtra	₹ 43.76 Lakh (Christ University– ₹ 21.81 Lakh and JNARDDC- ₹ 21.95 Lakh), duration = 3 yrs	i. The PI has relevant expertise and competence in plasma spray related coating technologies. ii. Applications sectors are well identified, however, specific component to be identified for technology demonstration. iii. Raw material such as nano YSZ synthesis should also be taken up as supply chain should not affect the project. iv. Comparison with sol-gel method to be done. v. Project duration to be reduced to 2 years.
-do-	Value added Electro-chemical Devices from Zircon obtained from Beach Sands of Odisha	School of Minerals, Metallurgical and Materials Engineering, IIT, Bhubaneswar, Odisha	₹ 39.92 Lakh duration = 3 yrs	i. Project well conceived and it is of high relevance. ii. Interaction with IREL has been established and it is already on. iii. PI has done significant prior work. iv. Project will have good impact value on successful completion. v. Duration to be reduced to 2 years only.

Source: *Minutes of meeting of 16th PERC held at MoM, New Delhi.*

Table -3: Detail of Project proposals to be resubmitted with revision to next PERC

Project Title	Implementing Institution	Project Cost & Duration	Recommendation for resubmission
Design and development of new approaches for recovering and removing copper from mine tailings	Department of Environmental Science and Engineering, IIT (ISM), Dhanbad, Jharkhand	₹ 31.58 Lakh, duration = 3 yrs	i. To measure the concentration of heavy metals including copper in and around selected mine sites of varying distance and depth. ii. To optimise the biomass of indigenous plant species and examine the Cu accumulation of selected plant species. iii. To Design the economic bio-reactor for mineral leaching and metal recovery from mine tailings. iv. To determine the optimal field conditions and limiting factors for the copper phytomining.
Treated Ferromanganese Slag as an Adsorbent Media for Arsenic and Fluoride ions from Water	Polymer & Process Engineering Department, IIT Roorkee, Uttar Pradesh	₹ 47.10 Lakh, duration = 3 yrs	i. To treat the ferromanganese slag and make it useful oxidant for harmful arsenate ions and subsequently use as an adsorbent for different ions from water. ii. To develop the commercial water filter by using the treated slag to remove arsenic and other ions removal from contaminated groundwater and arsenic contaminated mining wastewater
High Performance rare Earth metal as Electrode material for Super capacitor applications and fuel cells	Department of Physics, Velammal Institue of Technology, Pancheti, Chennai, Tamil Nadu	₹ 29.55 Lakh, duration = 3 yrs	i. To synthesise thin layer of Rare earth oxide/polymer thin film ii. To synthesize the composites of cerium, Terbium rare earth oxides with transition metals and conducting polymers. iii. To characterise the synthesised films using optical studies using U-Vis spectrometer, Photo luminance, Photocatlytic activity. iv. To investigate their optical, electrochemical, morphological and photovoltaic properties using U-Vis spectrometer, Photo luminance, SEM,TEM, TGA, XRD, FTIR, RAMAN, v. To analyse the effect of rare earth oxide/ polymer nanomaterial on Supercapacitors and fuelcells.
Development of Novel Cr-Free Nickel Based Metal Alloy as Filler Materials for Welding Stainless Steel	Mechanical Department, R. V. College of Engineering Bengaluru, Karnataka	₹ 42.92 Lakh duration = 3 yrs	i. To Develop Cr-free nickel based metal alloy as filler materials for welding stainless steel. ii. To generate phase diagrams for developed alloys. iii. To optimise the chemical composition of the Cr-free nickel based alloy based on phase diagram, mechanical properties and corrosion resistance. iv. To characterise the weld joints (Base metal stainless steel) for mechanical and corrosion properties.
Development of open cell aluminium foams for heat sink and EMI Shielding Applications	CSIR-Advanced Materials and Processes Research Institute (CSIR-AMPRI)	₹ 47.38 Lakh, duration = 2 yrs	i. Development of a process for open cell aluminum foam with uniform and finer cell size. ii. Design of aluminium foam with most effective heat transfer through finite element simulation.

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Project Title	Implementing Institution	Project Cost & Duration	Recommendation for resubmission
			iii. To develop open cell foams with different densities, cell size. iv. Effect of cell size, densities on thermal conductivity, specific heat, heat extraction coefficient, specific surface area. v. Effect of graphene addition on thermal conductivity of the foams. vi. Effect of cenosphere and red mud addition on the elctro-magnetic shielding of aluminium foam. vii. Component design, fabrication and performance evaluation.
Rare-earth free inter-metallic compounds to develop a new generation of high-performance Permanent Magnets	Material Science and Technology Division, CSIR National Institute for Interdisciplinary Science and Technology (CSIR-NIIST), Trivandrum, Kerala and Department of Physics, Central University of Rajasthan, Bandar Sindri, Dist. –Ajmer, Rajasthan	₹ 60.28 Lakh, duration = 3 yrs	i. The aim of the project is to investigate the effect of composition, doping, preparation routes (induction melted followed by rapidly quenching bulk samples, chemically synthesised nanomaterials & epitaxial thin films), preparation conditions and post annealing temperature on the structural and magnetic properties of the MnX (X = Al, Bi and Ga) alloys to have a better understanding on the underlying physics and optimise the magnetic properties (high magnetic anisotropy, high Curie temperature and large coercivity) for requisite applications. ii. An investigation of the structural and magnetic properties of these MnX compounds at the nano-scale i.e., chemically synthesised nanoparticles, nanostructured ribbons and 2D thin films will be carried out. iii. To develop soft magnetic phases viz. Fe,Co and FeCo via chemical routes. iv. The focus will be to exploit the hard magnetic phases of Mn-X in combination with the controlled microstructure for hard magnetic applications with the eventual goal of integrating these phenomena in thin film vertical heterostructures with complex, magnetically coupled exchange media. v. To design and develop the exchange spring magnet compositions with hard magnetic phases of Mn-X nanoparticles along with soft magnetic phases Fe,Co and FeCo. The design of the exchange spring magnets by microstructure engineering will be optimised to get maximum properties. Hence, this project aims at developing RE-free permanent magnets of energy product of at least 12 MGOe by above said methods. vi. Development of magnetic nano composites with energy product of at least 12 MGOe, their synthesis and secondary processing methodology and magnet making procedures at lab scale so that industries can scale up.

Source: *Minutes of meeting of 16th PERC held at MoM, New Delhi.*

Research & Development

As per information of R&D work carried out by various mining & mineral based industries and research organisations relating to mineral/metal, details of some R&D work conducted or completed by various organisations during 2016-17 are given below:

1. Manganese Ore India Ltd

Some of the R&D projects in MOIL are given below:

(i) Mine Environment: Ventilation reorganisation studies for deeper levels have been conducted at Gumgaon and Chikla Mine by Indian Institute of Technology (IIT), Kharagpur. Recommendations have already been implemented at Gumgaon and the implementation is in progress at Chikla Mine.

(ii) Mines Safety: Mining Subsidence: In-house scientific 3-D analysis of subsidence parameter has been carried out for forest cover of Ukwa Mine. The monitoring stations with 5 (five) subsidence monitoring pillars have been properly erected in line with strike and dip directions of the ore body on the surface land area and quarterly measurement is being done by total station and GPS to monitor the 3-D coordinates.

(iii) Mineral conservation: R&D studies have been conducted at Chikla Mine by National Institute of Rock Mechanics (NIRM), KGF.

(iv) Mining Technology: (a) Method of Stoping: R&D project for mechanised stoping operation has been prepared by IIT (Formerly Indian School of Mines), Dhanbad and implemented for mechanised stoping operations and support systems at Ukwa Mine. This helps in improvement in production, safety and productivity by mechanisation of stoping operation. **(b) Alternative to Cartage Explosives:** To reduce the ground vibrations, fly rock and noise as also to increase operational efficiency, Site Mix Emulsion (SME) Explosives have been used with shock tubes at Dongri Buzurg opencast mine on experimental basis. The results are encouraging and it is now planned to switch over to the new blasting method.

(v) Collaborative work with Academic and Research Institutions: (a) MOIL is carrying out joint collaborative R&D project with VNIT, Nagpur for alternative to sand for fill material. Bench scale hydraulic stowing plant has been installed at Department of Mining Engineering, VNIT, Nagpur. This project has given a new avenue for paste fill engineering. Further studies for paste fill are going on. (b) MOIL is also making collaborative research for slope stabilization with NIT, Rourkela for Slope Monitoring Instruments (under S&T Scheme of Ministry of Mines)

(vi) Substitute of fill material - (a) R&D wing has conducted the study for filling of underground sections at Ukwa Mine by bottom ash on experimental basis. Around 400 cum (m^3) of bottom ash have been filled in underground by hydraulic stowing. Further trials are continued for confirmation of the outcome. (b) Mill tailings of Malanjkhand Copper Project of Hindustan Copper Limited have been utilised for hydraulic stowing operation at Ukwa Mine. Mill tailings have been used to replace sand by in-house R&D studies.

Pre-cast RCC Columns & Sections: In-house developed pre-cast RCC columns and sections have been rapidly erected in drift development and thus improved the safety standard of drift development in underground besides increasing efficiency in concreting operations.

2. Hindustan Zinc Ltd

Some of the R&D projects or innovation in HZL are given below:

(i) Waste management with 'Paste Fill' technology: Paste fill plants commissioned at the underground operations of Rampura Agucha Mine and Sindesar Khurd Mine have ensured fast filling of voids with practically no bleeding. It has offered other advantages like minimum water consumption and drainage with lesser fill and wall dilution in stopes, better recovery of intervening pillars along with better regional stability and surface integrity. The process utilises tailings, a waste of our milling operations, thus freeing up precious land requirements for long term tailing storage.

(ii) Single Shot Stope blasting: Underground conditions at Rampura Agucha Mine are under high stress environment which poses challenge for safe and economical extraction of shear hosted high grade reserve of zinc and lead. The drill design was changed for improved ore yield by

inducting solo drill rigs and emulsion charging for executing single shot stope blast versus time consuming conventional slot blasting in long hole open stopes. Single shot stope blasting ensured enhanced production rates in shear hosted mineralisation with a void ratio as low as 11% and resource recovery over 95% in single choked stope blast. This eliminated rework and ground squeezing issues that are encountered after blasting and reduced cycle time from 15-17 days to just 1 day.

(iii) Zinc Fumer Process making the smelting process sustainable: Our hydrometallurgical zinc smelting process generates hazardous wastes which are then neutralised and stored in secured landfills, which requires 4 acres of land per smelter per year. Zinc fuming technology is integrated with the existing leaching process eliminating this land requirement and converting hazardous wastes into commercially usable slag. Also it will improve recovery of zinc and start recovering metals like lead, silver and copper from hydro route which were earlier going with waste into secured landfills.

(iv) Enhancing energy efficiency in the Jumbo Casting process: In an effort to optimise energy consumption, the LPG burners at Pantnagar Plant are being replaced with electric top heaters, which is adding to the energy efficiency of Jumbo Casting process. With four burners modified as yet, the specific consumption has dropped from 10 kg/MT to 6 Kg/MT. The conventional electrical LPG vaporisers have been replaced with heater-less vaporisers, thus eliminating the usage of electricity for the purpose. Also, a direct pipeline connection between GAIL depot to Chanderiya plant is being installed to reduce the cost of procurement and also to lessen the environmental footprint.

(v) Research and Development improving yield: To improve silver recovery from ore, experiments related to kinetic study were conducted for Kayad ore which necessitated change in dosing pattern of chemicals for improving silver recovery. After successful laboratory and plant scale trials, silver recovery improved from 44% to 51%, while consumption of hazardous chemicals was reduced by one third.

Exploration Techniques taking Deeper: Technologies like motorised directional drilling to ensure that deep holes of more than 1 km below surface hit the targeted mineralised zones and down hole electrical geophysical techniques to locate potential off-hole ore zones are now being used. We have implemented new software such as Leapfrog to provide high quality 3D visualisation of integrated geological, geochemical and geophysical exploration data and acquire to manage its drilling geochemical database. All these have resulted in enhanced reserve and resource at lower cost.

3. Hindustan Copper Ltd

Some of the R&D projects in HCL are given below:

(i) Recovery of copper through leaching from ESP dust of flash smelter has been taken up.

(ii) Recovery of nickel metal from nickel waste produced at customer refinery.

(iii) Malanjkhand Concentrator plant uses pine oil as a frother in Concentrator plant process, being natural product extracted from pine trees its availability and quality is not consistent. The Company has taken R&D initiatives to find a suitable substitute. During the year, the Company has undertaken R&D test of the other probable chemicals in the plant and found one of the chemical product suitable for the application as well as cost effective. Thus, pine oil will be replaced by the above item in phased manner.

(iv) Combination of both sized (80 mm and 90mm) hi-chrome grinding media was studied and specific consumption of grinding media was brought down to 0.78 Kg/MT of milling. Now all the four ball mills are being run with the combined grinding media in 1:1 ratio.

4. National Mineral Development Corporation

Some of the R&D projects in NMDC are given below:

(i) Improve the screening efficiency of Iron ore over previous year: The objective of this project is performance evaluation of the secondary screens (fines screening) in the production units and evolving remedial measures to improve the screening efficiency. The results of Plant trials

with novel design screen cloth on existing screens at NMDC plants (SP -2, Kirandul) are as under-

(a) The average screening efficiency of the screen fitted with novel design screen cloth are 7.79% to 39.70% higher than the screen fitted with woven wire screen cloth.

(b) There has been an increase of 21958 tonnes in the production from the line with new screen cloth (from 15.03.2017 to 25.03.2017) as compared to the line with conventional screen cloth and the average feed rate for the line with new screen cloth is about 140 TPH more than the line with woven wire screen. Till 8th April, the tonnage handled has been 1.73 lakh tonnes, average tonnage handled by conventional screen (with multiple times welding repair work) is 80-85000 tonnes.

(c)The screen fitted with novel design screen cloth can be run with higher feed rate than the screen fitted with conventional screen cloth and still attain comparatively better screen efficiency.

(d) It is also observed that the new screen cloth apertures are not clogging/blinding even while screening 8% moisture ore at around 400 TPH to secondary screen.

(ii) Development of an ecofriendly tailing disposal system by filtration of iron ore tailings and study of issues related to their transportation and storage (Phase - 4): This project was undertaken in 2013-14 and envisaged to be completed in 4 phases. The objective of this phase are (a) To evaluate the flow properties and paste rheology of the engineered tailing samples; (b) Address issues related to the storage and transportation of tailing samples. The results of this phase are -

(a) The filtered tailings can be transported by conveyor belt and stacked up to moisture content of 20.2%, 22.6% and 26.7% respectively for samples 1, 2 & 3.

(b) This moisture is about 3% more than the expected filter cake moisture of all three tailing samples.

(c) The yield stress of the tailing samples 1, 2 and 3 at 68%, 59% and 58% solid concentration by weight are 29Pa, 70Pa and 3.7Pa respectively.

(d) The yield stress values indicate that the paste tailing can be transported by Centrifugal Pumps from deep bed thickener to paste disposal location.

To develop a process which can recover maximum water from the iron ore tailings and enable disposal of tailings in solid or semi-solid form which would minimise the environmental hazard and also make iron ore mining sustainable.

The tailing samples are amenable for paste thickening as well as filtration. It is possible to get a paste with 56 - 72% solids and yield stress in the range of 75 - 300 Pa. The filtration tests revealed that it is possible to produce a filter cake with moisture content ranging from 14 to 24%.

5. JNARDDC

Some of the R&D projects carried out or completed by JNARDDC during the year are given below:

(i) Development of a real time instrument/system to measure bath ratio, alumina concentration, bath temperature and super heat of the aluminium electrolysis bath: This project has been completed successfully which has resulted in development of a real time instrument which is the combination of thermocouple arrangement, data acquisition system and software for analysing the data to estimate/calculate the bath parameters such as bath ratio, alumina concentration, bath temperature and superheat of the aluminium electrolysis bath. Validation trials were conducted at Nalco Angul smelter and the instrument was successfully demonstrated by carrying out about 25 measurements. Bath parameter values obtained using real time instrument and using conventional existing methods were in confirmity. Real time instrument is bound to replace the conventional existing time consuming laboratory method as it facilitates taking instantaneous corrective measures for controlling the aluminium electrolysis cell.

(ii) Optimisation of parameters for ultrasound precipitation of aluminate liquor with emphasis on production of special fine hydrate and liquor productivity: The project aimed at application of ultrasound for production of special fine hydrate and improved yield of product hydrate in precipitation step of bayer process has been completed recently. The 22 KHz ultrasound with 80% amplitude is required for 15 minutes duration for fine seed followed by conventional precipitation for 8 hrs to obtain a special fine

hydrate of d50 of 10.5 micron with liquor productivity of 85.43 gpl (against 84.59 gpl without ultrasound). Encouraging results were obtained when ultrasound is used with conventional coarse seed giving more fines than the conventional precipitation without ultrasound.

(iii) Synergistic utilisation of aluminium industrial wastes for development of geopolymeric building materials: This project primarily aims at investigating utilisation of synergy among various rejects of aluminium and other industries for development of green building material based on geopolymer process. The preliminary studies identified 75 mix designs comprising rejects of aluminium, steel and biomass industrial origin. Geopolymer bricks prepared with aluminium industry reject and biomass combination confirm IS-3495 (part-I): 1976. Blocks prepared with single and multi components in the mix design reported crushing strength in the range 10 – 25 N/mm^2 for hard bricks and 5 to 8.5 N/mm^2 for light weight foamed geopolymer (LWFGEOP). Setting up of mini-pilot plant is in progress for estimating the economics.

(iv) Development of hard and high temperature refractory material/aggregate from saprolite: Objective of this project is to develop refractory material/aggregate from saprolite which is waste, unutilised material generated during bauxite mining. De-ironing and leaching trials carried out for removal of iron oxide from raw saprolite. Carried out sintering test with different additives and parameters such as temperature, time and grain size to obtain high quality refractory product. Characterisation and properties evaluation of sintered granules is complete. Results of tests conducted to check suitability of sintered aggregates for preparing castables which finds extensive use in different industries.

(v) Effect of modified seed properties in precipitation of aluminium hydroxide from Bayer liquor: The project aims at exploring the possibility of using seed aluminium hydroxide by altering/modifying/ changing its surface properties to enhance the liquor productivity/yield in precipitation process. This may lead to new process and product development in precipitation. Presently thermal activation of fine and conventional seed and their characterisation is in progress.

(vi) Studies on trace liquor impurities, its behaviour and control in Bayer's process with respect to reduction in product hydrate: Liquor and solid samples (bauxite, mud, hydrate and alumina) collected from refinery were duly prepared and thoroughly characterised. The spent liquor and green liquor was analysed for trace potassium and zinc concentration. Literature search is on to finalise the suitable plan for impurity control/removal from spent liquor and settler overflow. A trial experiment was conducted using surfactant (reagent) to remove impurities from spent liquor. The results obtained were encouraging.

(vii) Mechanical activation of bauxite: Mechanical activation of bauxite can alter the process condition used in various steps in Bayer process. This project aims to investigate the effect of mechanical activation of bauxite on desilication, digestion and setting process steps. It aims to establish new process parameters to achieve maximum extraction of alumina, low alumina and soda losses in red mud and to obtain an acceptable silica level in the liquor. Presently, simultaneous milling and leaching studies (on low and high silica bauxites) in attrition mill are in progress.

IMPORTANT ORE DRESSING INVESTIGATIONS

R & D (Ore Preparation & Process)

1.1 Copper Ore:

Bench scale beneficiation studies on a Copper ore sample from West of Nanagwas, Sikar district Rajasthan : A copper ore sample from West of Nanagwas (NW-1&2), District Sikar, Rajasthan was sent to Regional Mineral Processing Laboratory, Indian Bureau of Mines, Ajmer for bench scale beneficiation studies. The aim of bench scale beneficiation study was to evolve a process flow sheet producing a copper concentrate more than 18% cu with maximum recovery.The as received sample assayed 0.36% Cu, 4.92% Fe(T), 38.27% SiO_2, 8.77% Al_2O_3, 47.28% AI, 0.11% S(T), 0.40% TiO_2, 0.06% Sn. The flowsheet comprises of grinding to 83% passing 200 mesh followed by flotation with three cleanings. A copper concentrate assaying 40.90% Cu, 13.27% acid insoluble with 84.64% copper recovery (Wt.% yield 0.74). Concentrate with two cleanings gave a concentrate assaying 30.31% Cu and 20.08% acid insoluble with 88.44% copper recovery (Wt% yield 1.04). The copper concentrate meets all the specifications required for smelter.

Bench scale beneficiation studies on gold bearing copper ore sample from Khera Main Block, Alwar district, Rajasthan: A Gold bearing copper ore sample from Khera main block, District-Alwar, Rajasthan collected as a part of G-2 exploration was sent to Regional Mineral Processing Laboratory, IBM, Ajmer for bench scale beneficiation study. The objective of the investigation was to evolve a process flow sheet for producing a concentrate assaying more than 18% Cu with maximum possible recovery. The as received sample assayed 0.59% Cu; 1.43 ppm Au(by fire assay) along with 3.94 ppm Ag, 66.83% SiO_2, 9.63% Al_2O_3, 1.48% S(T), 4.39% Fe(T), 4.62% CaO; 4.35% MgO; 0.37% Na_2O, 3.15% K_2O; 71.62ppm-Zn; 20.75ppm-Pb; 308ppm-As and 100ppm-Bi; 32.56ppm-Co with 77.46% Acid insoluble. By adopting flotation process, a composite concentrate obtained assayed 22.59% Cu with a recovery distribution of 74.8% (Wt.% yield is 2.03).

1.2 Dolomite

Beneficiation studies on a Siliceous Dolomite sample from Kadapa Dist., Andhra Pradesh : A dolomite sample was received for bench scale beneficiation studies at Regional Ore Dressing Laboratory, Indian Bureau of Mines, Bengaluru. The objective of the investigation to develop a process flow sheet with silica content less than 5.0% .The as received sample assaying 32.41% CaO, 12.02% MgO, 11.76% SiO_2, 0.74% Fe_2O_3, 1.19% Al_2O_3, 0.07% P, 39.49% LOI. By adopting flotation method, the concentrate obtained assayed 36.24% CaO, 12.41% MgO, 4.50% SiO_2, 44.38% LOI with about 50% recovery of CaO & MgO (wt % yield 42.9). The concentrate obtained suitable for steel industry.

1.3 Glauconite:

Bench Scale Beneficiation Studies on a very low-grade Glauconite Bearing Drill-Core Sample (G2-stage) in Barwadih and Kurchha Area, Sonbhadra District, Uttar Pradesh: A very low-grade Glauconite bearing drill-core sample from district Sonbhadra, Uttar Pradesh was received for conducting bench scale beneficiation studies at the Modern Mineral Processing Laboratory, Indian Bureau of Mines, Nagpur. The objective of the study was to study the amenability to produce a glauconite rich concentrate that can be used as a raw material for manufacture of fertilizer. The as received sample assayed 3.82% K_2O (T), 0.29% Na_2O, 10.18% Al_2O_3, 3.55% Fe_2O_3, 50.68% SiO_2(T), 10.60% CaO, 5.58% MgO, 0.32% TiO_2, and 14.33% LOI (Glauconite 5-10%). Beneficiation test works employing attrition scrubbing & screening could yield assayed 5.79% K_2O with 26.1% K_2O recovery (wt. % yield: 17.1). Alternately, by adopting Roll crushing followed by wet stage grinding of -10 mesh sample and wet screening of the ground product assayed 4.96% K_2O with 63.1% K_2O recovery (Wt%. yield: 48.8) (Glauconite 25-30% approx.). By employing beneficiation test conditions produced the K_2O enriched product with a reasonably good recovery.

1.4 Iron Ore

Bench scale beneficiation studies on bulk sample of iron ore from Nayapalli, Bhubaneshwar District, Odisha : A bulk sample of iron ore from Nayapalli, Bhubaneshwar District, Odisha was sent at the Modern Mineral Processing Laboratory and Pilot Plant, Indian Bureau of Mines Nagpur, for conducting bench scale beneficiation studies. The objective of the study was to develop a suitable beneficiation process flow sheet to produce an iron ore concentrate suitable for industrial use.The as received iron ore sample assayed 60.26% Fe, 4.23% Al_2O_3, 5.00% SiO_2, 0.141% Mn, 0.099% TiO_2, 0.051 % CaO, 0.025 % MgO, 0.069% Na_2O, 0.048% P & 3.54 % LOI. Two process routes were attempted employing different gravity separation techniques such as classification, Tabling and Multi Gravity Separation.

i) The as received sample was subjected to screening, classification, tabling and multi gravity separation obtained a composite Fe concentrate assaying 63.45% Fe, 2.75% Al_2O_3, 3.05% SiO_2, and 2.56 % LOI with 60.2% Fe recovery (wt.% yield of 57.2).

ii) The as received sample was subjected to stage grinding, classification followed by tabling and multi-gravity separation could yield a composite concentrate assaying 64.62 % Fe, 2.26 % Al_2O_3, 2.43 % SiO_2, and 2.33 % LOI with 53.8% Fe recovery (wt. % yield of 50.5).

Both the concentrates may be suitable for industrial use.

1.5 Limestone (Core):

Beneficiation studies on a Siliceous Limestone (Core) sample from Muddapur mines, Bagalkot Dist., Karnataka : A Limestone (core) sample was received from Muddapur Mines, Bagalkot, Karnataka for beneficiation studies at Regional Ore Dressing Laboratory, Indian Bureau of Mines, Bengaluru. The objective of the investigation is to reduce silica less than 12 % and to produce a concentrate suitable for cement manufacturing. The as received sample assayed 33.68 % CaO, 22.75 % SiO_2 (T), 3.06 % MgO, 3.13 % Fe_2O_3, 4.25% Al_2O_3, 0.48 % K_2O, 0.08% Na_2O, 0.005% P, Traces of Sand 30.20% LOI. By adopting the flotation test with three cleanings produced the concentrate assayed 49.15 % CaO, 5.32 % SiO_2 (T) with 82.4% CaO recovery (Wt % yield 58.20). The flotation with two

cleanings assayed 45.64 % CaO, 9.1 % SiO_2 (T) with 91.3 % CaO recovery (Wt % yield of 69.4). The concentrate obtained is suitable for cement manufacturing.

1.6 Phosphate:

Pilot scale beneficiation studies on a low grade Phosphate sample from Hirapur, Sagar Dist., M.P. :

A low grade Phosphate sample was received for pilot scale beneficiation studies at Regional Mineral Processing Laboratory, IBM, Bengaluru. The objectives of pilot plant studies were: i) to confirm /verify the process scheme developed in the laboratory to produce a phosphate concentrate suitable for phosphoric acid manufacturing on continuous basis simulating commercial plant configuration and conditions and ii) to determine and obtain process technical data required for preparation of techno- economic feasibility report required for commercialization of the project. The sample assayed 20.26% P_2O_5, 38.13% SiO_2(T), 6.0% reactive silica, 24.55% CaO, 0.55 % MgO, 3.17% Al_2O_3, 5.55% Fe_2O_3, 0.04% Na_2O, 0.36% F.C, 0.70% S(T) , 0.06% S(py), 1.36 % fluorine, 0.09% Cl, 1.73% SO_3 and 1.70 % LOI. The beneficiation scheme adopted comprised of Grinding followed by Flotation obtained the phosphate concentrates assayed 35.55% P_2O_5, 8.73% SiO_2(T), 3.52% reactive silica, 1.11% Al_2O_3, 1.4% Fe_2O_3, 44.46% CaO, 3.27% F, 0.53% SO_3, 0.1% Cl and 0.36% MgO with 76.4% P_2O_5 recovery (wt% yield 43.3). The concentrate thus produced meets the specifications required for phosphoric acid manufacturing.

- The fresh water requirement after recovery of water found to be 2.64 m^3per tonne of fresh ore.
- The pressure filtration productivity of phosphate was found to be 0.393 tonnes/sq.meter-hr.
- The unit thickener area required for concentrate was 0.108 sq.m/tonnes of dry solids-24 hr.
- The thickener area required for combined reject was 0.067 sq.m/tonnes of dry solids-24 hr.
- Bond's work index value of the sample was 7.04 Kwh/ short tonne.

R&D FOR RECOVERY

BY-PRODUCT RECOVERY

1.1 Graphite

Bench scale beneficiation studies on a low grade Graphite sample from Betul, Madhya Pradesh for the recovery of Rare Earths and Calcite.

A low grade graphite bulk (BLK-01) sample from Betul District, Madhya Pradesh was received at the Modern Mineral Processing Laboratory & Pilot Plant, Indian Bureau of Mines, Nagpur for the recovery of graphite, but it was observed that presence of calcite in the sample which can be upgraded i.e. By-product recovery from graphite tails.

I. The analysis of graphite tails assayed 7.84% FC, 2.53% VM, 0.59% Moisture, 56.19% ash and 32.85% acid soluble. The analysis of as received sample is 17.56% CaO, 1.09% MgO. 5.49% Al_2O_3 , 42.23% SiO_2 and 3.59% Fe_2O_3.

By adopting Froth flotation of graphite flotation tails yielded a calcite concentrate assaying 43.23% CaO, 3.7% Al_2O_3, 15.02% SiO_2, 0.048% P_2O_5, with 31.4% CaO recovery (Wt.%. yield : 12.6). The calcite concentrate obtained may find application in cement industry.

II. The as received graphite sample assayed rare earth elements 16.6 ppm La, 15.9 ppm Ce, 9.91 ppm Nd, 4.5 ppm Gd, 2.9 ppm Yb, and 27 ppm Y. By Gravity, Magnetic and Electrostatic separation, a pre-concentrate assaying 0.88% La with 69.1% La recovery, 0.89% Ce with 73% Ce recovery, 0.65% Nd with 85.3% Nd recovery, 0.18% Gd with 52% Gd recovery, 0.15% Yb with 66.2% Yb recovery, and 1.35% Y with 64.9% Y recovery (Wt.% yield: 0.13).

Thus recovery of graphite and recovery of rare earth minerals and calcite as by- products from graphite (BLK-01) surface sample is a step towards achieving zero waste mining.

1.2 Copper Ore:

Bench scale beneficiation studies for Calcite by-product recovery from Copper tails obtained in Lab tests on Copper bearing ore from west of Nanagwas, District Sikar, Rajasthan.

A Copper bearing sample from West of Nanagwas (NW-1&2), District Sikar (Rajasthan) was sent to the Regional Mineral Processing Laboratory, Indian Bureau of Mines, Ajmer for bench scale beneficiation studies. The aim of bench scale beneficiation study was to evolve a process flow sheet producing a copper concentrate more than 18% cu with maximum recovery. The as received sample assayed 0.36% Cu, 4.92% Fe(T), 38.27% SiO_2, 8.77% Al_2O_3, 47.28% AI, 19.65% CaO, 4.31% MgO,0.11% S(T), 0.40% TiO_2, 1.11% Na_2O, 2.37% K_2O, 0.20% Mn, 0.06% Sn,72 ppm Pb, 140 ppm Zn, 34 ppm Co, 50 ppm Ni, 3.15 ppm Ag, 124 ppm Bi, 17.34% LOI. It is observed from the chemical analysis of as received sample that, apart from Copper as valuable mineral about 40% - 45% Calcite is present, which represented CaO content of 19.65% and in terms of $CaCO_3$ about 35.06%. The Froth flotation process adopted for calcite recovery tests. The sample was chemically analyzed which assayed 20.29 % CaO, 38.29% SiO_2, 5.10% Fe(T), 8.29% Al_2O_3,4.14% MgO,

0.43% TiO_2, 1.74% Na_2O, 2.02% K_2O,0.03% Cu, 3.49%Fe_2O_3,3.72% FeO, 15.81% LOI .By employing flotation test and two stages of cleaning produced a Calcite concentrate assaying 47.79% CaO, 6.69% SiO_2 with 80.07% CaO recovery (Wt.% yield 34). This Calcite concentrate is suitable for Cement industry and can be also used as sweetener to blend with the lower grade limestone used in some of the Cement plants.

UTILISATION OF WASTES

1.1 Iron Ore Dump:

Recovery of Iron Values from Low – Grade Dump Sample of Thimmappanagudi Iron Ore Mine, Sandur Taluk, Ballari District, Karnataka.

A low grade iron ore dump sample of Thimmappanagudi mine was received for beneficiation studies at Regional Ore Dressing Laboratory, Indian Bureau of Mines, Bengaluru. The objectives of the test work are a) Characterization studies of the as received sample and b) to develop a process scheme to produce a concentrate suitable for steel industries.

The as received sample assayed 36.43% Fe(T), 0.12% FeO, 26.0 % SiO_2, 11.78 % Al_2O_3, 0.40 % CaO, 0.1 % MgO, 0.05 % Na_2O, 0.11 % K_2O, 0.24 % Mn, 0.04 % P, 5.78% LOI and trace amounts of sulphur .The final process comprises of crushing followed by grinding, classification followed by gravity and magnetic separation. The gravity concentrate assayed 65.31 % Fe (T), 2.54 % SiO_2, 2.05 % Al_2O,,with 1.79% LOI weight percent yield of 20.4% and Fe (T) recovery 37.2%.The combined concentrate (Gravity & Magnetic) assayed 60.31 %Fe (T), 6.02 % SiO_2, 4.24 % Al_2O, ,with 3.01% LOI weight percent yield of 31.8% and Fe (T) recovery 53.5%.

By adopting simple process, the waste dump from Thimmappanagudi Iron Ore mine could be upgraded for use in steel industry.

1.2 Iron Ore (Waste Dump):

Beneficiation studies on an Iron ore sample (Waste Dump) from Subbarayanahalli Iron ore Mines, Sandur taluk, Ballari District, Karnataka .

A iron ore waste dump sample from Subrayanahalli iron ore mine was received for beneficiation studies at Regional Mineral Processing Laboratory, Indian Bureau of Mines, Bengaluru. The objective of the test work is to develop a process scheme for up-gradation of the iron ore sample to produce a concentrate containing the grade 62% Fe(T).The as received sample assayed 40.50% Fe (T), 0.21% FeO, 16.29% SiO_2, 14.67% Al_2O_3, 1.48% TiO_2, 0.35% CaO, 0.02% MgO, 0.02% Na_2O, 0.01% K_2O, 0.09% Mn, 0.07% P, 8.87% LOI and trace amounts of sulphur. The final process flow sheet comprised of grinding followed by gravity separation. Gravity concentrate assayed 63.50 % Fe (T), 3.56 % SiO_2 , 1.86 % Al_2O_3 with weight percent yield of 26.1% and Fe(T) recovery 40.6 %.

By adopting simple process, the waste dump can be utilized.

TECHNOLOGICAL DEVELOPMENT IN MINING INDUSTRY

Globally, the mining industry is in transformation stage. Initially being a labor intensive industry, focusing on traditional mining methods, the industry has now understood the requirement of the technological developments and is focusing upon the innovative technologies for more and more automation. The focus is now on more efficient, safe, environment friendly and scientific and sustainable mining.

Application of state-of-the-art mining technology

Although being a large producer of many minerals, India lags very far in terms of full mechanization of mine operations. Mining operations are still done through traditional methods in most of the mines in India. Small scale of operations, easy availability of cheap labour in mining areas, less capital investment on R &D, safety and environmental aspects are some of the reasons of not adopting the state of the art technologies in Indian mining industry.

Surveying

Surveying is the basic part of the mining activity. In open cast mines, it involves the topographic survey, bench face survey, stockpile survey etc,. It has always been a time taking activity with the use of traditional equipments, viz: theodolite, GPS, DGPS etc. Now days, use of drones equipped with Light Detection and Ranging (LiDAR) technology to assess the quantities and map the areas is gaining importance. This has improved the efficiency and decreased the human effort.

Exploration

Exploration is one of the fundamental activities during mine life cycle. During the past two decades, tremendous improvements happened (Figure-1) in mineral exploration technology, thanks to GPS navigation and digital revolution. Multi-array and multi-channel geophysical setup detect electrical conductors at 1000 m depth and map fault structures and rock alteration to 2 km depth. A variety of GIS software systems integrate layers of a wide range of data types

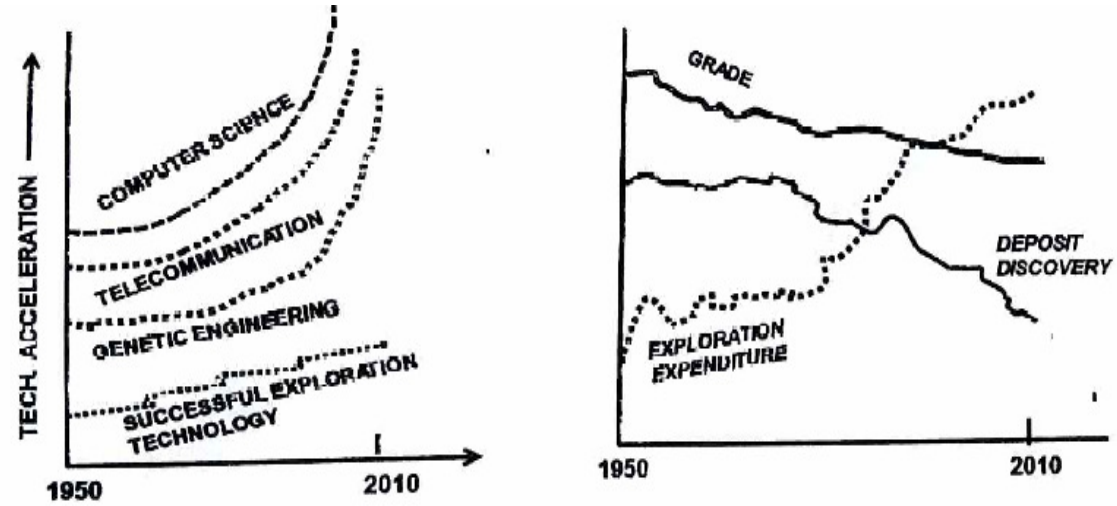

Figure-1

and formats. High resolution (100 to 400 m line spacing) airborne surveys for electromagnetic, magnetic and gravity mapping guide exploration targets. New remote discoveries are the result of a combination of persistent teamwork of experienced specialists and timing. Unmanned Aerial Vehicles (UAVs) are being used now, for a number of applications viz., aerial photography, geophysical surveying, mapping mission etc. The low altitudes of UAV can result in higher accuracy than conventional aerial photogrammetric techniques, ease of operation and overall visibility.

The sub-surface drilling used in present day exploration includes diamond core drilling, diamond core drilling with hydrostatic rigs with wire lining system, down-the hole hammer drilling (DTH), rotary air blast drilling (RAB) air core drilling (ACE), reverse circulation pneumatic rigs (RC) and multipurpose drilling rigs. In case of diamond exploration 1 m diameter drill rigs is used for grade evaluation.

Mining

Drilling & Blasting

Blast-hole drilling pays a tremendous role in affecting the productivity of a mine because it initiates the production sequence. Everything downstream the drilling activity; loading, material handling, crushing, etc. is affected by its performance. In the last few years, top hammer blast hole drills have been gaining more ground in surface application (mainly in quarries) thanks to the straight- hole systems, which combine the high penetration rates of top-hammer drilling with the sought after hole quality of DTH drilling. Thus Top-Hammer drilling system has allowed mining engineers to cut costs and reduce its fleet due to its high penetration rate low operating cost. In the process of making drilling an environment friendly operation, recently Sandvik-Tamrock has tackled the Noise and dust problem in drilling with supplying the drill machines which uses shroud that completely encloses a drilling rig's mast.

Now days, as drilling advances, the performance-enhancing features such as GPS locators for the monitoring and control of rigs, strata-recognition systems and an assortment of mine management/ equipment information systems are increasingly available. Operators are now having visual display in their cabs, data storage facilities and diagnostic systems. The exact drilling pattern (defined by fixed co-ordinates of the collars of holes) can be pre-programmed on a small desk-top computer. There have also been improvements in operator's safety and comfort with ergonomically designed rig cabs, featuring reduced noise levels, reduced gas and dust emissions as well as array of amenities.

Blasting has been transformed into a highly skilled discipline and detailed blast planning, modern explosives and sophisticated initiation systems, viz: Nonel, electronic detonators etc. have taken away much of the risk. However, designing an optimum blast has become a complex task. Now, mining industry is switching over from use of slurry explosives to Bulk explosives. The advantage of the Bulk loading system is that the non-explosive components are transported by truck or trailer, mixed on site and sensitized whilst being loaded. This has the added advantage of reducing the need for the storage of explosives on site. Sophisticated softwares e.g. JK Simblast, SHOTplus 5 developed by M/s Orica, AlphaBlast are now available to support optimum blast design and predict the mean fragmentation size of blasted rock.

Excavation and Hualage

Application of shovel-dumper combination in mechanized open cast mines is the most prevalent methodology adopted world-wide and India is no exception. "Bigger is the Better" concept has engulfed the whole mining industry due to adaptability of state of the art mining technology which ultimately leads to better productivity and cost-effectiveness. Gevra Project of SECL, a subsidiary of Coal India Limited has installed Electric excavator of 42.0 cu.m capacity in combination of dumper of 240 T. This project boasts for the biggest HEMM deployer in Indian Mining Industry. Major players of metalliferrous open cast mines, i.e. NMDC, TATA Steel, SAIL have deployed 100 T Dumper in combination with 10.0 Cu.m shovel and planning for bigger size equipments for its green field mining projects.

Application of Information technology

Application of information technology in Indian mining Industry is still taking fledgling steps towards the vision of real time seamless flow of data/information from bore hole to Board room.

Advances in mine planning software as primary method of improving productivity and efficiency. Gemcom, Surpac & Datamine are the major international players in this arena and made successful inroads in Indian Mining Industry as well. These softwares are used for Resource modeling and optimization, Resource/ Reserve estimation, Ultimate Pit design. Mines of Tata Steel, NMDC, SAIL, Sesa Goa, Vedanta etc. are avid user these softwares. For production scheduling and pit optimization also use of softwares such as Whittle, Mineshed, XPAC etc are being used in Indian mines. Financial modeling softwares developed particularly for mining industry are also available worldwide but its penetration in Indian Mining Industry is still elusive.

Noamundi & Joda Iron ore mines of Tata Steel and Rampur-Agucha of HZL are pioneer in installing GPS based fleet management system for better productivity, safety and real time data collection for preventive maintenance of their HEMM fleet. In Sukinda Chromite Mines and Joda Iron ore mine of TATA Steel and Rampura-Agucha of HZL, Slope Stability Radar is being used for real time monitoring of slope stability of their pit and dumps.

Bulk Material Handling Systems

Sometimes, the mines are having sufficient capacity, but their transport system becomes a hurdle in catering to its requirement. The automated transport system such as Slurry pipeline system gives a scope to increase the capacity. This type of transport system is cheaper when compared to the other modes of transportation such as railways and roads. NMDC has also installed a 5.0 km long single flight conveyor with gantry system for easy maintenance. Requirement of transfer points in the conventional conveyor system has been annulled. NMDC is in process of constructing a 600 kms long slurry pipeline transport system, i.e. from Bailadila to Vizag via jagdalpur for feeding the raw material to pellet plant industry.

ROLE OF INDIAN BUREAU OF MINES

Mining Tenement System (MTS)

Indian Bureau of Mines is in the process of establishing the Mining Tenement System (MTS) which would primarily involve automating the entire concession life-cycle, starting from identification of area and ending with closure of the mine; and connecting the various stakeholders for real-time transfer of electronic files and exchange of data. This shall enable effective management of mineral concession regime and transparency in operations at the Centre as well as States. At the tactical level, efficiency of operations increase and at the strategic level, management information is available at click of a button for interventions and policy decisions.

The Mining Tenement System is used for systematic management of data on concessions, including status of applications, relinquishment and renewal of leases. While the registry enables processes in the mineral concession regime, this web-based system would also integrate with GIS, such that information could be shown spatially in the form of map based service.

MTS has been contemplated in a manner that Centre shall be providing the requisite degree of support to all mineral rich states.

Star Rating of Mines

The Ministry of Mines has launched a Scheme of Star Rating of Mines/ Mining leases for implementation of Sustainable Development Framework (SDF) vide notification dated 23.05.2016. The Star Ratings will be awarded, based on evaluation of performance of mines on technical, socio-economic and environmental parameters and give objective reporting of their activities, the evaluation template for the same was given at IBM Portal. It has been instituted as a two tier system providing self-evaluation templates to be filled in by the mine operator followed by validation through

Indian Bureau of Mines. Based on the performance of the mining leases, 1 to 5 star rating would be given to the mines which have been operational for more than 180 days in the reporting period. The online star rating system will also be integrated to the Mining Tenement System and the existing online returns system.

Mining Surveillance System (MSS)

To curb on menace of illegal mining, a satellite-based monitoring system namely Mining Surveillance System (MSS), has been developed and launched which aims to establish a regime of responsive mineral administration through automatic remote sensing detection technology. It has an online portal & user-friendly mobile app for official reporting and also to enable public participation. Any discrepancy if found is flagged-off as a trigger. The triggers will be studied and then transmit them to the district level mining officials for field verification.