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(Part- I : GENERAL REVIEWS)

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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, Bioleaching, Beneficiation, Rock Mechanics, Ground Control and Non-ferrous Metallurgy and environmental issues related to mining and metallurgy. During 2012-13, two meetings were held by Project Evaluation and Review Committee (PERC). Based on Committee's scrutiny report, Standing Scientific Advisory Group (SSAG) considered and recommended Grant-in-Aid under S & T programme of the Ministry of Mines. The SSAG approved nine project proposals in the meeting held on 1st December 2012.

The highlights of work carried out during 2012-13 by IBM along with industries and National Institute of Rock Mechanics relating to mineral beneficiation and mining & environment are given below:

1. BENEFICIATION

1.1 Barytes

A low grade Baryte sample received from M/S GIMPEX A P Baryte Beneficiation Pvt.Ltd., Chennai for pilot plant scale beneficiation studies at IBM's RODL, Bengaluru. The objective of the study being to generate technical data required for scale-up and design of commercial plant, as the company is planning to set-up a baryte processing plant at Korlakunta near Mangampet, Cuddapah, Dist. Andhra Pradesh.

The as received sample assayed 75.72% $BaSO_4$, 12.79% SiO_2, 3.22% Al_2O_3, 1.8% Fe(T), 0.60% CaO, 0.54% MgO, 0.74% S (Py) and 1.28% L.O.I. The sample contained approximately 75-80% baryte, 7-10% cherty quartz, 7-10% clayey shale, 2-3% pyrite and trace amounts of carbonates, feldspar, goethite and magnetite. By adopting the selective speciality froth collector Armoflote-17 for flotation, a baryte concentrate assaying 92.19 % $BaSO_4$, 4.59% SiO_2, with baryte recovery 75.6% (wt% yield 62) and specific gravity 4.22 could be obtained. The concentrate obtained meets the specifications of the party required for drill mud grade. Also a super grade baryte concentrate assaying 97.06% $BaSO_4$ (wt% - 48.0) could be obtained after regrinding of the drill mud baryte concentrate and subjecting it to flotation.

Some of the highlights/advantages of the process developed after in depth study in laboratory and pilot plant are as follows :

1. Denver grindability studies indicate that sample belongs to 'soft' category. The work-index determination value of the sample was found to be 6.08kw-hr / short ton. Therefore wear and tear on processing machinery is less and the energy requirement for size reduction is less.
2. Unlike coarse concentrates in gravity process, it produces required size concentrates.
3. Armoflote -17 is a specialty collector with consistence in quality and selective for siliceous and pyritic gangue together.
4. A super grade concentrate assaying over 97% $BaSO_4$ can be obtained in the extended circuit after regrinding the oil-well grade concentrate with two stages of flotation.
5. There is no effect on process results with the use of mine water.
6. There is an overall saving of 15% in flotation reagents consumption after recirculation of process water in the flotation circuit.

Several other useful data for scale-up of commercial plant, like angle of repose, bulk densities, specific gravities, size analysis of all products, percentage of solids by weight of all streams, reagent quantity, point of addition at different stages, water requirement at different stages, have been determined.

1.2 Bauxite

Study of heat treatment process for destruction of toxic cyanide of Spent Pot Lining (SPL) (NALCO) at JNARDDC: Optimization trials for quantitative determination of fluoride with aluminium fluoride, cryolite, sodium fluoride and SPL samples were completed and analysis of components alumina, soda, silica, fluoride, cyanide, iron oxide etc. in real sample is initiated. Fabrication work of special heat treatment furnace for SPL sample was done.

Preparation of low ferric alum from low grade aluminium dross at JNARDDC: The main objective of the project is to produce low ferric alum from NALCO dross. Iron content in RPU dross is found to be 6-7%. Experimental trials conducted in the scale of 100-200 gms were successful and the same can be extended to various grades of aluminium dross. NALCO suggested to extend laboratory trials to 10 kg production. Furthermore, It is proposed to reduce the iron content in dross through separation by magnetic separator.

Characterisation of Various Casting Defects for Strip Cast Aluminium Alloys at NALCO RPU at JNARDDC: The main objective of the project is to identify the casting defects observed in the NALCO strip cast Al-8011 rolled sheets and render suggestions to minimise these defects to improve the quality of the product and minimise the rejections. The work involves monitoring of strip casting facility at NALCO, IR thermography, micro-structural characterisation and identification of inclusions by SEM / EDAX. The work was completed and the final report is under preparation. NALCO opined that quality, in particular surface finish, has improved after implementation of certain recommendations drawn from the present project activity.

Beneficiation of low grade bauxite/laterite of Sabarkantha deposit in Gujarat,GMDC, Ahmedabad at JNARDDC: The objective was to study the beneficiation of low grade bauxite/ laterite thereby leading to optimum utilisation of the bauxite / laterite for metallurgical uses. Final report was submitted to GMDC.

Pilot plant studies on extraction of alumina from partially laterised khondalite at JNARDDC:The pilot plant scale studies were conducted on PLK samples from MSIS, Russia. These studies include digestion, precipitation and red mud separation from the liquor. The detailed report was submitted to NALCO.

Development of Certified Reference Materials for selected Indian Ore(NALCO) at JNARDDC: Objective of the project is to prepare certified reference materials for various ores and materials pertaining to aluminium industry. Draft final report was submitted to NALCO.

1.3 Copper-Lead-Zinc

***Generation of Bulk Cu-Pb-Zn concentrate from exploratory sample of Tikhi Project, Udaipur. Rajasthan for MECL, Nagpur*:** A Copper-Lead-Zinc sample from Tikhi Project, Udaipur, Rajasthan was sent by M/s Mineral Exploration Corporation Ltd., Nagpur to IBM's RODL, Ajmer with an objective to obtain a bulk concentrate of copper, lead & zinc and an individual concentrate of copper, lead and zinc.

The as received sample assayed 0.1% Cu, 3.6% Pb, 0.8% Zn, 3.68% Fe(T), 32.6% SiO_2 and 56.35% acid insoluble with Ag 47 ppm , Au 0.19 ppm , Co 15 ppm , Ni 25 ppm . A bulk cleaner concentrate assaying 1.98% Cu with 84.7% Cu recovery, 54.47% Pb with 78.1% Pb recovery and 9.42% Zn with 69.76% Zn recovery could be obtained after two cleanings.

Further, Semi bulk flotation of Cu-Pb minerals, three stage cleaning followed by differential flotation of Cu mineral from Pb mineral and Zn mineral flotation and two stage cleaning yielded: (i) a copper concentrate assaying 18.49% Cu, 10.15% Pb, 1.53% Zn and 22.24% Fe(T) with 87.8% Cu recovery(wt% yield of Cu concentrate:0.7) (ii) a lead concentrate assaying 67.88% Pb, 0.29% Cu, 0.37% Zn and 1/42% Fe(T) with 79.4% Pb recovery (wt% yield of Pb concentrate:4.05) and (iii) a zinc concentrate assaying 45.57% Zn, 0.21% Cu, 0.54% Pb and 20.89% Fe(T) with 76.1% Zn recovery (wt% yield of Zn concentrate 1.35).

The investigation confirms that despite the low tenor of copper and zinc, the sample is amenable for beneficiation to obtain bulk copper, lead & zinc concentrate as well as individual copper, lead and zinc concentrate by flotation. The concentrate obtained meets the requirements of local smelter. A continuous pilot scale study is recommended to confirm and generate conceptual data.

1.4 Graphite

Pilot Scale spiral classification of a Mill Feed Graphite sample from Sivaganga, Tamil Nadu for M/s Tamilnadu Minerals Limited, Sivaganga: Graphite sample from M/s TAMIN, Sivaganga was sent at IBM's RODL, Ajmer for Pilot scale scrubbing and spiral classification of mill Feed Graphite sample with an objective to evolve the flow sheet for separation of (-) 0.6 mm material from rod mill feed, so as to increase the through put of rod mill from existing 7 tph through put and maintaining 93% of (-) 0.6 mm MOG, 40% solids pulp density, for flotation circuit.

The as received sample when subjected to dry size analysis, wet size analysis and scrubbing followed by wet size analysis over 0.6 mm screen indicated that 33%, 37.5% and 65% material finer than 0.6mm screen was present.

Scrubbing and dispersed pulping is key to efficacy of separation of (-) 0.6 mm material from mill feed for both wet screening/spiral classification. Though the sample under investigation appears to be marginally finer than reported by TAMIN, implementation of screening followed by wet screening 1mm/low weir straight spiral classification may increase the throughput to 10.5 tph, provided subsequent circuit has enough spare capacity and work index of ore does not drastically increase.

1.5 Heavy Mineral Sand

Recovery of Rutile Mineral from Heavy Mineral Sand Sample for M/s Zibal Exim, Hyderabad, A.P.: Heavy mineral sand sample from South Africa was sent by M/s ZIBAL EXIM, Hyderabad at Modern Mineral Processing Laboratory and Pilot Plant, Nagpur with an objective to recover mineral assaying over 90% TiO_2.

The as received sample assayed 59.76% TiO_2, 15.72% SiO_2, 5.91% Fe(T), 0.34% FeO, 4.85% Al_2O_3, 5.21% ZrO_2, 0.229% CaO, 0.560% MgO, 0.064% P_2O_5, 0.284% MnO, 0.316% Cr_2O_3, 0.149% Nb_2O_5 and 2.72% LOI . The sample is close size ranged sand with very little fines below 75 micron and is coated with organic matter and has specific gravity of 3.8.

A composite concentrate of conductor and middling fraction assaying 81.19% TiO_2, 4.97% SiO_2, 0.58% Fe(T), 3.69% Al_2O_3, 6.72% ZrO_2 and 0.87% LOI with TiO_2 distribution of 39.5% (wt% yield 29.4) could be obtained.

The sample is amenable to beneficiation to produce stipulated grade rutile concentrate with limited recovery. However, an iron rich titanium concentrate of pseudo rutile concentrate can be obtained as magnetic fraction that can find its use as marketable grade titanium ore.

1.6 Iron Ore

Bench scale beneficiation studies on a sub-grade Iron ore sample from S.R.M.E. Mines, Ramgad, SandurTaluk, Bellary District, Karnataka State for M/s V.T. Industrial Corporation Limited, Bengaluru: A sub-grade iron ore sample assaying 58.42% Fe (T), 1.08% FeO, 3.70% SiO_2, 5.88% Al_2O_3, 0.08% P_2O_5, 0.10% S(T) and 5.88% LOI was sent by M/s V.T. Industrial Corporation Limited, Bengaluru at IBM's RODL, Bengaluru with an objective to evolve a process flow-sheet for production of pellet grade concentrate assaying Fe > 64%, SiO_2< 4%, Al_2O_3< 4% , LOI < 4% and evolve other parameters i.e. Sp. Gr. & Bulk density. The sample contains mainly fines & minor amount of brown to black coloured hard and compact lumps up to 100 mm size. The bulk density of as received sample was 2.2 t/$m^3$and the specific gravity was found to be 4.0. After stage grinding the sample to minus 65 mesh and subjecting it to desliming, Gravity and Magnetic separation, a concentrate assaying 64.09% Fe, 2.46% SiO_2, 2.98% $Al_2O_3$and 2.92 % LOI with 62.0% Fe recovery (Wt.% yield 57.2) could be achieved. The concentrate obtained meets the specifications stipulated by the party.

***Upgradation of low grade Banded Iron Ore – Quartz sample for use in Pellet making*:** A low grade iron ore sample from Dhutanurkaval village, C.R. Patna Taluka, Hassan, Karnataka was sent at IBM's RODL, Bengaluru with an objective to evolve a process flow sheet for production of Pellet grade concentrate containing Fe > 63%, $SiO_2 + Al_2O_3$ < 6% and LOI < 2% and for determination of work index.

The as received sample assayed 35.11% Fe(T), 2.08% FeO, 47.12% SiO_2, 0.77% Al_2O_3, 0.39% CaO, 0.18% MgO, traces of P_2O_5 and 0.89% LOI.

The sample when subjected to stage grinding in rod mill to minus 65 mesh, tabling followed by wet low intensity magnetic separation (WLIMS) yielded the magnetic concentrate assaying 65.37% Fe, 4.10% SiO_2, 0.15% Al_2O_3, & traces of S&P and 0.20% LOI with 82.3% Fe recovery (wt% yield 43.6).

The concentrates obtained meets the specification stipulated by the party for use as pellet grade concentrate. The Bond's Ball Mill Work Index of the sample was found to be 6.56 Kwh/short ton.

1.7 Lead Zinc

Upgradation of Lead-Zinc sample from Abakaliki Project, Abbuja, Ebonyi state, Nigeria for M/s Royal Salt Limited: M/s Royal Salt Limited sent a lead-zinc sample from Abakaliki Project, Abbuja,

Ebonyi State, Nigeria to Modern Mineral Processing Laboratory and Pilot Plant, Nagpur with an objective to develop a process flowsheet so as to achieve the lead and zinc concentrate suitable for end use industries.

The original sample assayed 8.52% Pb, 6.46 Zn, 0.06% Cu, 22.71% Fe(T), 9.19% S , 25.05% SiO_2 , 6.40% Al_2O_3, 4.42% CaO, 5.27% MgO, 1.12% Graphitic carbon, 0.04% Ni, 0.01% Co, 0.76% Mn, 0.13% Ti , 0.02% Cd.

By adopting flotation route for concentration, a lead concentrate assaying 72.69% Pb, 0.49% Zn, 0.13% Cu, 1.42% Fe, 12.71% S(T), 1.71% SiO_2, 0.26% Al_2O_3, 0.58% CaO, 0.10 MgO, 8.23% LOI with 92.7% Lead recovery (wt% yield – 10.4).

A Zinc concentrate assaying 53.16% Zn, 0.86% Pb, 0.07% Cu, 3.14% Fe, 25.45% S(T), 0.78% SiO_2, 0.11% Al_2O_3, 0.58% CaO, 0.10% MgO and 14.41% LOI with 94.3% Zn recovery (wt% yield – 12.4).

The Lead and Zinc concentrates obtained meets the desired specifications suitable for respective smelters.

1.8 Lime Kankar

Bench Scale beneficiation studies on a Lime Kankar Sample (Screen Reject) for M/s The India Cement Ltd., Tirunelveli, Tamil Nadu: A Lime Kankar Sample (Screen Reject) from Maravarperungudi/Maniyakkaran-patti Mines for M/s The India Cement Ltd., Tirunelveli, Tamil Nadu was received at Modern Mineral Processing Laboratory, Nagpur with an objective to develop a flow sheet to obtain Limestone concentrate preferably by dry mineral beneficiation technique.

The as received sample assayed 28.38% CaO, 2.77% MgO, 31.22% SiO_2, 6.55% Al_2O_3, 2.75% Fe_2O_3, 0.15% TiO_2 and 25.40% LOI. By adopting dry beneficiation technique, the desired grade concentrate could not be achieved. Hence, a flow sheet comprising rougher flotation at a grind of 82.4% minus 200 mesh (~67% < 325 mesh), at a pulp density of 28/20% solids, using sodium oleate as collector was adopted. The rougher float after subjecting to two cleanings at a pulp density of 18/13% solids yielded the concentrate assaying ~ 47% CaO, ~ 2.50% MgO, ~ 6% SiO_2, 1.70% Al_2O_3, 1.13% Fe_2O_3 & 40.20% LOI with ~ 75% CaO recovery (wt% yield ~ 45).

The concentrate meets the grade as stipulated by the party and may find utility in cement making.

1.8 Rock Phosphate

Upgradation of Rock Phosphate sample from La-Negra Mine, Hidalgo Mexico for M/s Ingwenya Mineral Tech Pvt. Ltd., **Bengaluru*:*** A Rock Phosphate sample from La-Negra Mine, Hidalgo, Mexico was sent by M/s Ingwenya Mineral Tech Pvt. Ltd., Bengaluru at IBM's RODL, Ajmer with an objective to develop a flotation process for obtaining a Phosphate concentrate assaying plus 32% P_2O_5 content.

The original sample assayed 24.56% P_2O_5(T), 18.28% SiO_2, 40.53% CaO and 6.92% Al_2O_3. By employing inverse flotation, a phosphate concentrate assaying 32.58% P_2O_5, 11.96% SiO_2, 46.79% CaO, 0.29% MgO & 2.31% LOI with 48.9% P_2O_5 recovery (Wt% yield 36.9) could be achieved. The concentrate meets the specification stipulated by the party.

3. ENVIRONMENT

Indian Bureau of Mines (IBM) : During 2011-12, Mining Reserch Cell of T.M.P. Division, IBM has carried out a study for Ground Vibration due to Blasting in mines. The salient features of this study is as follows:

Blast Induced Ground Vibration Study at Sitapuram Limestone Mines, M/s Zuari Cements (Italcementi Group), Sitapuram, At & P.O. Dondapadu, District: Nalgonda (A. P.) **:** A study of ground vibrations due to blasting at Sitapuram Limestone Mine, over an area total extent 1329.28 Hect. in two leases,of M/s Zuari Cements Ltd., (Italcementi Group), was carried out to assess the impact of blast induced ground vibrations on the nearby structures, human settlements and to suggest control measures to minimize the adverse impact of the same. During the period, a total number of 13 blasts were monitored on different dates from three locations at a time. Based on the monitoring data a regression analysis for PPV versus scaled distance was carried out. From the regression analysis and the field observations, it has been found that there is no adverse impact on the structures belonging to owner and structures not belonging to the owner in the nearby villages, due to blasting with maximum charge per delay upto 300 kg as per the present blasting practice.

It has been further observed that, considering the frequencies <8 Hz are NIL, 8-25 Hz are 17% and >25 Hz are 83%, the air over pressure (Sound level) due to blasting is also well within the safe limit.

For minimizing the vibration effects and fly rocks due to blasting, some control measures have been suggested in the report submitted to the party.