MBD-2022 Conference

[A] KEYNOTE ADDRESSES

Rare Earths Minerals and Materials- The Vital Building Blocks for Clean Energy Technology

Deependra Singh, CMD

IREL (India) Limited, Mumbai

Corresponding Author Email: cmd@irel.co.in

Abstract

The swift growth of clean & low carbon energy especially hydrogen as an energy carrier underpins major growth in demand for RE bearing minerals. The growing desire to avoid generating greenhouse gases and development of alternate energy sources has triggered the need for new materials derived from rare earth minerals. Rare earths, for instance, which were not used at all in the Indian manufacturing sector just a decade ago, has become an essential requirement for most green technologies. They are considered as 21st century materials and the need for such rare earth materials in the world will continue to increase. Nicknamed as "**vitamins of modern society**", they have become an essential element for many high-tech industries especially for the defence and **low-carbon technologies** such as magnets in wind turbines, EVs, etc. The limited resource of endogenic rare earth deposits such as pegmatitic rock (Chhota Nagpur), and metamorphic-metasomatic veins in India do not appear to be very attractive for commercial exploitation while the exogenic coastal beach placer deposit is the principal source of rare earths in India. The economically viable heavy mineral deposits are governed by the presence of the source rock being in close proximity, the existing drainage pattern, topography, climate, and coastal processes. These factors permit the identification of regions where the formation of placer deposits is favoured. Monazite is the principal ore/mineral for REE for India which is radioactive in nature and is associated with six other minerals in a very low concentration of less than 0.1%. Being a prescribed

mineral, IREL (India) Limited, a front runner Government of India Public Sector Undertaking is the only entity to produce monazite from beach sand placer deposit and produce rare earth compounds from monazite in a safe, sustainable and environmentally friendly manner without damaging the natural eco-system. The mining, mineral beneficiation and production of monazite from such a low concentration is a complex process. IREL is also in the process of facilitating setting up of industries in the value chain of minerals and rare earths, besides expanding its existing mineral producing capacity to cater the clean energy programme and strategic needs of the Government of India.

Steel & Metallurgical Waste and Resource Generation

Suddhasatwa Basu, Director

CSIR-Institute of Minerals & materials Technology
Bhubaneswar 751013

Corresponding Author Email: sbasu@immt.res.in; Tel: 067326739400

Abstract

There has been an unprecedented upsurge in global generation and stockpiling of steel and metallurgical wastes, produced as a by-product during the extraction of essential metallic values. This has not only put serious repercussion on the global community in terms of endangered ecosystem but also in terms of environmental pollution.

On an estimation, the share of mineral & metal sector to total solid waste generation in India is around 28% and fly ash generation is around 25%. The generation of steel plant wastes globally is approx. 0.55 kg/tone of crude steel i.e., a total generation of around 635 Mt during 2019 and in India it is around 61 Mt. Similarly, Red Mud generated during the production of alumina is one of the largest industrial by-products in modern society with existing global inventory of around 3 billion tonnes growing at a rate of 150 million tonnes/annum.

As these waste puts enormous challenges for their effective storage, handling and mitigation, the concern still looms large, as only 20-30% of these wastes are effectively utilized, leaving the bulk quantity still unused as land fill. At the same time, there are immense opportunities of converting these waste into resources through waste management techniques, like reduce, reuse, recycle and recover by technological intervention.

The major steel plant waste generated are blast furnace (BF) & Steel Making Slag (SMS) slag, BF Dust & Sludge, SMS sludge, coke breeze, mill scale, etc. SMS Slag has extremely good engineering properties and can be used as aggregate for civil construction but suffers from lack of dimensional stability due to presence of free lime. It can be utilised as a replacement for BF grade limestone but presence excess amount of phosphorous puts a restriction. BF/SMS dust and sludge contains good amount of iron and carbon values and therefore can be managed through recovery and recycle of iron values in BF as aggregates and as media in coal washeries and carbon values in coke making. Similarly, red mud (bauxite residue) is a repository of iron, alumina, titanium and REE mineral which can be tapped. CSIR-IMMT, Bhubaneswar, has made significant R&D in waste utilization in some key areas which are as follows:

- Recovery of iron value from low/lean grade iron ore, dumps, slime and tailings,
- Utilization of BF and SMS dust and Sludge for making micro-pellets/briquettes,
- Recovery of carbon and iron values from BF Dust,
- Utilization of fly ash in manufacture of building materials,
- Beneficiation of high ash Indian coal washery fines and slimes,
- Production of alum from waste aluminium dross,
- Holistic utilization of red mud for its effective recovery of alumina, iron and REE, and
- Recovery of high pure metals from spent catalysts, alloy scrap, sludges, secondaries, effluents, primary and low-grade ores (Co, Cu& Ni and Zn) and spent Lithium-Ion Batteries (LIB).

Overall, a structured approach is needed to minimize-waste generation, wherein R&D activities with industries should be emphasized to enhance the synergistic effect to convert this waste into secondary resources.

Keywords: Iron Ore Fines, Slimes, Sludge, Scrap, Bauxite Residue, Aluminum, Dross, Fly ash.

[B] INDUSTRIAL MINERALS

An over view of Clay Mining, processing and uses in Gujarat

Pradeep Kothari

Chief Executive Officer,
Gimpex-Imerys India Private Limited
Corresponding Author Email: pradeep@gimpex-imerys.com

Abstract

The presentation is an overview of value addition in Clay Mining, specifically in the region of Kutch, Gujarat. Considering the developments in the past 25 years, it is required to make a strategy about the development application for minerals based on their reserve, locality, market, etc., keeping conservation and value of minerals in mind. Industrial clay can be categorized into four groups: High-Quality Clay, Unique Specialty Clay, Relatively Low-Technology Clay of Moderate Quality, and Variable Quality Clay. These categories are elaborated further in the presentation, their major suppliers, and their characteristics. Additionally, numerous statistics are given regarding the presence of bentonite and China clay, along with their production units.

After the industry's introduction, major clay minerals of Gujarat bentonite and China clay are introduced in the presentation. Their characteristics, flow sheets according to the industries, process, processing pattern, and market share in the current scenario are given. Besides these details, value change patterns, applications, enhancement, and up-gradation of these minerals and their uses are provided based on their rheological and absorption properties. All the investors, developers, exporters, clay experts and government officials need to come together to take advantage of the opportunities available in clays and make Kutch clay more valuable.

Keywords: Clay, Bentonite, Value added clay products

Limestone – A Review with Special Reference to Iron & Steel Industry

P. K. Jain[1] and Gaurav Sharma[2]

[1]Chief Mineral Economist, IBM, Nagpur
[2]Deputy Mineral Economist (I), IBM, Nagpur

Corresponding Author Email: pkjain3661@gmail.com

Abstract

Limestone, Fluorite and Calcium carbide are the materials used as flux in steel making. For steel making, superior grade of limestone is required to control slag volume and improved productivity. As per BIS specification the specifications of limestone for steel making are having CaO should be 53% minimum, MgO - 1.5% maximum, SiO2 - 1.5% maximum, total Sulphur - 2% maximum and Alkalies - 0.2% maximum. This grade is available in some quantities in Rajasthan, Himachal Pradesh and Sikkim. Mostly, these resources are far away from the existing Iron & Steel industries or plants; hence, movement from these areas involves high logistics cost and steel industry imports this material from UAE, Oman, Malaysia, Vietnam and Iran. India is having the limestone reserves in the states of Andhra Pradesh, Karnataka, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand and Odisha but steel grade limestone are limited to few states only. The limestone requirement is about 100 kg per tonne of liquid steel produced. At 255 MTPA crude steel productions, requirement is 25.50 MT. An attempt has been made in the paper to discuss about usage, applications, export & import and demand & supply of steel grade limestone in India.

Keywords: Flux, Limestone, Steel industry, Import.

Graphite and its Value Additions- A Review

S.K. Biswal and Puruvi Poddar

Tirupati Graphene and Mintech Research Centre, Bhubaneswar
Corresponding Author: skbiswal61@gmail.com

Abstract

Natural graphite is a mineral consisting of elemental natural form of carbon. It is one of the three allotropic forms in which the element carbon exists in nature, the other two being coal and diamond. The carbon atoms are arranged hexagonally with rhombohedral symmetry in a planar condensed ring system. The layers are stacked parallel to each other. Graphite is one of the most versatile non-metallic minerals in the world. Graphite is one of the softest minerals, good conductor of electricity and heat, very good lubricant, high resistance to corrosion, stability at high temperature and opaque nature. Because of its unique physical and thermal properties, it has found wide industrial applications. It is used

for manufacturing carbon refractory, electrodes, crucibles, lubricants, pencils, batteries, paints, coating etc.

There are three distinct types of natural graphite which occur in different kinds of ore deposits, namely, flake graphite, amorphous graphite and high crystalline graphite. In today's world, graphite is considered a key factor i.e., flake size, grade, purity and purification cost. It is estimated that the world reserves of graphite exceed 800 million tonnes in different countries i.e., China, Brazil, Canada, Mexico, Sri Lanka, Madagascar, India, Norway, Zimbabwe, Germany, North Korea, Austria, Russia and Ukraine.

The fixed carbon in graphite ore varies in general from 2-30% apart from rare vein deposits which contains from 30-95% carbon. The liberation size in graphite particle is generally less than 1 mm. It depends on the mineralogy of graphite ore. Every ore contains flaky as well as amorphous graphite. It is the general trend in graphite ore that the flaky percentage increases when fixed carbon of ore increases. Graphite particles are hydrophobic in nature. The gangue minerals are silicate and alumina bearing minerals. Hence, the flotation process is adopted in all over the world to recover the graphite particles. The ore is ground to its liberation size, and then it is floated in conventional flotation cell or column flotation. The major challenge is maximizing the flaky recovery during processing as well as to enhance carbon content to 95-96%. It depends on mineralogical characteristics of ore and suitable design of beneficiation circuit.

Quality of product plays an important role for competition in global market. Up-gradation of existing technology is more essential to improve the product quality. Graphite has become indispensable for a variety of end uses in modern industries due to its unique properties like refractoriness, high heat and electrical conductivity, softness, chemical inertness and low coefficient of friction. By conventional beneficiation process, it is difficult to achieve more than 96% carbon value in the concentrate. To achieve high purity graphite (more than 99% Carbon value), environmental-friendly chemical process has been developed using normal chemicals. High purity graphite is widely used for battery, catalyst, additive material for plastics and rubber products, carbon brushes, powder metallurgy, lubricants, coatings, crucibles and energy related applications in the emerging green technology including electric vehicles, photo voltaic, nuclear reactors, fuel cells, solar panels etc.

The high purity graphite is used for production of expandable graphite, colloidal graphite, spheroidal graphite, graphene oxide and graphite, which have wide application in high tech area of different sectors.

Keywords:* *Graphite, Unique Physical & Thermal Properties, Wide Industrial Application, Upgradation, High Purity.

A Sustainable Process for the Recovery of Potash Fertilizer and Iron oxide from Glauconitic rock

Saurabh Shekhar[1,2],

S. Sinha[2], D. Mishra[2], A. Agrawal[2] and K. K. Sahu[2*]
[1]Academy of Scientific and Innovative Research (AcSIR)
[2]CSIR-National Metallurgical Laboratory, Jamshedpur - 831007, India
Corresponding Author Email: saurabh@nmlindia.org, Mobile no.: +91-9430742429

Abstract

Potassium is one of the basic macronutrients along with nitrogen and phosphorus which is essential to maintain and enhance quality food production. Currently, it is being produced from underground evaporite beds deposited in Canada, Russia, Belarus, Chile, USA and Germany or recovered from natural sea brine solution. Thus, there exists a strong dependence on these countries for the import of potash fertilizer. Rising price, limited geographical availability of these conventional sources and increasing demand has stimulated a search for alternative potash containing sources. Glauconitic sandstone and shale are natural occurring iron-rich, heterogeneous, phyllosilicate rock which contains around 4-8% of K_2O, thus, considered a promising alternative source for potash fertilizer. Processes with potash recovery alone, from low grade in glauconite rock may not be economical. Therefore, a sustainable process is developed for the recovery of potash fertilizer and iron oxides from two different glauconite rock samples. Potassium is a part of stable structure (dioctahedral T-O-T) in glauconite and locked in alumino-silicate matrix. In order to break the matrix and maximize potassium dissolution, the glauconite rock sample containing 5-6% K_2O and 10.75-31.9% Fe_2O_3 was subjected to pre-treatment followed by acid leaching. The leach liquor containing more than 95% recovery of iron and potash, which was further treated through precipitation and solvent extraction route for recovery of final products in form of potassium chloride, magnetite and hematite. Different process parameters were studied and optimized for the development of complete flow sheet.

Keywords: Glauconite, Pretreatment, Leaching, Precipitation, Solvent Extraction.

Synthesis of calcium silicate from low grade Bentonite clay as a paper filler - An Energy and cost-efficient approach

Anuj Kumar Verma[1]; Gaurav Chordia[2]; Pradeep Kothari[3]

1. Manager R & D; Gimpex- Imerys India Pvt Ltd.
2. GM; Gimpex- Imerys India Pvt Ltd.
3. CEO; Gimpex- Imerys India Pvt Ltd.

Corresponding Author Email: anuj.verma@gimpex-imerys.com

Abstract

Nowadays, new types of fillers are being developed for paper industry. This not only improves the paper properties but also reduces energy and fibre consumption. In this paper, a simple synthesis method of calcium silicate manufactured from low grade bentonite clay is being used. Here the effects of newly developed calcium silicate on newsprint paper properties as a paper filler are analysed. Initially the reduction of alumina percentage as well as enhancement of montmorillonite content achieved simultaneously from natural Bentonite by thermal and acid treatments. In this process, the silica rich clay is directly treated with sodium hydroxide of varied concentrations (0.83 M to 12.5 M) to obtain sodium silicate solution. Carbon dioxide (99.98% purity) is passed through the sodium silicate solution at different operating conditions (220 OC & 15 Bar) to get the precipitated silica. The concentration of two slurries (CaO & SiO2) is adjusted in the final mixture to get the desired product in high pressure vessel. Synthesized calcium silicate is utilised as paper filler. Various physical and optical properties, such as whiteness, brightness, smoothness, stiffness, and breaking length were analysed and compared with conventional filler such as PCC/GCC. Synthesized calcium silicate obtained from an energy and cost-efficient approach is showing superior properties as compared to conventional filler.

Keywords: Filler, Newsprint, Calcium Silicate, Bentonite, Formulation, Newsprint Properties.

Adopting a pragmatic approach in industrial minerals exploration

Alok Sood,
Mining Business Consulting
Corresponding Author Email: sood.alok@ymail.com

Abstract

Significant hidden potential of additional resource identification, characterization, & categorization of various grades of industrial minerals in India is well recognized. This is a major contributing factor hindering innovation and discovery of new industrial minerals. The country, as a result, ends up importing high-end value added mineral based products.

China clay, like many other industrial minerals finds application across various sectors of the industry like textile, rubber, paper, ceramics, and refractory, all of which require distinct properties. Various state and central government agencies have carried out exploration of China clays but data generation and presentation needs to be pragmatic keeping in mind the user's requirements. As a common practice, no other data is generated apart from the chemical composition in exploration reports, which has very limited applications and relevance.

The data generation on industrial minerals grade must include physical properties, oxide phases, purity of content, etc. which indicate their grade, specific applications and therefore, the economic value. This is unlike in the base metals, iron ore, limestone, etc, wherein the economic viability and the ultimate usage of the minerals is largely determined on the basis of chemical composition alone.

The presentation will deal with how this gap can be filled by the exploration agencies.

Key words: Industrial Minerals, China Clay, Exploration.

R3 is the key!

Maithili Bhakre, Subhasis Nayak, Gaurav Sinha, Satyaki Mandal, and Parul Kumari

Calderys India Refractories Ltd., Katni
Corresponding Author Email: gaurav.sinha@calderys.com

Abstract

Deposits of premium quality raw materials are depleting at a faster rate due to over exploitation and measures must be taken to preserve them for future generations. Calderys India Refractories Limited makes all the efforts to develop environmentally friendly technologies to save minerals that are on the verge of extinction. The R3 project revolves around *Reducing* the use of virgin raw materials, *Reusing* the downgrades from the processes and *Recycling* the consumed refractory or industrial waste that were using space as land filling without affecting the product performance. The project aims to develop techno-economic solutions by producing high-performance greener products using materials salvaged from dismantled used refractory lining. The project work involves identification of the alternative raw materials and its right source, performing extensive testing and product reformulation. It also includes responsible supply chain management and upskilling the sub-vendors to increase their technical know-how and ability to supply the right grades of raw materials. This process conserves precious resources, requires less mining, reduces quantities ending up in landfill and uses less energy. Discarded used refractories are basically of two types, bricks and monolithics. Used monolithic lining often has metallic elements embedded in it, which makes it difficult to reprocess compared to bricks. At the same time monolithic products offer immense potential for use of recycled refractories. The recovered refractory materials originate from diverse industries such as iron andsteel, glass, electrical insulator, aluminium, etc. and hence it is critical to analyze and evaluate them for the presence of any adverse constituents to decide right usage. In this way, R3 aims to find a balance between sustainability and profitability. Our consistent efforts have given us a CAGR for reclaimed material consumption of 10.8% for the period of 2015-2020.

Keywords:* *Recycle, Reuse, Sustainability, Raw Materials, Monolithic Refractory, Reclaim.

Import Substitution of Raw Material in the Refractory Industry – Self-Reliant Initiative (Atmanirbhar Bharat)

Suparna Basu, Sushavon Sarkar, and Sumit Samanata
Calderys India Refractories Limited, Butibori, Nagpur, India
Corresponding Author Email: suparna.basu@calderys.com

Abstract

The world strongly relied on the supply of refractory raw materials like dead burned and fused magnesia, tabular alumina, refractory bauxite, chromite and graphite from China over the past decades. However, China's environmental crisis and shortage of high-quality mineral resources in India, have wreaked havoc in the raw material supply chain taking prices to new highs. Of concern was the availability of low-iron refractory bauxite and the need for research ofthe commercially viable fusion of Indian magnesites. More composite synthetic materials are gradually getting utilized like zirconia-mullite, silicon carbide, Al_2O_3-Cr_2O_3, Mgo-CaO, MgO-Cr_2O_3, spinel, etc.

In order to remain competitive in the current scenario, the need is to enhance domestic raw material production, developing and using alternative sources by continuous R & D and extensive brainstorming for recycling of refractory waste in product formulations.

Continuous work is going on to investigate the potential benefits of replacing imported raw material with alternate sources of indigenous raw material. Descriptive laboratory tests were conducted before we had decided to explore this idea, and so far, there have been positive results pertaining to the product performance. In this paper, the substitution of imported aggregates, by the indigenous ones, has been evaluated. The results will help us determine theadvantages of replacing imported raw material with equivalent one from alternate domestic sources, leading to improved process efficiency.

Keywords:* *Shortage of Mineral Resources in India, Recycling of Refractory, Substitution of Imported Aggregates, Developing Indigenous Equivalents.

Beneficiation of Low Grade Graphite Ore and Recovery of Vanadium as a By-Product from Central India Graphite Deposit

S. Pani, S.K. Nanda, V.A. Sontakkey, L.B. Toal, D.R. Kanungo, and S. Lohiya

Mineral Processing Division, MMPL&PP, Indian Bureau of Mines, Nagpur-440016
Corresponding Author Email: pp-nagpur@ibm.gov.in

Abstract

Graphite is utilized in many industrial applications due to its unique physical and chemical properties. India has a huge potential of graphite but about 90% of the Indian graphite ore falls in the category of remaining resources and majority of them are low grade. Apart from

graphite, the demand of vanadium is high due to its strategic importance. The vanadium bearing minerals are associated with low grade graphite ore bodies and can be recovered as by-product during concentration of graphite. The study carried out on a low grade vanadium bearing graphite ore assayed 6.5% FC, 5% VM, 0.6% Moisture and 0.12% V_2O_5, with an objective to enrich the graphite and pre-concentrate vanadium bearing minerals. Mineralogical study revealed that graphite is present in association with quartz, feldspar, mica, calcite and pyrite. Mica is the principal vanadium bearing mineral in the sample. Grinding followed by magnetic separation and flotation was found to be effective for upgradation of graphite and pre-concentration of vanadium. The graphite value could be enriched up to 65% FC with wt% yield of 6% and FC recovery of about 60%. The vanadium as a by-product could be recovered up to 20% with V_2O_5 grade of 0.40%. Further enrichment of graphite content was hindered due to the complex characteristic of minerals. The graphite concentrate from the developed process may find its application in foundry and other industries. The pre-concentrated vanadium can be further extracted by leaching through hydrometallurgical route.

Keywords: ***Graphite Beneficiation, Vanadium Concentration, Froth Flotation, Magnetic Separation.***

Gainful Utilization of Waste High Siliceous Limestone for Iron Making

Shobhana Dey, Abhishek Kumar and Laxmikanta Sahu

Mineral Processing Division, CSIR-National Metallurgical Laboratory, Jamshedpur, India

Corresponding Author Email: sd@nmlindia.org

Abstract

Limestone is used by various industries such as cement, plastic, paper and metallurgical industries. In the iron making process, it acts as a flux material which reacts with impurities like silica and alumina to form slag. To meet the desired grade of product for different industries, selective dry size classification is carried out to recover the high-grade limestone having silica content about 3%. The fines (-10mm) containing high silica are usually dumped. The consumption of limestone increases with the increase in the production of iron and steel, which encourages for the utilization of low grade or dumped sample through beneficiation to make it suitable for proper application and resource conservation. The

sample used for the present study is a low grade dumped limestone sample having 36.8% CaO with silica of 8.1%, 3% Al_2O_3 and 2.25% Fe. The attempt was to reduce the silica level to below 3% for its utilization in iron making.

Beneficiation of the waste limestone was initiated with the desliming of the feed sample of -100 μm to remove the siliceous ultrafine particles for improving the feed quality. Column flotation technique was adopted with varying collector dosage, superficial airflow velocity, and froth depth to assess their effect on silica reduction and CaO recovery. It was observed that increased collector dosage and superficial air velocity had a positive impact on the recovery of CaO; however, increase in the froth depth, reduces the silica content in the product. By optimising the process variables, it was possible to achieve the concentrate assayed 47.3% CaO, 2.8% silica with 72% CaO recovery.

Keywords: Waste Limestone Sample, Column Flotation; Waste Utilization; Froth Recovery.

Bentonite Beauty in Fertiliser Manufacturing: Approach to Fulfil the End User Need

Dhananjay Choudhary[1], Gaurav Chordia[2], and Pradeep Kothari[3]

[1]Technical Advisor, Gimpex-Imerys India Pvt. Ltd.

[2]G.M., Gimpex-Imerys India Pvt. Ltd.

[3]C.E.O., Gimpex-Imerys India Pvt. Ltd.

Corresponding Author email: pradeep@gimpex-imerys.com

Abstract

Bentonite is a naturally occurring mineral of montmorillonite group with absorbing properties. On exposure, almost all bentonites assume a slightly darker shade due to absorption of moisture. Two type of bentonites, viz. swelling and non-swelling types are commonly known in trade. Compared to sodium bentonite, calcium-based bentonite is immediate and highly wettability bursting. The commercial importance of bentonite depends more on its physio-chemical properties, such as base exchange capacity, thixotropy, settling time, swelling/dispersion power. Calcium based bentonite is activated bentonite designed to meet the requirements of sulphur fertiliser industries and used as Sulphur Pastilles Binding & Dispersing Agent for all kind of micro nutrients as well. Sulphur is the fourth major nutrient, and as per agriculture dept survey, Indian soil is 42% deficient in sulphur whereas world field deficit is around 37% of sulphur. In sulphur bentonite manufacturing, bentonite is used as binder, dispersing agent, as direct elemental sulphur application in fields is of no use for growing of plant, as plant roots absorb sulphate very slowly. The sulphur bentonite pastille is prepared in 90:10 ratio, i.e. 90% sulphur & 10% bentonite. When a sulphur bentonite pastille comes into contact with soil moisture, the bentonite begins to swell, breaking the pastille apart into fine tiny size particles, thus allowing oxidation into sulphate form to take place by microbes in the soil. But sometimes the end users are not getting results in farms as pastille didn't break. This may happen when sub-standard/ high moisture bentonite is used, here lies the crux. So, to avoid the same, bentonite wettability and dispersion can be enhanced by adding small quantity of wetting & dispersion agent. The aim is that the end user of fertiliser should get the intended benefit.

Keywords: Bentonite, Sulphur, Sulphur Pastilles, Pastille, End User of Fertiliser.

[B] FERROUS MINERALS

Role of Different Binders on Pelletisation of Multimetallic Magnetite Ore of Nagaland

Biswajit Mishra[1] and Dr. G. S. Mahobia[2]

[1] Research Scholar, Dept. of Metallurgical Engineering,
Indian Institute of Technology (BHU), Varanasi, India
[2] Associate Professor, Dept. of Metallurgical Engineering,
Indian Institute of Technology (BHU), Varanasi, India
Corresponding Author email: biswajitmishra.rs.met19@itbhu.ac.in

Abstract

Three organic binders, namely, corn-starch, carboxymethyl cellulose (CMC), dextrin and one inorganic binder, namely colemanite, have been used in this study and their effect on the pelletisation of the rare multimetallic magnetite ore of Nagaland has been investigated. The multimetallic magnetite ore is rare as it contains significant amount of chromium and nickel, which if extracted simultaneously with iron could lead to cost savings. Four separate green mixtures were made for each binder, corresponding to a particular binder dosage (0.5, 1, 1.5, 2 wt.%). The oven dried pellets were fired for two hours at four different temperatures, i.e., 1000°, 1100°, 1200° and 1250°C. Porosity of the hardened pellets were also measured. The hardened pellets were characterized using HR-XRD and SEM. Pellets bonded with dextrin and corn-starch gave sufficient green strength and dry strength but failed at higher temperature. CMC bonded pellets gave good green strength and dry strength and much better cold crushing strength (140 kg/pellet) than dextrin (21.6 kg/pellet) or corn-starch (24.3 kg/pellet). Pellets bonded with 1.5 wt. % colemanite gave the optimum properties with cold crushing strength of 294 kg/pellet and porosity of 24 vol%. These pellets can be used in DRI-EAF or SR processes by iron & steel industry in India.

Keywords: Multimetallic Magnetite Ore, Nagaland, Colemanite, Organic Binders.

Characterization and Direct Reduction of Fluxed Pellets Made of Waste Iron Ore Fines

Amit Kumar Singh

Research Scholar, Dept. of Metallurgical Engineering
Indian Institute of Technology (BHU), Varanasi, India
Corresponding Author email: amitkumarsingh.rs.met18@itbhu.ac.in

Abstract

Iron ore lumps of size -45+15 mm with +60% Fe_2O_3 are charged directly into the blast furnace as raw material for iron & steel making. -15 mm iron ore particles are generally discarded as waste. But nowadays some industries are using this as feed material after agglomeration. In the present study we aim to utilize iron ore fines in the range -0.25+0.05mm with a suitable binder for application in iron & steel industry. Iron ore fines based on size were classified into 3 size ranges (SR1 (-0.25+0.1mm), SR2 (-0.1+0.05mm) and SR3 (-0.05) mm). Pellets of above material were prepared using lime as a binder for basicity 0, 1, 2 respectively to observe hardening and reduction behavior. It was found that the cold crushing strength of hardened fluxed pellets decrease (222-12 kg/pellet) and porosity increase (30-43%) with increase in selected particle sizes. Percent reduction increases (89-99%) with increase in the iron ore particle size. X-ray diffraction plots and scanning electron microscope images shown increasing Fe peak intensity and growth of iron whiskers respectively in reduced pellets with increasing particle size. Waste iron ore fines in size range -0.1+0.05 mm (SR2) with lime as binder can be pelletized successfully and used for DRI making owing to its high reducibility (90-99%).

Keywords: Fluxed Pellets, Direct Reduction, Waste Iron Ore Fines, Pelletization.

Flowability Characteristics of Iron Ore and Their Influence on Material Handling System Design Parameters

T.V.S. Subrahmanyam, Somiran Mandal, Bhagwan Singh, and S.K. Chaurasiya
R&D Centre, NMDC Limited, Hyderabad, INDIA
Corresponding Author email: tvssubrahmanyam@nmdc.co.in

Abstract

The total production of iron ore in India was 246 million tonnes in 2019-20 and 188.6 million tonnes (estimated) in 2020-21 according to annual report 2020-21 of Ministry of Mines. Odisha state is the leading producer of iron ore accounting for nearly 59.64% of total production followed by Chhattisgarh (14.11%), Karnataka (12.76%), Jharkhand (10.93%) and remaining (2.56%) production was reported from Andhra Pradesh, Madhya Pradesh, Maharashtra and Rajasthan. The production of millions of tonnes of iron ore involves intensive material handling operations including storage and conveying the Run-of-Mine (ROM) and finished product. During the handling of the iron ore in interplant processing, the ore is stored in stockpiles or silos, transported by means of series of conveyors that is accomplished through transfer chutes. The flawless movement of iron ore during the entire process plays a key role in realizing highest levels of productivity and plant capacity utilization. However, iron ore flowability problems, like plugging/choking of transfer chutes, arching/bridging/rat holing in silo/stockpiles are often encountered especially while handling wet and sticky ores during monsoon and post monsoon seasons. This necessitates to have a scientific understanding of the flowability characteristics of various grades of iron ore simulating the field conditions. The material handling systems are required to be designed and tailor made based on the flowability characteristics established by standard test methods simulating field conditions. The flow properties are dependent on particle size distribution, particle shape, chemical composition, moisture content and temperature. The present study involves evaluation of flow properties of different grades of iron ore samples collected from Odisha-Jharkhand region and calculation of design parameters for material storage and handling systems like silo/stockpiles and transfer chutes. The influence of flowability characteristics on various material handling system design parameters was analyzed.

Key words: Iron Ore, Flowability, Shear Test, Silo, Hopper, Transfer Chute, Jamming, Arching, Rat holing, Moisture.

Mineralogical Process Audit of Slimes from Kirandul Plant, Bailadila Iron Ore Mine, Chhattisgarh, India to Investigate Process Efficiency by Automated Mineralogic System

Basant Rath[1], Dr. Vibhuti Roshan[2], S.K. Chaurasia[3], and Dr. P.V.S. Raju[4]

[1]Sr. Manager (Geology), Head Mineral Characterization, Research and Development Centre, NMDC Ltd, Hyderabad-500007, India,
Corresponding Author email-basant_rath@nmdc.co.in
[2]Asstt. General Manager (Metallurgy), Head Agglomeration & Pyrometallurgy, Research and Development Centre, NMDC Ltd, Hyderabad-500007, India,
[3]General Manager, Head Research & Development Centre, NMDC Ltd., Hyderabad-500007,
[4]Senior Principal Scientist, CSIR-NGRI, Hyderabad, Telangana-500007, India
Corresponding Author email: basant_rath@nmdc.co.in

Abstract

Iron ore slimes from the processing plant of Kirandul, Bailadial Iron Ore Mine, Chhattisgarh, India, were characterised by optical microscopic techniques and 'Automated Mineralogical' techniques to understand the distribution of iron bearing phases and their recoverability. The study indicates that the dominant mineral phase is limonite with minor gibbsite, porous goethite, low iron limonite and goethite. quartz, magnetite and porous hematite are present in trace proportions. The total iron content in the sample is 44.76%, out of which major proportion is distributed in limonite (55%), porous goethite contains around 10.15% Fe, and goethite contains around 5% Fe. The primary iron ore minerals i.e., hematite and magnetite contribute only 0.37% Fe or 0.17% of the total Fe in this sample under study. Limonite is the dominant phase in the tailings sample with majority (83%) occurring in liberated form. Monomineralic limonite is constituted by limonite particles covers around 36% by weight which contains around 96.91% limonite only. In the sample Around 80% of the phosphorus (P) (0.02% with respect to oxygen.) is found in limonite. Around 0.55% Si silica is found in the sample and is distributed dominantly between quartz (34%), limonite (23%) and the low Fe limonite (18%). Aluminium concentration is 2.67% of the sample and is dominantly found in gibbsite (35%), limonite (36%) and low Fe limonite (11%). The study indicates that the process for iron ore minerals recovery is functioning well with a low amount (less than 1%) of valuable hematite or magnetite present in the slime. Magnetite, hematite, porous magnetite, and porous hematite are typically found in a middling or locked occurrence.

Keywords: Automated Mineralogy, Processing of Ore, Monomineralic, Liberation, Interlocking.

Fine Size Dry Iron Ore Beneficiation Using Thin Bed Air Fluidized Dry Separator

Ganesh Chalavadi[1,2*], Ranjeet K Singh[2], Ajit K Swain[2] and Monica Sahoo[2]

[1]Academy of Scientific and Innovative Research (AcSIR)
[2]CSIR-National Metallurgical Laboratory, Jamshedpur - 831007, India
*Corresponding Author email: gc@nmlindia.org, Mobile no.: +91-8789798324

Abstract

Iron ore beneficiation is generally done through a wet processing route. Wet processing has inherent issues like rejects generation in the form of a slurry containing fines that cause environmental problems. At various stages of wet beneficiation, nearly $1m^3$ of water is required for processing one tonne of iron ore. Processing the iron ore through a dry processing route may be considered an alternative method where the air is used as fluid media instead of water, which reduces the slurry generation. In the present study, iron ore feed with a size range of -1mm to +0.1mm with an assay of 58.28% Fe is subjected to dry processing on a thin bed air fluidized dry separator (TBAFDS). This unit is a gravity-based separator that utilizes the difference in minimum fluidization velocities of heavier and lighter particles. Airflow rate, vibration frequency, and side tilt are three parameters that were considered for the experimentation. Single-stage dry separation studies of iron ore were carried out, and nearly 4.5 to 5% enhancement of Fe content was achieved in heavy stream products of TBAFDS.

Keywords: Dry Beneficiation, Fluidization, Iron Ore, Minimum Fluidization Velocity, Frictional Force.

Utilization of Lean Grade Iron Ore Resources of India – The Way Forward

S. Pani, V.A. Sontakkey, D.R. Kanungo and S. Lohiya

Mineral Processing Division, MMPL & PP, Indian Bureau of Mines, Nagpur-440016
Corresponding Author Email: pp-nagpur@ibm.gov.in

Abstract

India is the fourth largest producer of iron ore and occupies sixth position in world's iron ore reserves. Iron and steel industry is one of the major contributors of GDP growth of the world as well as of developing countries. In the changed policy regime and Covid-19

pandemic scenario, the industry faces a lot of challenge for the iron ore feedstock and presently there is an enormous demand for iron ore. If the current rate of demand continues, the total reserves of feed grade iron ore assaying >60% Fe will be exhausted in near future. Lean grade iron ore resources need to be utilized maximally to overcome this challenge. The present work dealt with a lean grade complex and aluminous iron ore assaying 50.5% Fe, 8.91% SiO_2, 9.0% Al_2O_3. The presence of high alumina content and intricate textural assemblage of valuable versus gangue mineral poses the challenge for its beneficiation. Different techniques like gravity separation, hydrocyclone and magnetic separation were employed varying various parameters. The concentrate product assayed +62% Fe with average wt% yield of 40%, suitable for utilization in iron and steel industries after agglomeration. The sub-grade product assayed 52% Fe with wt% yield of 15% can be upgraded further by employing other novel beneficiation techniques, like reduction roasting followed by magnetic separation for maximum utilization. The remaining product assayed <45% Fe considered as reject, can be utilized in other industries like cement.

Keywords: Gravity Separation, Magnetic Separation, Hydrocyclone.

Significance of Mineralogical Characteristics in Beneficiation of Low Grade Iron Ores - A Comparative Study on Ores of Eastern India

S.K. Nanda, L.B. Toal, D.R. Kanungo and S. Lohiya

Mineral Processing Division, MMPL&PP, Indian Bureau of Mines, Nagpur-440016
Corresponding Author Email: pp-nagpur@ibm.gov.in

Abstract

Indian iron and steel industry sector largely depend upon haematitic iron ore. Out of the total resources of iron ore in India, hematite accounts for 68% and magnetite accounts for 32%. Majority of these resources are endowed in the states of Odisha, Jharkhand, Chhattisgarh, Karnataka, and Goa. The eastern Indian states viz. Jharkhand and Odisha are the major producer of iron ores in the country. Due to rapid depletion of high-grade iron ores, low grade resources need to be utilized to make country self-sustainable. In the iron ores from eastern sector, alumina is one of the major impurities and is mainly contributed by gibbsite and clay minerals. Textural complexity coupled with higher content of alumina-bearing minerals makes the iron ore challenging for beneficiation. In this paper two types of iron ores from the sector were studied for their mineralogical characterization. Sample-I assayed 51% Fe, 9% SiO_2, and 9% Al_2O_3 comprising major amounts of hematite and goethite/limonite with subordinate amounts of clay and minor amounts of gibbsite and

quartz. Sample-II assayed 55% Fe, 12% SiO_2, and 2% Al_2O_3, consisting predominately of hematite with subordinate amount of goethite and quartz with minor amount of clay. The study revealed that the hematite to goethite ratio is 1.58 and 3.51, clay to quartz ratio is 5 and 1.41 for the sample I and II respectively. Besides, liberation percentages of iron bearing minerals are more in case of Sample II. The wt% recoveries at 63% Fe grade are 40% in case high aluminous ore (sample I) whereas 55% in case of siliceous ore (sample II). The study deciphered that nature of mineralogical assemblages, their modal distribution and liberation characteristics are vital for development of beneficiation route and recovery of iron values.

Keywords: Hematite, Goethite, High Aluminous Iron Ore.

Technological Interventions for Utilisation of Iron Ore Tailing to Achieve Zero Mine Waste

Vishal Shukla, C. Raghu Kumar, and D.P. Chakraborty
Process Technology Group, Jamshedpur, Tata Steel Limited, India
Corresponding Author Email: vishal.shukla@tatasteel.com

Abstract

While the processing of iron ore (ROM), a large quantity of waste low-grade tailings ~15% containing abundant iron values ~ 55% in fine particle size (-150μm) is produced. Due to increase in demand of high-grade iron ore product for the metallurgical operations and the stringent environmental conditions due to slime pond, it is essential to utilize of waste tailing from slime pond to achieve zero waste of ROM from mines extraction. Recovery of iron values form tailing ponds will not only enhance the life of the mines operation but also give the opportunity for the self-sustenance in iron ore through beneficiation route.

In this paper, an attempt is made for comparative study within the available enhanced technologies by lab and pilot study to achieve zero mine waste and select suitable one. The present study aims to recover iron values from discarded slime containing assay ~56% Fe, ~6.5% SiO_2, and ~7.0% Al_2O_3. The results of investigation indicate that technological intervention is capable for producing the iron concentrate assaying ~ 60.2% Fe and ~4% alumina with yield of ~75 % on weight basis. More importantly that this corresponding final tail which consists ~30% Fe value. To achieve zero mine waste, several products are explored where this tailing can be used and as per chemical analysis it was found that this

final tailing could be a right material for civil and cement industry purpose and may be utilise in Geopolymer, Sintered bricks and tiles making. Hence, these approaches briefly say beneficiation approach of low grade waste and civil work accessories will lead to results in zero waste of ROM material for iron bearing material.

Key words: Low Grade Tailing, Advanced Technology in Beneficiation, Zero Waste, Geopolymer, etc.

Potentiality and Prospect of Beneficiation of Low-Grade Iron Ore For Steel Making

Subrat Kumar Kar

Director, Giridhan Metal Pvt. Ltd
Corresponding Author Email: subrat.kar@supershakti.in

ABSTRACT

Last 20 years have witnessed significant development in Iron and Steel production in India. After liberalisation of steel policy in 1991, a number of private players have emerged in steel production. The journey of crude steel production from 17.1 million tonnes in 1991 to 102.49 million tonnes in FY 2020-21 was possible because, India has huge deposit of suitable grade of iron ore for steel making and emerged as the second largest steel producer in World.

In last two decades, Indian steel industries are smelting steel only from high grade iron ore, mostly with +63 percent Fe content; consequently, the reserve of high-grade iron ore depleting extremely fast.

Presently per capita steel consumption in our country is quite less compared to the world average but is growing extremely fast and expected to reach 165 kg by 2030. This means three hundred million tonnes of steel for domestic consumption. To meet such huge quantity, around 450-500 million of iron ore will be required every year.

Further, to meet the demand, the iron ore producers must face challenges like stringent environmental regulation, concerns of public livelihood and rapid depletion of high-grade ore, utilisation of low-grade iron ores, handling, storage, and utilisation of slimes, etc., besides meeting other challenges like logistic, power and water requirements. All these apprehensions augment to find ways to use low grade iron ore in steel making as it has been in practice in other countries. Necessary amendment has been made in policies to lower the cut-off grade of iron ore from 60% to 45% Fe content.

This paper briefly outlines the need of hour and how to effectively beneficiate low grade iron ore to make them suitable for direct use in end use plant in a techno economic and environmentally friendly manner.

Keywords: Iron and Steel, Iron Ore, Low grade, Beneficiation.

Recovery of values from Low & Lean Grade Iron Ore Resources

Dr Ashok K Sahu

Chief Scientist & Head
Mineral Processing Department
CSIR-Institute of Minerals & Materials Technology, Bhubaneswar
Corresponding Author Email: aksahu@immt.res.in

ABSTRACT

Iron ores are valuable natural resources being finite and non-renewable. India has 33 billion tonnes of iron ores reserve out of which more than 10 Billion tonnes magnetite and nearly 23 billions tonnes hematite ores. After revision of threshold limit from 58% to 45% Fe, the national reserve improved further. Simultaneously addition of BHQ/BHJ/BGQ lean grade resources in the reserve, the total national reserve again will improve further. So low & lean grade iron ore deposits constitute the vital raw materials for iron and steel industries and are a major resource for national development. As per the recent National Steel Policy of Govt. of India, steel production will be enhanced to 300 MTPA in 2030 with an objective to achieve 500 MTPA in 2047 from current production of 112 MTPA. For the production of 300 MTPA, India needs iron resources around 450 MTPA in the form of calibrated ores/sinter or pellet and the total requirement of iron ore will be around 780 million tonnes. The country is not endowed with high grade requisite iron ore resources. It is, therefore, imperative to achieve the optimal use of available low & lean grade iron ore resources through scientific methods of mining, beneficiation and agglomeration processes.

To maximize the recovery of iron values from low and lean grade resources, CSIR-IMMT has done ample research on different lean and low-grade ores by reduction roasting followed by low intensity magnetic separation processes. In this process, hematite and the goethite is converted to magnetite phases. The main variations in the reduction roasting process are temperature profile, residence time, particle size and reductant quantity and quality. The thermodynamics and kinetics of the reduction roasting process play the key

role to control the phase changes up to magnetite phase by controlling the partial pressure of carbon monoxide. Otherwise, Wustite would be formed and it will have detrimental effect on recovery.

The studies conducted at the Institute used non-coking coal from Talcher coalfield as reductant. The continuous study was carried out in rotary kiln at the feed rate of 60-100 kg/hr. In another process, bench scale reduction roasting studies are being carried out in a fluidisation system to reduce the residence time and cost etc.

A washing plant tailing feed of Fe % 44.15 from Chatishgargh state gives 58% wt, recovery of with a grade 64.7% while processed in reduction roasting route. The banded iron ore feed of 47.15 % Fe from Karnatak State gives a grade of 66.42% with a weight recovery of 72%

Some of the advantages can be achieved by adopting reduction-roasting process over present conventional beneficiation technology. The reduction roasting process increases 15-20% extra yield with grade of concentrate, it reduces the grinding energy upto of 30% due to pyro process of the feed, process water recovery is maximised by filtration of both concentration & tailings. Tailing pond is not required. Solids tailings can be stacked in mines area. Since the concentrate is magnetite, pellet making becomes easy and nearly 20-30% energy consumption is reduced during pelletisation process due to exothermic reaction for conversion from magnetite to hematite. Therefore, the pellet quality is improved. Moreover, the consumption of ores per tonne of concentrate is reduced which improves the conservation of ores and reduces the impact on environment.

[C] NON-FERROUS MINERALS

Studies of Ilmenite Sand Along the Indian Kerala-Karnataka Coastline

P.K. Mandal

Assistant Professor, Department of Metallurgical & Materials Engineering,
Amal Jyothi College of Engineering, Kerala, India.
Corresponding Author email: pkmmet@yahoo.in, Mobile no.: +91-9193505699

Abstract

The beach placer at the Arabian Sea's Kerala-Karnataka seashore (~900 km long) is rich in ilmenite, rutile, garnet, sillimanite, zircon, monazite, etc. and varies mainly due to the natural process (i.e., tidal wave) and the provenances of the deposit. These states are endowed with fairly rich mineral wealth distributed along the seashore. Specially, ilmenite rich major beach and dune sand deposits occur in the coastal stretches of Kerala (Chavara), and Karnataka. India has the world's largest ilmenite reserve of around 10% of the total. The natural ilmenite ($FeOTiO_2$) as available in the beach sand deposited which mostly situated such as Kerala to Gujrat coastline in India. The beach sand samples were collected from different stations along the Kerala-Karnataka seashore and were processed for the estimation of total heavy mineral (THM) content. The results have shown concentration of total heavies at collecting stations in Karnataka, namely, Bengre ~45%, Ullal ~34.6%, Someshwar ~42.5%, and Karwar ~14.6%. Moreever, around 25-30 sample collecting stations had been chosen and samples mostly collected from sea-bed also shown deposition feature on the spots. It is concluded that sand contains mostly ilmenite and minor parts are rutile, zircon, sillimanite, monazite, garnet and quartz. The experimental part mainly focused on roasting of THM part with coke powder (# +150 to -150) in tubular furnace at high temperature (900-1150°C) in inert atmosphere and separated metallic-Ti, subsequently.

Keywords: Seashore, Ilmenite and Monazite Sands, THM, Roasting, Metallic-Ti.

Development of High Alumina Synthetic Aggregate Based on Impure Raw Bauxite

Maithili Bhakre, Subhasis Nayak, Gaurav Sinha, Satyaki Mandal, and Parul Kumari

Calderys India Refractories Ltd., Katni
Corresponding Author Email: gaurav.sinha@calderys.com

Abstract

The refractory industries in India are facing the challenges of unavailability of good quality raw materials, lack of continuous and assured supply as well as increased raw material price. It is difficulty to produce high quality refractory raw materials in the country due to high impurity content in the available mineral resources such as bauxite, magnesite, etc. Hence, manufacturing of premium refractory products are dependent on imports from China. On foot of its global commitment to reduce carbon emissions, the government of China has levied several restrictions on refractory raw material manufacturers which in turn affected production and deliveries. This in effect resulted in rising import cost and ultimately affected the cost of products. To circumvent this problem and to cater to the increasing domestic demand for quality products we decided that an attempt has been made to explore ways and means to produce value added products from the inferior quality raw bauxite available in India. The synthetic high alumina aggregates were manufactured by pyro-processing route from locally available bauxite, Bayer process alumina and judiciously chosen additives. Extensive experimental work has been carried out to optimize the additive concentration and process to achieve required properties in the aggregate. The produced synthetic aggregate is of superior quality with 93% Al_2O_3 & 5% porosity as compared to 86-89% Al_2O_3 obtained in Chinese bauxite. The refractory products manufactured using these aggregates have shown improved performance. Thus, development of high alumina synthetic aggregates will open doors for manufacturing of high-quality refractory products used for various customers like Iron & Steel, Cement, Aluminium Industries, etc. As a result, the organization has reduced the dependency on supply of Chinese bauxite.

Keywords: Raw Bauxite, Pyro-process, Synthetic Aggregate, Porosity, Chinese Bauxite.

Value Chain Development of Rare Earth Minerals and Titanium Minerals in India Needs to Be Fast-tracked for Achieving "Aatmanirbar Bharat" and "Make in India" Targets

Chellakkan Swamydas & T. Srinivasagan
Corresponding Author Email: cswamydas@gmail.com

Abstract

Rare Earths (RE) value chain products have applications like defense, atomic energy, green energy technologies like solar energy, wind energy and electric and hybrid vehicles, fuel cells, electronic devices like smart phones, GPS systems, color display, rechargeable batteries, hard drives, visors and protection in aerospace, missile guiding systems etc., advance communication, health care and many more applications in day-to-day life.

Titanium value chain products are mainly Titanium dioxide pigment, Titanium metal and Nano titanium TiO_2 pigment is used in paints, plastics, paper, textiles, rubber and cosmetics. Titanium metal finds application in aerospace components, medical implants and in industrial components. Nano Titanium is used ion optics, material science, electronics and catalysts.

One of the minerals containing REs is monazite which is a rare earth phosphate, containing around 65% of REO along with around 9-10% thorium and 0.3% uranium. Indian monazite reserve of monazite is estimated to be 12 million tons containing 6.9 million tons of REO.

Titanium is available mainly in ilmenite mineral which contains around 50% titanium dioxide along with iron oxide. It is estimated that around 30% of the world ilmenite reserves occur in India. The production of ilmenite in India is around 2-3% of world production. But value chain development is still negligible.

Both these minerals are found to coexist in the Beach Sand Mineral (BSM) deposits in the country. India is in the BSM industry for more than a century. The country was in titanium pigment industry based on ilmenite mineral and mixed rare earths production from monazite mineral for more than seventy years.

However, India was not increasing the BSM activities and value chain of titanium and rare earths to commensurate with the requirement in the country resulting in import and outgo of valuable foreign exchange.

For meeting the **"AATMANIRBAR BHARAT" and "MAKE IN INDIA"** targets of the country, it is of paramount importance to improve the country's performance in BSM mining and development of value chain for titanium and rare earths.

Improvement of capacity of mining, processing of BSM deposits and development of value chain products on war footing to meet the requirement in the country is the need of the hour.

Keywords: Rare Earths, value chain, titanium

Exploratory Study for the Utilization of Low-Grade Kachchh Bauxite and its Prospects for Rare-earth Elements

Govind Sethia[1,2*], Bhavana Mishra[1,2], Dimple K. Bora[1,2], and Prayag Gajera[1]

[1]Inorganic Material and Catalysis Division, CSIR-Central Salt and Marine Chemicals Research Institute, Bhavnagar, 364002, Gujarat, India
[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad- 201002, India
Corresponding Author email: govinds@csmcri.res.in

Abstract

The mineral deposits in the Kachchh region of Gujarat contain bauxite of all different grades, with a huge amount of low-grade bauxite. The low-grade bauxite from Kachchh is characterized in detail using different physicochemical techniques like X-ray diffraction (XRD), wavelength dispersive X-ray fluorescence (WD-XRF), Field emission scanning electron microscopy (FE-SEM) with energy-dispersive X-ray (EDX) detector, nitrogen adsorption/desorption isotherm at 77^{o}K and Inductive Coupled Plasma-Mass spectrophotometer (ICP-MS). The different mineral phases present in the low-grade bauxite were identified from the X-ray diffraction studies. The different elements present in the mineral were identified and quantified using WD-XRF and EDX measurements. The composition of the mineral, particularly total alumina content, gibbsite content, silica module (2.93) indicated the low-grade category of the Kachchh bauxite mineral. The low-grade Kachchh bauxite is explored for the possible extraction of alumina and scandium. The quantification of rare earth elements particularly scandium is carried out by ICP-MS analysis. The digestion method has been optimized for the complete mineral digestion and precise measurement of scandium. The ICP-MS analysis shows the presence of approximately 80 ppm of scandium. Regarding the REE prospects, the BR from low-grade Kachchh bauxite is comparable with BR from other locations and could be used as a source of scandium. The low-grade bauxite has approximately 39% alumina, which is predominantly gibbsitic in nature. The alkali digestion conditions were optimized for the maximum dissolution and extraction of gibbsite. The aluminium hydroxide extracted from the low-grade bauxite is converted into alumina with high specific surface area and porosity. The developed alumina with high specific surface area and porosity may be used as catalyst support.

Keywords: Low-grade Bauxite; Characterization of Bauxite; Porous Alumina as Catalyst Support; Bauxite Residue as a Source of Scandium.

Need For Value Addition to Abundant Beach Minerals in India to Achieve Self-Sufficiency in Critical Materials to Meet "Make in India" Objectives

Sakthi Ganapathy

Secretary, Beach Minerals Producers Association
Corresponding Author email: bmpatamilnadu@gmail.com

Abstract

India is endowed with abundant Beach Sand Mineral (BSM) reserves consisting of heavy minerals like ilmenite, garnet, rutile, zircon, sillimanite and monazite. Ilmenite and rutile are titanium minerals, garnet is an abrasive mineral, zircon is a high tech mineral and sillimanite is a refractory mineral. Monazite is a rare earth bearing mineral. India contain 30% of the world reserves of ilmenite and 70% of the monazite reserves of the world.

The value-added products of ilmenite are titanium dioxide, titanium metal and nano-titanium and these products find applications in paints, paper, plastics, rubber and cosmetics, aerospace components, industrial applications and medical implants, electronics, catalysts and material science. The value-added products of monazite find application in green energy, defense, electronic devices, computer components, aerospace, advance communication, health care etc.

The domestic production of value added products based on these minerals does not commensurate with the available resources in the country and needs a boost for avoiding dependence on imports, mainly from China. Presently, the production and value addition of these minerals in India is at a very negligible scale and the bulk of the requirement is being imported. Challenges also exist in the value addition technologies. India has the capacity to overcome both the minerals production as well as the value addition problems.

Presently, the operation of the BSM sector in the country is reserved to the government sector and there seems to be no concrete plans to improve the performance of this industry by the government sector for the next few decades. Proper policy challenges and procedure modifications are needed in the country to achieve the "MAKE IN INDIA" goals in the country.

Keywords: Beach Minerals, Garnet, Ilmenite, Rutile, Zircon, Rare Earths and Value Addition.

[D] WASTE UTILIZATION AND GENERAL

Sustainable Use of Waste Generated in Mining & Downstream Industry

Dipak Behera[1], Niladri Bhattacharjee[2], and Atanu Das[3]

[1]AGM (External Affairs & Sustainability), Tata Steel Mining Limited
[2]ADM (New Ventures), Tata Steel Mining Limited
[3]ADM (New Ventures), Tata Steel Mining Limited
Corresponding Author Email: dipak.behera@tatasteelmining.com

Abstract

Mining operations consist of excavation (extraction in pits and underground mine workings) to remove ore; beneficiation units, such as mills and processing facilities for upgrading or concentrating the ore; refining facilities for further purification of the metal and manufacturing of finished products. However, mining operations generate large quantities of wastes as well.

Further, in the downstream industry, during the iron, alloy making and steelmaking processes, several by-products are produced, such as slags, dusts, mill-scales and slimes.

Ideally, the reuse and recycling of mine wastes, like all other recycling efforts, create financial assets, responsible consumption of natural resources, limit waste production, encourage innovation and local industries, create jobs and teach responsibility for the environment shared by all. In addition, the reuse and recycling of solid mining wastes and mine waters may also decrease the exposure of humans and ecological receptors to contaminated materials. Various reuse and recycling options have been proposed for mine wastes after numerous studies by stakeholders in line with Sustainable Development Framework (SDF) implemented by Ministry of Mines.

Over the last few decades, the downstream industries have focused its efforts on the improvement of by-product recovery and quality, based not only on existing technologies, but also on the development of innovative sustainable solutions. These activities have led the mining & metallurgical industry to save natural resources and to reduce its environmental impact, resulting in being closer to its "Zero-Waste" goal by sustainable use of mining waste.

Keywords: Mining, Recycling, Sustainable development, Zero waste.

Bottom Ash a Feasible Alternative to Sand for Stowing in an Underground Coal Mine

H.P. Sharma

General Manager (Mining)
Steel Authority of India Ltd., India
Corresponding Author email: jitpuroffice@gmail.com

Abstract

River sand is recognized as the best stowing material due to its properties which are favourable for stowing and hydraulic sand stowing in underground coal mines has been popular due to its simplicity in operation. In India, the scarcity of river sand nowadays has made the sand stowing operation practically unfeasible and with its restricted availability in monsoon period as well as economical availability for use as a stowing material for underground mines is a matter of concern for every mining company. These very constraints not only stop production but also endangers safety of a mine, thus the necessity to explore alternate of sand as a stowing material is the need of the hour.

On the other hand, Bottom Ash, the coal combustion by-products (CCBs), which are generated from the thermal power plants are available in abundance, creates environmental problems and requires a safe disposal and utilization in bulk. Realizing the problems of both the mining and power sectors and studying the properties of Bottom Ash, the researchers have identified Bottom Ash as a suitable alternative to river sand for stowing in an effective manner. In India, initiatives have been taken and full-fledged stowing with Bottom Ash in two mines namely, RK 7 Incline of Singareni Collieries Company Ltd. (SCCL) and Surakachar 3 & 4 mine in the Korba area of South Eastern Coalfields Ltd. (SECL) is being carried out since 2014 & 2017 respectively. The stowing results of both the cases are highly encouraging; and this has been a driving force for Jitpur Colliery, Collieries Division, SAIL to try and establish the success of Bottom Ash. This paper deals with the suitability of Bottom Ash for stowing at Jitpur Colliery, SAIL with respect to Laboratory Investigation of coal Ash samples vis-a- vis trial stowing with Bottom Ash.

Keywords: Sustainable & Responsible Mining, Bottom Ash Stowing, Strata Control, Economical Availability.

Role of NMDC in Mineral Conservation

G. Venkateswara Rao[1]* and S. K. Chaurasiya[2]

[1]Deputy General Manager (MP)

[2]General Manager (R&D)

R&D Centre, NMDC Limited, Hyderabad, India

*Corresponding author email: gvrao@nmdc.co.in, Mobile No: 9490759605,

Abstract

Ores and minerals are site specific, non-renewable and finite natural resources. Anything on the earth is derived from the earth by mining or farming. Minerals were derived through Mining. Minerals are the raw materials for manufacturing industry. Hence, minerals play a key role in the development of any country. The use of minerals has increased tremendously after the independence of India. Due to improper and excessive use, minerals in certain regions are on the verge of extinction. Hence, there is a need of conservation of minerals.

Mineral conservation can be done through improvement in mining methods, beneficiation and utilisation of low grade ores, rejects, recovery of associated minerals and mandating zero waste technology. Minerals can be conserved through value addition, latest technique of beneficiation, blending, sizing, concentration, pelletisation, purification and general customisation of product.

Converting waste to wealth is one of the methods in mineral conservation. R&D plays a vital role in utilization of mine waste, low and lean grade ores, leading to mineral conservation. The latest context of R&D in mineral conservation is recovering minerals from waste/ rejects. This article deals with the role of R&D in conservation of minerals, particularly low-cost bulk commodity, iron ore. Discussion includes mineral conservation through development of process flow sheet for production of pellet grade concentrate from Banded Hematite Quartzite (BHQ), Banded Hematite Jasper (BHJ), Sub Grade Iron Ore (SGIO) and iron ore slimes of NMDC mines. Some of the beneficiation studies and research work carried out at R&D Centre, NMDC Limited, Hyderabad was presented in the paper.

Keywords: R&D, Mineral Conservation, Iron Ore, BHQ, BHJ, Sub grade Iron Ore and Iron Ore Slimes.

Optimizing process control with near infrared online analysis: Case studies in sinter

Petra Mühlen[1]

[1] CEO, SpectraFlow Analytics Ltd, Switzerland
Corresponding Author email: petra.muehlen@spectraflow-analytics.com

Abstract

Process control optimization depends a lot on the availability of timely data from production to give operators a chance to make adjustments before potential process upsets or disruptions happen. A lot of data is already available with newer and updated machine technologies, but what about the process upsets coming from the raw materials that we use? They are natural products and with that they are not of a stable composition or mineralogy. The production process depends on a certain chemical or mineralogical stability of the input materials when they come to a roaster, kiln or sintering stage. Only then the proposed reactions can take place and the equipment can be operated at stable temperatures.

Laboratory analytical technologies have the limitation that they depend on representative samples and have a long time delay. Therefore online (real time) analysers are nowadays used in mining applications to get an early indication of the actual mined or to be processed ore. Most available technologies can only analyse inorganic content on an oxide or elemental level. Near Infrared (NIR) based online analysers can overcome that limitation and give a real time analysis of organic as well as inorganic composition, if required on a mineral level.

Whilst the NIR technology is well established in the cement industry and becoming increasingly popular in many different mining applications (like potash, copper, rare metals) on in the mining as well as processing stage, the paper will present case studies where the NIR online technology was implemented in the sinter process very successfully for process visibility and improvement and presented a very short ROI on the equipment.

Keywords: Online Analyzer, NIR, Mineral Phase Analysis, Digitalization, Sinter, Iron Ore

Efficacy of Pilot Scale Batac Jig: Utilization of LVC Coal for Coke Making

Mohana Rao Andavarapu[1,2*], A. Vidyadhar[1], Ranjit Prasad[2]

[1]Mineral Processing Division, CSIR-National Metallurgical Laboratory, Jamshedpur, India

[2]Metallurgical and Materials Engineering Department, NIT Jamshedpur, India

* Corresponding Author email: Mohana Rao Andavarapu; Email: mohanrao@nmlindia.org

Abstract

The demand for coking coal has increased vastly in India due to rise in steel industry production. The reserves of good quality coking coals are inadequate and hence the scope for proper utilisation of abundantly available poor quality low volatile coking coals needs to be focussed for improving their coking potential through beneficiation. Jigging is one of the most efficient gravity-based beneficiation techniques and suitable for pre-concentration of coarser industrial minerals and coals. The aim of the present study is to beneficiate the coarser sized fraction (–13+1 mm) of LVC coal from Jharia coal fields using pilot scale Batac Jig by varying the most influencing process parameters. The feed coal properties were measured in terms of proximate and ultimate analysis. The gross calorific value of the coal was observed to be 5784 Kcal/kg. The theoretical feasibility of as received coal was estimated by sink-float analysis revealed that LVC coal possessed difficulty in washability characteristics. The performance of jigging process was studied layer wise and the results indicate that stroke length and air pressure were mainly effecting the efficiency of the process. For better understanding of the jig products, layer wise size and ash analysis were performed and corroborated with feed characteristics. The pilot scale jigging experiments revealed that 24.6% ash content of concentrate product was achieved with a yield of 76% from the feed ash content of 32.5% under the optimized process conditions, whereas bottom layer contained 57.4% of ash and treated as final reject. The jig product can be used as a blendable coking coal for making metallurgical coke.

Keywords: LVC coal, Washability, Coarse coal beneficiation, Gravity separation, Batac jig

Sustainable Methods of Dewatering and Disposal of Mineral Processing Plant Tailings

K.S. Raju

Ex-Controller General, Indian Bureau of Mines
Email: satyamhari@hotmail.com

Abstract

Mineral processing is carried on low grade ore to recover valuable minerals as concentrate and reject unwanted minerals as waste, generally termed as tailings. Mineral separation when done by dry processing (without using water media) either employing gravity or magnetic separation techniques, the tailings are generated in dry state and can be transported by conveyor belts or closed tube conveyors to designated tailing dumps. In such cases there may not be much environmental control issues except using some dust suppression measures. But, in case mineral separation is carried out by wet methods of processing (using water media in flotation, fine gravity and wet magnetic separations) the tailings generated is a mixture of water and solids in the form of slurry.

In general practices the tailings in the form of slurry is pumped to designated tailing ponds or tailing Dams for long storage. The disposal of tailings as slurry with large quantities of water has many environmental concerns and is one of the major problem facing mineral industry to maintain environmental controls and safety standards. Impoundment of tailings in to tailing dams along with large quantities of water has environmental concerns such as water conservation, pollution of ground and surface water which are of regular immediate concerns and hazards of dam breaches and land degradation have a long time impact.

In view of water scarcity expected in coming years the water contained in tailings needs to be recovered and recirculated. Now several regulations are promulgated at Government level to restrict the use of water and also to reclaim and recirculate slurry water. Secondly, make up water to compensate the losses of water at varies stages of processing should be lower as far as possible. This depends on the type of ores processed and may vary between 10 to 30 percent of feed water to the plant. For this reason, permissions to establish mineral processing units are given only when these guidelines are adhered to. Recently environmental regulations also restrict the disposal of tailings as slurry into natural or artificial ponds. In this regard it is recommended to adopt and use several methods of dewatering equipment like high capacity and efficient thickener's, vacuum or pressure filters, etc. Secondly dry methods of processing as well as pre concentration by dry methods are encouraged. Many mining companies in the world are now making efforts to reduce water consumption and reuse and also financing R&D projects to develop dry methods of ore process.

Tailing management is considered one of the major environmental challenges for mining industry. Under Sustainable Development Frame work (SDF), there are many new guidelines to handle and dispose mining waste and plant tailings. More emphasis is given for recovery of water from tailings prior to its disposal. Presently, several methods of dewatering and safe disposal of tailings have been evolved in recent years and the industry is keen to adopt sustainable methods. In this paper some of these methods are discussed.

Keywords: Low Grade Ore, Dry Method of Processing, Wet Method of Processing, Environmental Concerns, Recovery of Water, Dewatering.