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R&D applications for sustainable mining

Introduction

India is bestowed with enormous mineral wealth and has tremendous potential for growth. India has been a dominant player in the mineral sector and is among the leading producer of several minerals like iron, coal, bauxite, etc.

Considering the growing nature of Indian economy, mining sector has an important role to play in improving the standard of living of the people and reduction in poverty levels. Thus, it is imperative to look at technological and process solutions to make this sector more efficient and sustainable.

Mining industry, often labelled as destructive sector as it is associated with resource exploitation activities, such as acquisition of land, clearance of flora and fauna for exploration purposes, drilling and blasting for excavation, mine waste disposal and related environmental degradation.

It is unfortunate but true that the mining process, from exploration to reclamation of exhausted mines, is highly destructive to the environment. Thus mining represents a conflict between economic and environmental interests.

In order to make mining sustainable and to minimize the tarnish in the era of stringent environmental norms, it is inevitable to strive towards achieving integrated approach for improving the value chain from mine to metal.

Deployment of advanced and sustainable technological solution in the entire mining process, fixing the gaps in its regulatory mechanisms and learning from the successes of specific domestic and international mining operations are certain solutions that have the capacity to make this sector more productive.

Upholding sustainable mineral development is not only the solution to strike the balance between economic interests and environmental imperfections, but also has the potential to represent India as a global champion that advocates incorporation of sustainable development principles within its mining sector.

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Sustainable mining

Sustainable mining refers to the development of our minerals and energy resources, onshore and offshore, in a way that maximises the economic and social benefits while minimising the environmental impacts of mining. It integrates environmental, economic, safety and community aspects in all phases of a project.

Australia is a world leader in sustainable mining because of a long history of strong environmental and safety regulations as well as wide-spread adoption of voluntary codes of practice and standards by the industry. Sustainable development of mining sector in India needs to be more successful in the years to come.

Indian Government is committed to protecting India's diverse and distinct natural environment while supporting investment certainty. To ensure the sustainable development of our resources, the government has been formulating Policies to ensure appropriate environmental obligations and best mining practices and also promoting investment in the science and research that underpins effective regulation, decision-making and addresses community concerns.

The Indian mining sector is extremely regulated with well-built legal and regulatory framework with the government introducing and overhauling several acts, policies, rules at both the central as well as state levels. Since mining sector is considered as a 'highly polluting industry' due to its severe environmental and social impacts, India has been vigilant and progressive in establishing institutions and regulatory mechanisms in order to counter balance the negative externalities caused by mining activities

Thus, the sustainable mining is that, which is financially viable; socially responsible; environmentally, technically and scientifically sound; with a long-term view of development; uses mineral resources optimally; and, ensures sustainable post-closure land uses.

Sustainability elements for mining industry

- Efficient mining and beneficiation technologies
- Sustainability innovation and R&D projects
- Mine transport/haulage optimization
- Water conservation
- Land, mine waste and tailings management
- Effective mine closure, reclamation and resettlement programme
- Conservation of biodiversity
- Energy savings and GHG management
- Renewable resource management
- Supply chain and sustainable sourcing
- Fugitive emission control
- Material stewardship

Apart from the above, achieving sustainability also depends on other factors such as compliance to: labour standards, code of conduct, human rights, health and safety standards, thrust on: training, corporate governance, vigilance and anti-corruption, customer satisfaction and value creation, stakeholder management, CSR, grievance redressal, marketing communication.

Mining and R&D's approach towards achieving sustainability

The purpose of mining is to meet the demand for metals and minerals resources to develop infrastructure and to improve the quality of life of the society. The primary products extracted from mining in many cases are the raw materials for the metallurgical and manufacturing industry.

Mining activities comprise drilling-blasting and excavation, by their nature are considered as the potential sources of destruction to the environment. The production of mineral commodities and extraction of metals invariably associated with large quantities of waste at each stage of value addition. The waste generated during the process is a major contributor for environmental degradation. Though, waste management is on the priority of every industry, it is an 'after the event' measure. Thus, there is a need for a different approach of dealing waste with an aim to reduce or eliminate it at the source to the possible extent. It is prudent to think of value addition to these wastes either by exploring the possibility of recovering certain secondary minerals or think of possible alternate usage to improve the value chain. Thus, the aim of mining need not be of use of the ore or mineral of business interest but certainly the aim ought to minimize the adverse impact on the environment by improving the value chain in entire domain of mining. For a mining company, sustainable practices are at the core of its license to operate. The time has come to realize that the only way to be economically viable is to operate environmentally and socially responsible.

Achieving sustainable productivity improvements will garner by fostering a healthy workplace. Productivity, it is a word that has always been hot on the lips of every miner and will continue to do so. Technology can leverage productivity by bringing new advancements which would make workplace safer and easier.

Apart from a few notable exceptions, it is large-scale mining enterprises that have been pioneering the move towards advanced technological solutions for achieving resource efficiency along with adoption of environmentally and socially sustainable mining practices.

Thus, moving towards increased adoption of automation in mining technologies through in-house capacity building initiatives by their respective R&D departments has become the need of the hour. Creation of a venture-capital funded process R&D set up is clearly required if the concept of zero waste mining is to be taken to its logical conclusion.

The onus on iron ore miners to set benchmarks for others to follow, to accomplish its objectives the Indian mining companies are continuously striving to improve the standards and leave no stone unturned. Adoption of technology in the forefront in creating better living standards for their stakeholders is a must. The recent one being promoting space applications in exploration and other mining activities for "Satellite based geological mapping and multidisciplinary exploration of iron, diamond and other mineral deposits", which is a step forward towards "Digital India" as space technology provides real-time data for generation of digital maps. Use of advanced software for mine planning and deploying advanced machinery for excavation and processing.

Following are the thrust areas in achieving sustainability:

- Research and development
- Environmental stewardship
  - Waste dump and tailing management
  - Mine closure plan
  - Water conservation
- Energy management
- Community outreach
  - Corporate social responsibility
  - Health and safety

Sustainable mining through R&D

R&D is a crucial tool for any nation or organisation for achieving sustainable mining goals. In terms of total investments in R&D, in India, it is 1/60 of Korea, 1/250 of USA and 1/340 of Japan. More significantly 71% of India's R&D spending is towards space, atomic and defence research out of the total R&D spending in science and technology. Very few R&D works are undertaken in agriculture, energy, telecommunication and other potential areas. Majority of the

R&D funds in mineral sector is spent towards salary and wages and investment towards equipment and other heads are limited.

India's R&D expenditure is around 0.88 per cent of GDP and number of R&D professionals per million population are 164.

Mission and objective of R&D application in iron ore mining

R&D approach in mining is committed to maintain its excellence in undertaking product and technology development projects related to ore and minerals through continual improvement in process performance for enhanced customer satisfaction.

It undertakes R&D work related to mineral processing, bulk solids flowability, mineralogical and metallurgical characterization, agglomeration etc.

The thrust areas for any R&D centres in mining should be:

- Providing technical solutions to the problems related to quality and productivity of mines.
- Upgradation of processing technology of existing process plants for better productivity and meet the customer requirement.
- Developing technologies for enhanced utilization of iron ore fines, dry processing of sub and lean grade iron ore, enhanced recovery of iron values, utilization of mine wastes.
- Development of value-added process and product through innovation.

Use of slimes as pellet feed

Extensive research work has been taken up for beneficiation and pelletization of slimes generated at mines. The iron ore slimes with less than 59% Fe content has been successfully upgraded to iron ore concentrate with more than 65% Fe. The pellets produced from the concentrate obtained from slime beneficiation have excellent physical and metallurgical properties and are suitable feed stock for iron making through BF and DRI route.

Use of waste generated during slime beneficiation

During the process of slime beneficiation lean tailings assaying around 41% Fe are generated to the tune of about 30% of the feed. This will be stored in tailing dam. Research programme has been identified for utilization of these slimes for further extraction of value added products such as nano iron powder, silica sol, in making of tiles, cement, bricks, etc. At present pavement tile has been developed from low grade slime and it is envisaged to put up pilot plant for pavement tiles manufacturing at mines/project site.

Utilization of ultra fines and slimes in hybrid pellet sintering

During beneficiation of low grade ore and slimes, the ore are ground to its libration size, In some cases it ground to below 100 mesh. Thus concentrate obtained is not suitable for feed to sintering process.

Research works were taken up for utilization of iron ore concentrate of -100 mesh size in hybrid pellet sintering. At pot grate level [100 kg batch] the hybrid pellets sinter of desired quality from iron ore fines have been produced successfully and further pilot scale level production will be taken up for techno-economic feasibility of the process.

Beneficiation of BHQ/BHJ for value addition

Banded hematite quartzite (BHQ)/banded hematite jasper (BHJ) is a low-grade iron ore with iron content ranging between 37% and 44%. India has vast deposits of other low-grade iron ore, including banded iron formations like banded hematite quartzite (BHQ), banded hematite jasper (BHJ) etc. Cost effective beneficiation process of BHJ/BHQ has been developed from mines of Karnataka. The concentrate obtained from BHJ/BHQ can act as a sweetener to the concentrate obtained from slime beneficiation in view of its negligible alumina content.

Alternate tailing disposal system

During the course of sizing and beneficiation of ROM ore 10% to 15% of iron values are rejected as tailing. Further capacity addition to existing mines will worsen the problem arises due to disposal of tailing. To overcome this problem, Alternate tailing disposal system is proposed wherein water will be recovered from the tailing. Tailing materials are dewatered to a >85% solids by weight (defined as weight of solids divided by weight of solids plus weight of water) using filters aided by a vacuum or confining pressure. The materials are transported by conveyor or trucked to disposal areas where they are handled by earthmoving equipment and may be stacked in eco-friendly manner.

Novel screening and WAP

In view of the obligation to operate the processing plants in dry mode is adversely affecting the productivity as well as quality due to inefficient screening. Model studies were carried out on the factors affecting screening efficiency and explored alternate viable options that would improve the screening efficiency as well as enhance throughput in the screening plant(s).

As a part of the studies, the following three alternatives were explored:

- Use of novel design screening media
- Use of a water absorbing compound (WAP) and
- A combination of novel design screen with water absorbing compound.

It is noteworthy to mention that the R&D has achieved significant breakthrough through laboratory, pilot scale and plant trials in addressing the issue of improving the screen ability and screening efficiency along with improving the flow characteristics of iron ore.

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