Study the Effect of Metallurgical Process on Enhancing of the Mineral Beneficiation in Indian Mining Scenario

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Abstract: The mineral beneficiation is the heart of ant mining industry. The complete economy of the extracted mineral depends on the mineral beneficiation process. Thus, this paper made an attempt to provide the detail information of the mineral beneficiation in the Indian mining scenario. In this regard, the paper has focused on two distinct definitions. From an economic perspective, beneficiation relates to adding value to a mined raw material. The paper discussed the five important stages of mineral beneficiation which may provide the clear and visionary thought for any mining industry. The five important beneficiation process which were discussed in brief are crushing, grinding, jigging, magnetic separation and electrical separation.

Keywords: Mineral beneficiation, Mining industry, Economy, Crushing, Grinding.

I. INTRODUCTION

The use of minerals playing a key role in improving the standard of living mankind. Sophisticated world of today scenario is largely the result of enlarged use of minerals for various purposes [1]. All engineering and structural material, machinery, plants, equipment's and anything from pin to plane are manufactured from metals extracted from mineral. Some minerals form the starting point for basic industries like cement, fertilizer, ceramic, electrical, insulating, refractory, paint and abrasive materials and a host of chemicals [2]. There is not a single industry which can run without minerals or they depended for their products. Minerals thus form part and parcel of our daily life. Mineral extraction is important part of the mining industry [3].

Mining is an industry which play a vital role in the economy building of any country [4]. Thus, its process should be efficient and reliable which improves its visibility in global market. Mining consists the various stages of operational process such as prospecting, exploration, development, exploitation and reclamation. Each stage has incorporated their unique value in overall operational efficiency and economy of the mining industry [5]. The term mineral beneficiation is a vital part of the exploitation process where mineral is extracted and processed for the further usage [6]. Mineral beneficiation is a key process on which the quality and economy of any mineral depends [7]. This process having various stages such as crushing, screening, grinding, classification and concentration. The concentration process is further divided in the process of concentrate and tailing [8]. The complete process of mineral beneficiation is shown in Figure 1. The flow chart presented in Figure 1 gives the information about each steps of mineral beneficiation process which are generally implies in any mining industry. The aim of this research is to study the effect of metallurgical process which are responsible for enhancing the mineral beneficiation in the present mining scenario.

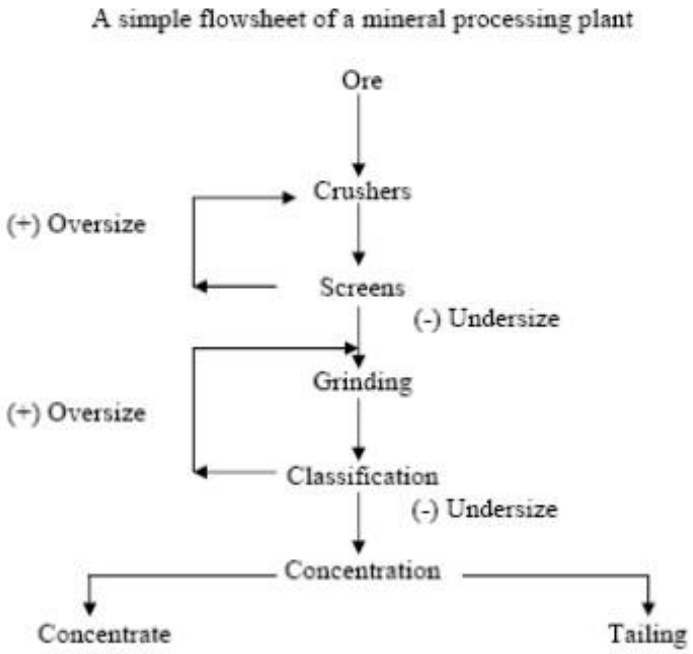

Fig. 1: Mineral Beneficiation Process Flow Chart

II. PHASES OF METALLURGICAL PROCESSING

The phases of mineral beneficiation include the three sub-discipline, namely liberation, separation and transformation. Metallurgical processing involves three steps of beneficiation, the first step of Mineral processing covers liberation and separation; the second step is pyrometallurgy, covers transformation for utilizing the thermal processes and the third step is hydrometallurgy which implies transformation for utilizing chemical processes [9]. Beneficiation of Run-of-Mines (ROM) ore generally involves three phases of metallurgical processing except coal and diamonds, where only mineral processing is applied. Figure 2 illustrates the subdivisions of extractive metallurgy.

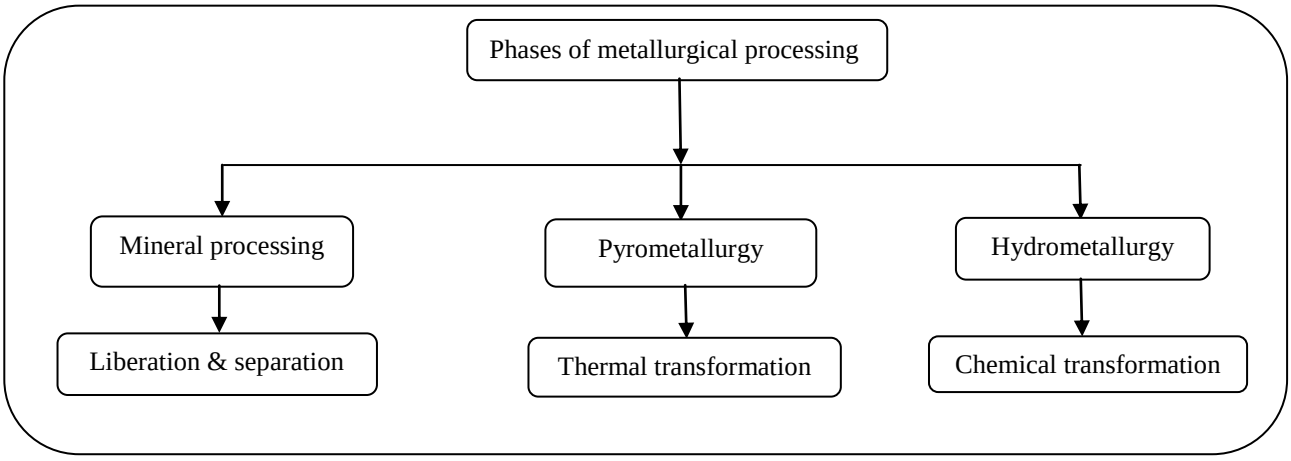

Fig. 2: The subdivisions of extractive metallurgy

The metal products resulting from the application of extractive metallurgy will then proceed to the physical metallurgy processes. These processes can start with the production of alloys such as stainless steel, brass, bronze, etc., followed by semi-fabrication processes [10]. The process of semi-fabrication involves the production of plate, rod, wire, pipe, etc., via casting, drawing, forging, rolling, annealing, etc.

The concentrate produced from ROM ore is usually involves three major process, namely crushing, milling, and flotation. When concentrates are obtained from ROM, it then converted to furnace matte while smelting the same in a reverberatory or flash furnace. Thereafter, it treated in Pierce Smith converters to produce blister metals. These metals can be sold for further treatment, but this is not common practice. The blister metals are fire refined in anode furnaces, which produce metal cast into anodes. The anodes can be sold for refining, but this is also not common practice. The metal anodes are refined in electrolytic refineries to produce metal cathode.

A good example of the requirement for numerous beneficiation steps is the production of copper. Most of the copper extracted in India is produced from copper sulphide ore. Table I shows the steps required and how the concentration of copper in the intermediate products increases

TABLE I. UPGRADING OF COPPER SULPHIDE ORE TO COPPER CATHODE

Upgrading step	Copper concentration
ROM ore	0.5–1.5%
Concentrate	25–35%
Furnace matte	50–60%
Blister copper	96–98%
Anode copper	99–99.5%
Cathode copper	99.99%

III. METALLURGICAL PROCESS FOR ENHANCING THE MINERAL BENEFICIATION IN INDIAN MINING SCENARIO

The Run-of-Mines ore are obtained through suitable extraction process such as cut & fill, stopping method, shrinkage method, open pit method etc. These ores have to undergoes the beneficiation process in order to obtain their economic value. Sometimes, the extracted ore may contain gases and acidic water which are harmful for their use. In such case, the ores are then treated in a separate beneficiation equipment like Heavy Medium Separator (HMS), cyclone separator, etc. More often, the ores which occur in the form of placer deposit also undergoes separate operation like leaching etc. For example, Gold, Copper, Silver etc. The metals like Gold, in their virgin state is recovered by electrolytic cells using steel wool as a cathode on which the metal ore is deposited. The process used in Ore Metallurgy are discussed in below sections.

A. Crushing of Extracted Ores

Crushing is defined as the first stage of liberation process which involves reduction of large lumps to small fragments as per the requirement of various industrial usage. In general, the action experienced by all crushing machines are the results of forces applied to the particles by some moving part working against a stationary or some other moving part. This stage is nothing but as the stage of size reduction where particle gets crushed by the application of external force. Since, the crushing operations require greater force which can be applied to particles. Therefore, the crushers need to be very rugged and

massive in nature. It is generally a dry operation and is usually performed in two or three stages.

As the crushing is performed in stages, crushing may be divided into primary, secondary and tertiary crushers and the association of the crushers are tabulated in Table II.

TABLE II. Classification of crushers

Sl. No.	Classification of the Crusher	Type of the Crusher
1	Primary crusher	Jaw crusher, Gyratory crusher
2	Secondary crusher	Roll crusher and cone crusher
3	Tertiary crusher	Impact crusher

The schematic diagram for the different types of crusher are shown in Figure 3 and Figure 4.

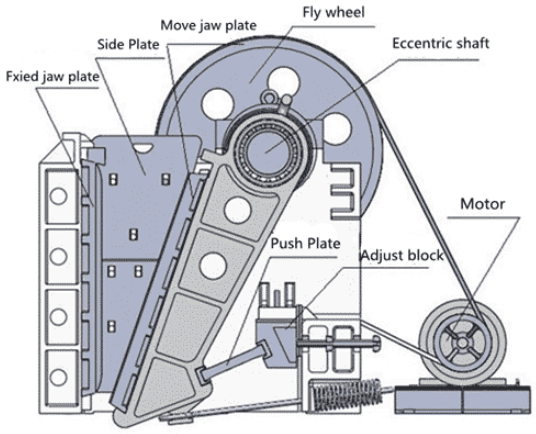

Fig. 3: Jaw crusher

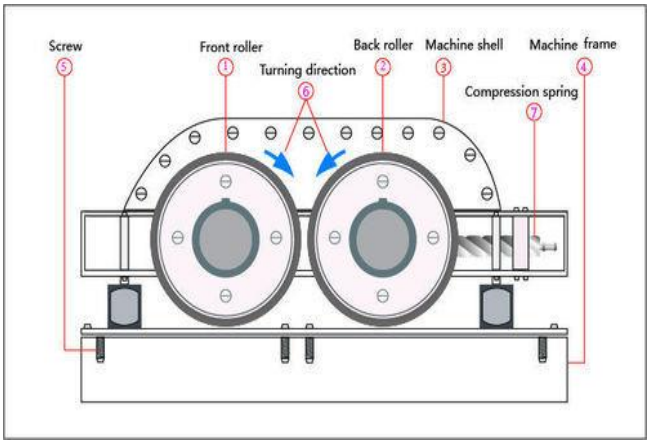

Fig. 4: Roll crusher

B. Grinding

In this process size reduction is done with the help of different grinding mills. Grinding mills carry the two-basic principle of impact and abrasion, which occurs in the grinding mills. These contains charge of loose crushing bodies and the grinding medium, which is free to move inside the mill. The principle of grinding mechanism is to perverts the particle and change their shape beyond certain limits determined by their degree of elasticity, this cause the particles to break. They can be operated wet or dry, batch wise or continuously.

The equipment used should be robust and the loose grinding medium can usually be added without stopping the mill. These equipments are higher power consumption capacity and require more economic investment than crushing equipments. Generally, there are four types of grinder used namely Ball Mills, Rod Mills, Tube Mills and Autogenous Mills. The schematic diagram for the different types of grinder are shown in Figure 5, Figure 6 and Figure 7

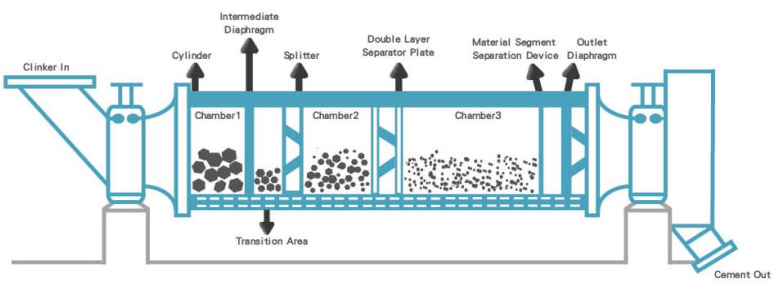

Fig. 5: Mechanism of Ball Mill Operation

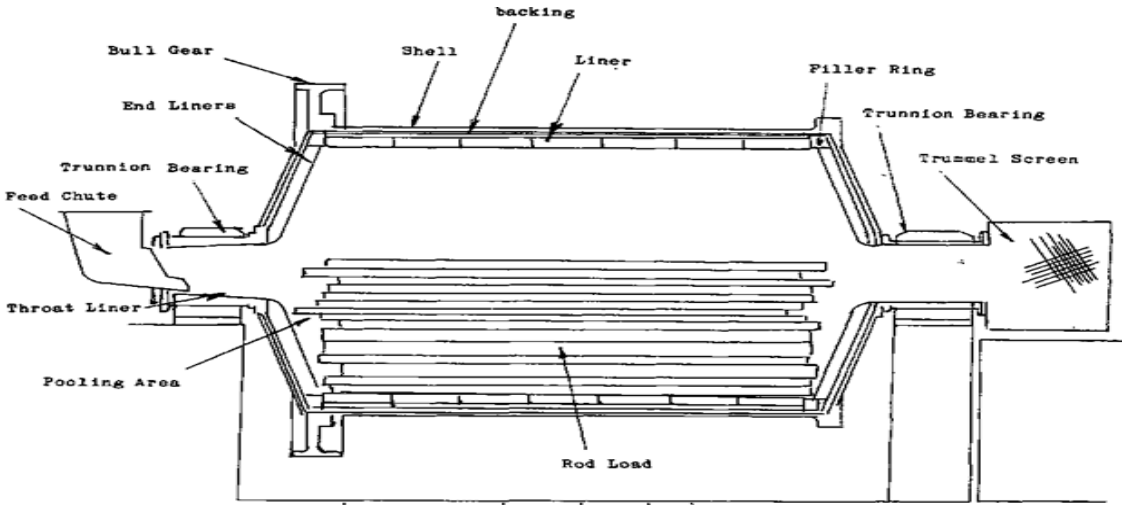

Fig. 6: Rod Mill Operation

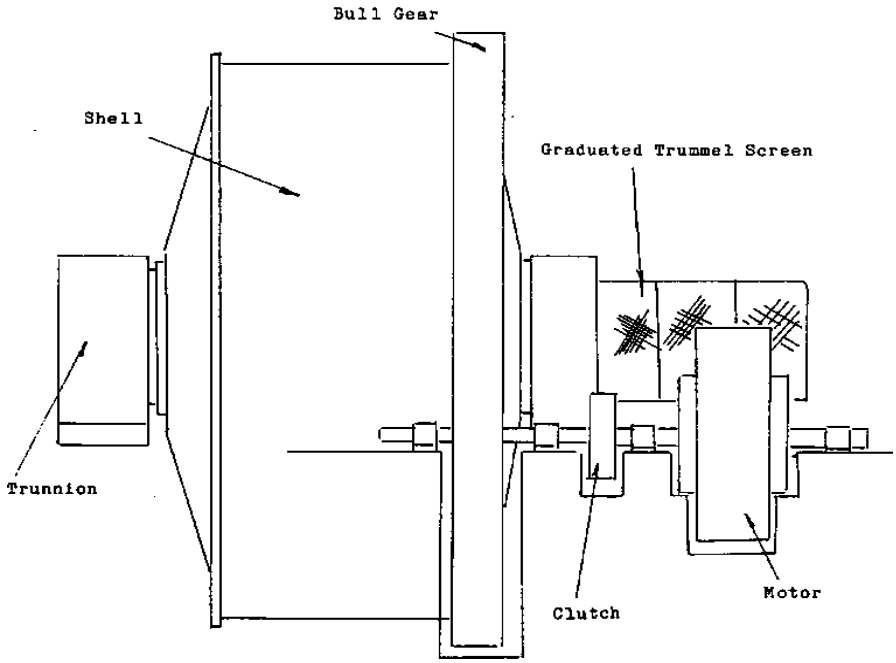

Fig. 7: Schematic view of Autogenous Mill

C. Jigging

Jigging is a process of separating of particles based on different specific gravities, size and shape by maintaining them on a perforated surface or screen through which the water is made to flow by passion and suction strokes alternately. In this process, the particles are allowed to settle only for a short period and the particles will never allow to attain their terminal velocities. It means that separation will depend on the initial settling velocities of the particles. The particles will settle during their acceleration period. In Jigging the Hydraulic Jigs use water as their fluid medium, whereas Pneumatic jigs use air. The device which is used for jigging is called jig. The schematic diagram for the different types of Hydraulic Jigs and Pneumatic Jigs are shown in Figure 8 and Figure 9

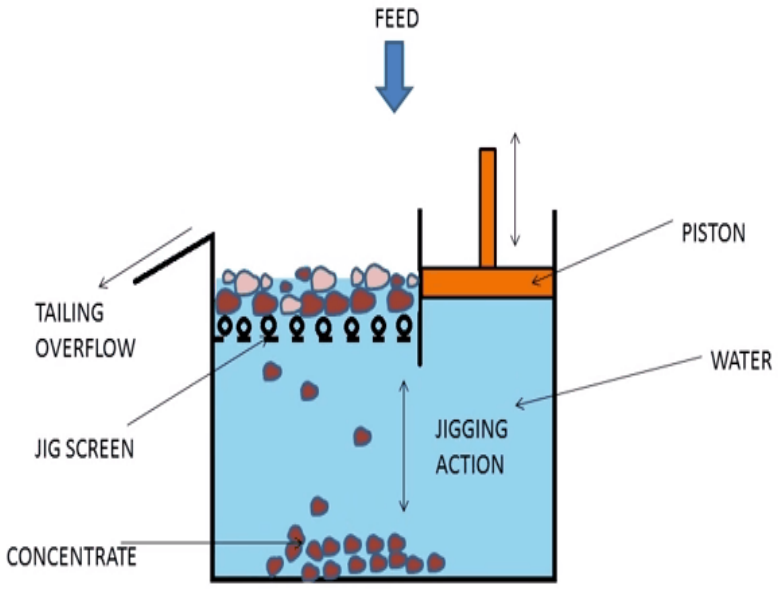

Fig. 8: Schematic diagram of Hydraulic Jig

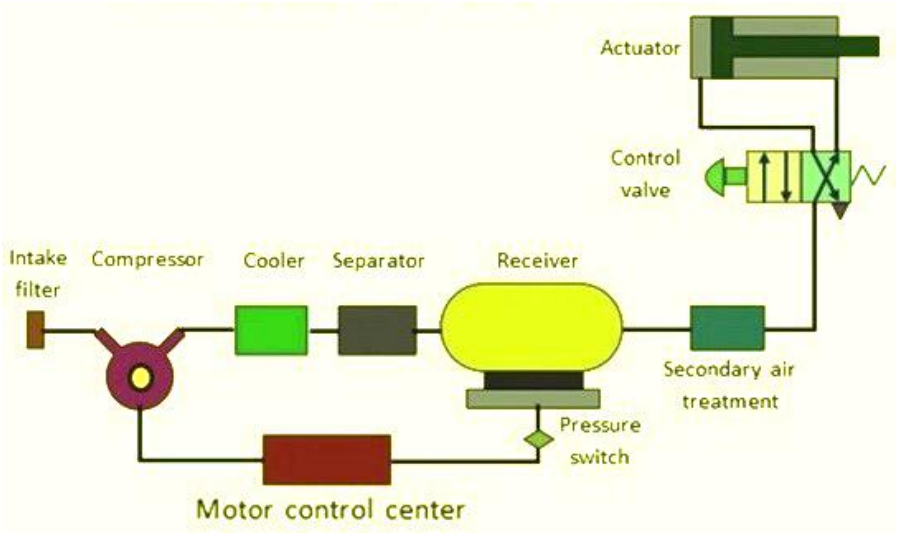

Fig. 9: Schematic diagram of Pneumatic system

D. Magnetic separation

Magnetic separation is a process of physical separation of the particles based on their magnetic property. In this, the term magnetic susceptibility is a property of a material that determines its response to a magnetic field. Based on this property, the minerals are classified into three groups such as Ferromagnetic, Paramagnetic and Diamagnetic.

Ferromagnetic minerals have high susceptibility to magnetic force and strongly attracted by the magnetic field like magnetite. The paramagnetic minerals are weakly attracted by magnetic fields. They can be concentrated by high- intensity magnetic separators. Examples of paramagnetic minerals are ilmenite, rutile, hematite etc. Similarly, the diamagnetic minerals are repelled along the lines of magnetic force to a point where the filed intensity is smaller and having the very small force of action.

The process of magnetic separation can be seen by Figure 10.

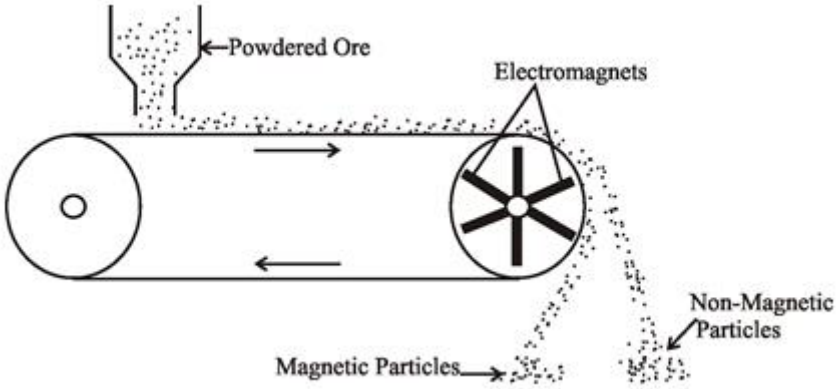

Fig. 10: Process of Magnetic Separation

E. Electrical Separation

It is a physical separation of particles based on their electrical properties. It can be divided into three major separation process such as Electrostatic separation, Electrodynamic separation and Dielectric separation. The first two separation process utilize the difference in electrical conductivity between various minerals which is present in the ore feed, whereas, dielectric separation utilizes the differences in dielectric constant of the mineral particles. The creation of high static filed in the process is done by the external power supply and the pictorial view of this process is shown in Figure 11.

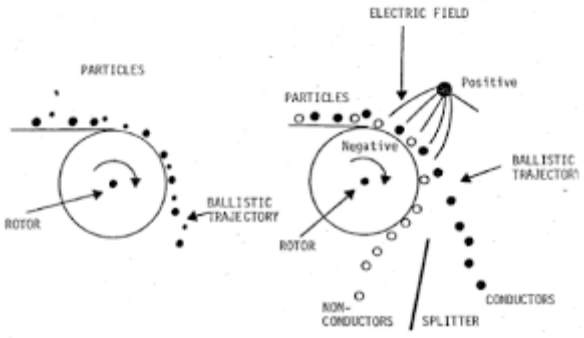

Fig. 10: Pictorial view of Electric Separation

IV. CONCLUSION

The mineral of any country carries a prestigious value in the country economy table. Thus, its complete process and beneficiation should be efficient and provide ease in operation. The aim of this research article is to provide a glance of the mineral beneficiation process in the Indian mining scenario. The complete beneficiation process was discussed in the five important stages, based on metal mining industry, which may provide the clear and visionary thought in the mining industry. There are several unique mechanical mineral processing methods adopted in earth science studies to improve the quality of any materials and make them economically viable. Thus, mineral processing technique helps to improve any raw materials in the sense of present market scenario. It also helps to identify critical minerals that are essential for an industry and emerging technology in domestic economy. Further, the identification mineral information and possible research initiatives that will enhance understanding of critical minerals and mineral products in a global context

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