Mineral Processing Route and Safety in Plant Operations

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Abstract

Sampling and Chemical characterisation of head sample are very important stage prior to choosing mineral processing route. Particle size analysis, Mineralogical assessment is another determinant for the liberation size of the mineral from the gangue; these guide in the determining the use of processing technique. Magnetic method, Gravity methods, Froth flotation, Dewatering and Scrubbing method are known mineral processing methods were used in arriving at a suitable processing route. The evaluation of health hazards within the treatment of mineral is gaining more and more importance in industries. The need to control occupational health and safety in plant operations has been recognized and regulations which describe general protective measurements for personnel provide a tool to protect their health. It is the aim of this paper to give details in the determination of mineral processing route and safety in plant operation for practical approaches to risk assessment and to present measures for exposure reduction.

Keywords: Mineral, Route, Safety, Plant, Processing

Introduction

Ore consist of extractable minerals and extraneous rocky material described as gangue. It can also be looked at as an accumulation of minerals in sufficient quantity so as to be capable of economic extraction. Types of ores are:

- Native ores - Metal is present in the elementary form e.g. gold, silver
- Sulfide ores - contains the metal as sulfide e.g. CuS, ZnS
- Oxide ores - valuable minerals occur as oxides, sulphide, silicate, carbonate or some hydrated form. e.g. SnO₂, Nb₂O₅
- Complex ores - contains profitable amount of more than one valuable minerals Cu – Pb – Zn – S ores are also classified according to their gangue, such as calcareous or basic (lime rich) and siliceous or acidic silicate

One must note that the minimum metal content (Grade) required for a deposit to qualify as an ore varies from metal to metal. Many non-ferrous ores contain as mined, little as 1% metal and others less. Gold is an example of this which may be required profitably in ores containing one (1) part per million (ppm) of the metal, whereas iron ore containing less than about 45% metal are regarded as low grade.

Mineral is the natural occurring material wealth mined from the earth crust[6]. In other word mineral is the form in which metals are found in the earth crust of the earth and as sea-bed deposit depend on their relativity with their environment[10]. Some are found practically with oxygen, sulphur and carbon dioxide (Sulphide, carbonate, and chloride form). Gold and platinum metals are found principally in the native or metallic form. Therefore, Mineral in a much sense include anything of economic value which is extracted from the earth. A particular mineral may be found mainly in association with one rock type e.g. cassiterite may be associated with granite rock, igneous rock or sedimentary rocks. Thus, when the granite is weathered, cassiterite may be transported and re - deposited as alluvia deposit. Due to the action of these natural agencies, mineral deposits are
found insufficient concentration to enable the metals to be profitably recovered. It is these concentrating agency and the development of demand as a result of research and discovery which convert a mineral deposit into an ore\(^5\).

**Mineral Processing**

Processing is the potential for value addition in other words termed beneficiation. In the nutshell Mineral processing or beneficiation is the potential for value addition to minerals that are produce either in its crude form or as a tailing dump until concentrate is achieved\(^6\).

Mineral beneficiation can cover the whole range of processes from basic ore dressing, such as Handpicking, ore crushing and screening, through to the manufacturing of final consumer goods.

**Why then the need to Process Minerals?**

Mineral processing is usually carried out to reduce not only smelting energy cost but also smelter metal losses, due to low metal bearing slag and also to reduce the penalty level being imposed by the smelter due to high level of impurities\(^7\). In other word, processing is aimed at value addition to minerals.

**Mineral Processing Route**

Mineral processing route is the systematic way toward separation of gangue from the crude or tailing to achieve concentrate of the ore, this involve Crushing, Grinding, Screen size analysis and Chemical composition determination which proceeded mineral processing proper\(^8\). However, it should be noted that the first stage in determining a processing route for a mineral is picking and analyzing a head sample to determine the chemical composition of the ore and the percentage of each element known as the assay. This then follows by Mineralogical assessment of the ore and screen size analysis which follow closely by crushing and grinding to its determined liberation size and finally adopt a processing technique.

**Crushing Process**

Mineral ores occurs in two basic ways namely Lode form and alluvial. The alluvia form is granular (sandy) in nature while the lode form is rocky in nature\(^9\). Thus the need for comminution process. Crushing of mineral is done using the following machines: Jaw crusher, Cone crusher and Roll Crusher.

**Jaw Crusher**

This is a primary crushing machine which reduces the size of material or mineral of interest from boulders of about 30 – 20 cm reduced to between 3 cm to 5 cm.

**Cone Crusher**

This is a Secondary crushing machine which also further reduces the size of minerals of interest from 5 cm to 2 cm.

**Roll Crusher**

This is a tertiary crushing machine which further reduces the size of mineral from 2 cm to 1 mm\(^10\).

**Grinding Process**

This is a mineral processing stage where by mineral is further reduced in size in order to be liberated from its gangue. It could be grinding or pulverized to less than 1 mm eg. 0.75 \(\mu\)m – 0.063 \(\mu\)m. Using either Ball milling machine, Rod milling machine, Grinding Plate machine or a Ring pulverizing machine.

**Mineralogical Assessment of an Ore**

This is the first stage in a mineral processing where by geologist pick samples prepare and mount sample toward viewing under the microscope. The microscopic analysis will determine the type of rock, the estimated liberation size and suggest he approach to mineral processing technique to be employed on the mineral as married with the screen size analysis\(^11\).

**Screen Size Analysis**

This is a very important stage in mineral processing in order to determine the liberation size of a mineral and to calculate the energy requirement for grinding of an ore to prevent over grind or under grind and to preserve energy used in grinding of mineral rock to its liberation size. This is usually done by arranging sieves from 1 mm to 0.063 mm. Prepared ore sample is charged into the array of sieve and shake for 15-30 minutes after which content of each sieves is measured recorded and calculated to determine the required size in which the ore should be grinded to achieve a good separation during processing\(^12\).

**Types of Processing Methods**

**Magnetic Method:** This exploit the difference in magnetic properties between the ore minerals and are used to separate either valuable mineral (magnetic) from non-magnetic gangue. This method can be classified into low and high intensity machines, which may be further classified into dry- feed and wet feed separator. However, low-intensity separators are used to treat ferro-magnetic material and some high magnetic material. This includes both wet method using Wet High Intensity Magnetic Separator (WHIMS) and dry method which include the use of Dry high intensity magnetic separator (Rapid machine or Cross Belt machine-BNF) for the removal of magnetite and hematite in mineral\(^10\) this is applicable in processing of Iron ore, Columbite - tin ore, Zircon sand, wolframite etc.
Gravity Methods: This can also be done using both Dry and wet gravity methods exploring the difference in density property of mineral to be processed. Dry method include the use of Kipp Kelly Air floating machine while wet method involve the use of Wifely shaking tabling, spiral concentrator and jigging machine (Jig). This is applicable in the processing of minerals like Iron ore, Lead – Zinc ore, Tin ore popularly known as casiteritetc[10].

Froth Floatation Method: This is a physic chemical separation process that utilizes difference in properties of valuable minerals and unwanted gangue minerals. The theory of froth flotation is complex involving three phases: Solids, Water and Froth (Air). This is the undoubtedly the most important and versatile mineral processing technique, and both its use and application are continually being expanded to treat greater tonnages and to cover new areas. It is a selective process and can be used to achieve specific separation from complex ores such as lead-zinc, copper-zinc, platinum, nickel, and gold hosting sulphates and oxides, such as hematite and cassiterite, fluorite, phosphates and fine coal. Processes of froth flotation involves:

- Selective attachment to air bubbles (or true flotation)
- Entrainment in the water which passes through the froth
- Physical entrainment between particles in the froth attachment to bubbles. (aggregation)

Types of froth flotation

a. Direct Flotation – Concentrate is usually transfer to the froth leaving the gangue in the floatation cell.

b. Indirect Flotation – Gangue is the froth leaving the concentrate in the floatation cell.

This involve the use of reagent (Chemicals) such as:

a. Collectors – Absorbs on mineral surface which rendered them hydrophobic and facilitate bubble attachment.

b. Frother – Help maintain a reasonable stable froth

c. Regulators – use to control the flotation process. It activate or depress mineral attachment to air bubbles and to control pH of the system[9].

Dewatering Process

This is a solid – liquid separation method, it produces a relatively dry concentrate. Partial dewatering is also performed at various stages in the treatment so as to feed for subsequent processes.

Dewatering process can be classified into the followings:

- Sedimentation  • Filtration  • Thermal drying

Sedimentation – this is most effective when there is a large density difference between liquid and solid. Rapid settling of solid particles in liquid produces a classified liquid which can be decanted, leaving a thickened slurry which may require further dewatering by filtration followed by thermal or sun drying. This is done or practice in the case of clayish material such as processing of Bentonite, Kaolin etc.

Scrubbing Process

This is the process whereby industrial minerals such as Barite, limestone, Beryl etc are processed by seizing to 2-5 cm, charged into the scrubbing machine drum agitated for a calculated time with sodium silicate added as a disliming agent. This is then discharged into a classifier that separates the concentrate from the gangue and classify the end product according to size after being free from clayish material adherence.

Safety in Plant Operations

Safety is the precautionary measures that need to be observed during processing or using machines in processing of minerals to prevent something undesirable from happening e.g. To prevent injury or damage. The evaluation of health hazards within the treatment of mineral is gaining more and more importance in industries. The need to control occupational health and safety has been recognized, and regulations which describe general protective measurements for personnel should be provided as a tool to protect their health. Occupational health and safety in all kind of operating plants is important because of the effect that the human being is a valuable good and must be protected[7].

Maintenance and control of cleaness is an important factor for the health and safety in every mineral processing plant. It guarantees not only health and safety, even the quality of work can be increased[7].

In the mineral processing industry everything should be done to protect the health of the employee. Therefore the health hazards have to be localized and assessed. Example of health hazards are inhalation of dust and powder, Noise, Smell, Stumbling, Cutting or stress in mineral industries[9].

The employer has a high responsibility for everyone working in his working environment. But even the employee plays a key role in protecting his own health by learning about the hazards and their control. He can learn what the standard requires and follows the standard. Signs and symptoms of health problems should be immediately reported to the employer and the employer is claimed to provide medical examinations or consultations[11]. Physically problems with individual occupational health and safety equipment (e.g. difficulty while wearing a respirator or nose mask) should also be reported and appropriate solutions must be found.

Exposure reduction is the main aim to protect the employee for (biological) hazards. With a totally casing of the
aggregates less dust and biological hazards can influence the surroundings. The danger can be minimized but not annulled, because for maintenance it is necessary to open some parts of the operating plant. For this situation the worker should be adequate equipped with personal safety equipment\(^8\). Personal safety equipment for a mineral processing plant are for example:

- Safety boots
- Helmet
- Safety Suit (Laboratory Coat)
- Filter Mask (Respirator)
- Hand Gloves
- Eye Protectors

In addition to this medical test and treatment should be conducted on employees regularly and an instruction of the employees through professionals regarding their health and safety should be conducted regularly\(^9\).

Furthermore, the assay and the consideration of environmental aspects concerning the occupational health and safety will motivate the employees and can reduce the lack of work through illness or injuries.

The security measures refer to as common preventive measures:

i. The employer has to accommodate the working method to the state of the art, he has also to choose suitable and safe procedures.

ii. The number of employees should be minimized, for no more than necessary are exposed to danger.

iii. Danger symbols should be visible and precautions for accidents and interruption of operations must be done.

iv. The way and duration of work is of importance for the occupational health and safety.

Everything has to be taken into account and has to be assessed.

In conclusion, the target was and has always been and still is to save the human resource because in spite of all technical developments and rationalizations work can never be done without human beings.

**Conclusion**

In conclusion, Mineral processing starts from sampling, Crude or head sample analysis, Particle size analysis, Mineralogical assessment, Crushing, Grinding through to selection of suitable processing methods such as Magnetic, Gravity, Froth flotation, Dewatering and Scrubbing processes until high concentrate is achieved alongside with this, personnel safety should be taken with seriousness by proving safety gears such as: Safety boots, Safety suit (Laboratory Coat), Filter mask (respirator), Hand gloves, Eye protectors, Helmet. With this, successful mineral processing route can be achieve in the industries in a healthy environment.

**References**


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