**Lecture 5: Methods of Mineral Beneficiation**

Mineral beneficiation is the first step in extraction of metal from natural resources. With the depletion of high grade metal ores it is important to increase the metal grade of an ore by physical methods; which are termed mineral beneficiation. The objectives of mineral beneficiation are:

* + тo increase the metal grade of ore
  + тo reduce the amount of gangue minerals so that lower volume of slag forms in pyromettallurgical extraction of metals. Slag contains mostly gangue minerals.
  + тo decrease the thermal energy required to separate liquid metal from gangue minerals.
  + тo decrease the aqueous solution requirement in hydrometallurgical extraction of metals.

What constitutes mineral beneficiation?

Ore is an aggregate of minerals and contains valuable and gangue minerals. The mineral beneficiation involves separations of gangue minerals from ore and is done in the following two stages:

* + ***Liberation of valuable mineral by size reduction technologies***. In most ores the valuable minerals is distributed in the matrix of ore.
  + Concentration technologies to separate the gangue minerals and to achieve increase in the content of the valuable mineral to increase the metal grade.

Sizes reduction technologies

Size reduction or communication is an important step and may be used

* + to produce particles of required sizes and shapes
  + to liberate valuable mineral so that it can be concentrated.
  + to increase the surface area available for chemical reaction.

It is often said that the efficiency of energy utilization during fragmentation of solid particles is only about 1% with respect to the new surface created. Energy consumption represents major cost in the mineral processing operation.

Crushing and grinding are size reduction methods. Crushing is applied to subsequent size reduction down to about 25mm. In grinding finer size is produced. Grinding or milling is an important size reduction method. In grinding force is applied by a medium which could either balls or rods. Both dry and wet grinding is done. Wet grinding has the following characteristics.

* + It requires less power;
  + It does not need dust central equipment:
  + Wet grinding uses more steel grinding media to mill the material/per ton of product, as a result there occurs increase in erosion of the lining material.
  + Water is required for wet grinding.
  + Material balance is important to determine
  + Amount of water in a milling circuit
  + *%* solid in slurry (slurry is a mixture of solid in water )

In wet milling water /solid ratio is important to control the viscosity of slurry. Too dilute slurry will lead to excessive wear of the medium. Too high a solid concentration results in cushioning of the medium. Percent solid in slurry can be determined by

Concentration technologies: Basics

The objectives of concentration technologies is to separate the valuable mineral from the gangue minerals. In all concentration methods feed is divided in three streams, namely concentrate, middling and tailings. Middlings are recycled within the plant and as such the plant output is two products, namely concentrate and tailings. Tailings are disposed whereas concentrate is sent to metal extraction.

Concentrate methods:

The most important processes are

1. ***Gravity concentration***
2. ***Flotation***
3. ***Magnetic and electrostatic separation***

Gravity separation separates the minerals according to their different densities. It is used for the concentration of very heavy or very light minerals within a wide range of grain sizes.

In heavy media separation the density of pulp is intermediate between that of valuable mineral and gangue minerals. In that case light minerals float on top and the heavy minerals sink to the bottom of the pulp independent of particle size.

Other methods of gravity concentration utilize a combination of gravitational, inertial, frictional and viscous effects. Commonly used methods are jigging, washing tables, spirals etc.

Separation by flotation is based on the ability or lack of ability of different surfaces to be wetted by water. Hydrophobic minerals will cling to the air bubbles and rise with them, whereas the hydrophilic minerals will sink. Reagents like frothers, collectors, activators, depressors and conditioners are added to make the separation. Floatation has found its greatest application in the concentration of the sulphide minerals.

Electro statics and magnetic separation is based on differences in electrical conductivity of the mineral and magnetic properties the minerals respectively.

An ore beneficiation technique may entail various unit operations, some of which are listed in Table 4.1

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 4.1** | **Unit Operations in Mineral Dressing** | | |
| **Process** | **Description** | **Properties of mineral exploited** | |
| Comminution | | | |
| **Crushing, grinding** | Subdivision of mineral lumps and particles into smaller sizes | Brittleness | |
| Sizing | | | |
| **Sorting or hand-picking, screening** | Separation according to size | Size difference among particles | |
| **Hydraulic classification** | Settling in fluid | Relative difference in size and density among mineral particles | |
| Concentration | | | |
| **Gravity concentration** |  |  | |
| Heavy media separa­ tion | Settling in liquid | Relative difference in density among particles | |
| Jigging | Settling in liquid | Relative difference in density among particles | |
| Tabling | Frictional movement along wet  vibrating solid surface | Density, size, shape, and coeffi­cient of friction | |
| **Magnetic separation** | Separation due to magnetic field  in dry or wet condition | Magnetic permeability and mag­netic susceptibility of particles | |
| **Electrostatic separation** | Charging and charge loss of  particles and their deflections in electrostatic field | Conductivity and charge-retention characteristics | |
| **Flotation** | Attachment of gas bubbles to  mineral in aqueous pulp con­ taining surfactants and frothers  Subsequent preferential froth flotation for some minerals | Surface properties  Affinity for specific surface-active reagents | |
| Dewatering | | | |
| **Sedimentation thicken­ing** | Settling of particles | Nonspecific | |
| **Coagulation** | Neutralization of charge or re­  pulsive forces | Adsorption properties of minerals may lead to beneficiation | |
| **Filtration** | Solid-liquid separation | Nonspecific | |
| **Drying** | Removal of moisture from moist solid | Nonspecific | |
| Agglomeration | | | |
| **Pelletizing, nodulizing,**  **sintering** | Obtaining bigger lumps from  small particles through adhesion or fusion of particles | | Solid-solid reaction at s of particles |

**Words and Word-Combinations to Be Memorized**

1. mineral beneficiation - обогащение полезных ископаемых
2. natural resource - природный ресурс
3. depletion - истощение
4. high grade metal - высокая степень металл
5. increase - увеличить
6. decrease - уменьшить  
   objective – задача, цель
7. reduce – снижать, уменьшить
8. liberation of valuable mineral - освобождение ценного минерального сырья
9. size reduction technologies - использования технологий измельчения

(сокращения размера)

1. comminution – измельчение
2. required sizes and shapes - необходимые размеры и формы
3. create – создавать
4. energy consumption – потребление энергии
5. crushing – дробление
6. grinding - размол
7. grinding – имельчение
8. balls or rods – шарики или стержни
9. dry and wet grinding - сухое и мокрое измельчение
10. dust – пыль
11. lining material – облицовочный материал
12. slurry – суспензия
13. water /solid ratio - соотношение вода(жидкость)/твердое
14. viscosity – вязкость
15. dilute – разбавлять
16. concentrate - концентрат
17. middling – промежуточный продукт
18. tailings – хвосты
19. dispose – выбрасывать
20. gravity concentration – гравитационное концентрирование
21. flotation - флотация
22. мagnetic and electrostatic separation- магнитное или электростатическое разделение
23. float on top - всплывает на поверхность
24. sink to the bottom – оседать на дно
25. in dependent of particle size - в зависимости от размера частиц
26. hydrophobic minerals will cling to the air bubbles - Гидрофобные минералы будут цепляться за пузырьков воздуха
27. hydrophilic minerals will sink - гидрофильные минералы утонет
28. frothers, collectors, activators, depressors and conditioners - пенообразователи, коллекторы, активаторы, депрессорами и кондиционеры
29. electrical conductivity – электрическая проводимость

Control questions:

1. What is mineral beneficiation?
2. Explain the objectives of mineral beneficiation?
3. What constitutes mineral beneficiation?
4. What purposes size reduction or communication?
5. Classify concentrade methods.