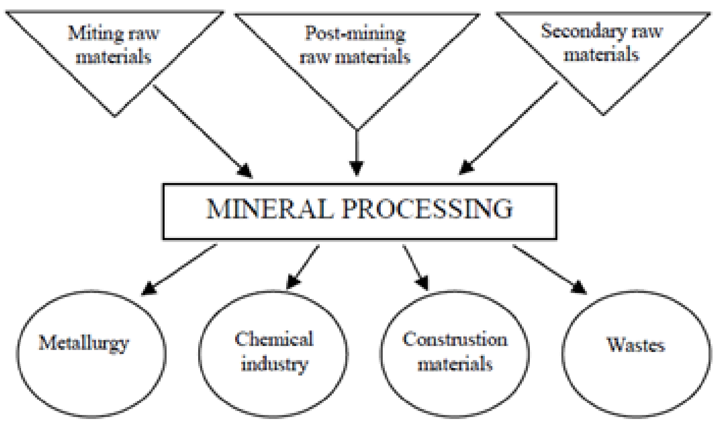
Mineral processing

Mineral processing is a branch of science and technology dealing with processing of natural and synthetic mineral materials as well as accompanying liquids, solutions and gases to provide them with desired properties. It is a part of technical sciences, although it contains elements originating from other fields of knowledge, especially natural sciences. Mineral processing is based on separation processes and is involved in performing and description of separations, as well as their analysis, evaluation, and comparison.

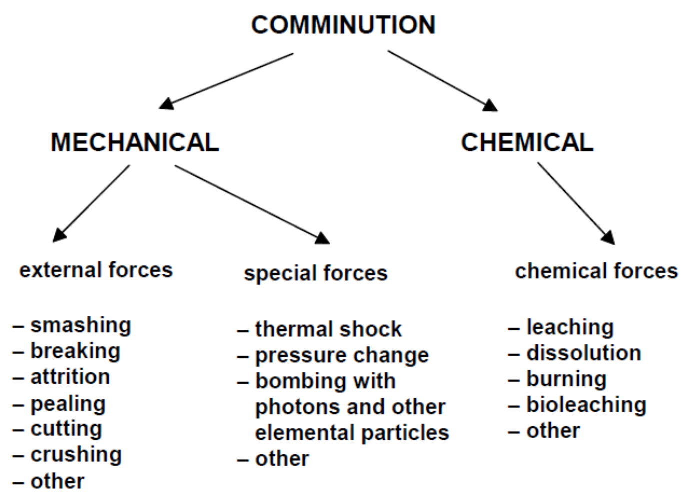
The history of mineral processing is as old as that of a man. Cleaving stones, sharpening flint stones and sorting were one of the first mineral processing activities practiced by humans. A considerable development of mineral processing and its physicochemical basis took place within the last hundred years. Processing of useful minerals has become a branch of science and technology closely cooperating with mining and chemical industry as well as other branches of industry. Minerallurgy also deals with utilization of industrial and municipal wastes. The products manufactured by minerallurgists are utilized by metallurgical, chemical, civil engineering, and environmental protection industries.



Place of mineral processing in science and practice

Comminution

Comminution is performed for the reduction of particle size. The process requires application of forces. It can be accomplished in a mechanical or chemical way Mechanical comminution is a result of operation of external or special forces while chemical size reduction is based on the removal of certain particles or their fragments by dissolution or leaching with or without precipitation of other substances. Chemical comminution is different in character from physical size reduction, therefore it is a part of extraction metallurgy rather than mineral processing.

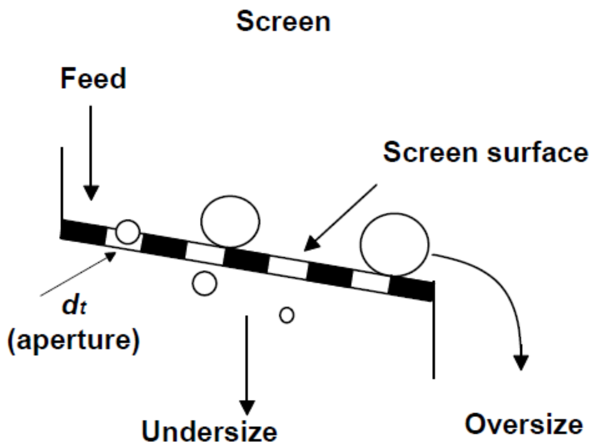


Methods of particle comminution

Comminution can be accomplished by crushing or grinding. Crushing is performed on large particles while grinding on particles smaller than about 50 mm grinding deals with particles smaller than about 50 mm and is performed in mills containing the feed, water and grinding media. Balls, cylindrical pebbles (cylpebs), bars, pebbles, as well as lumps of the same material are used as grinding media. The grinding media can be metallic or ceramic. Grinding consumes considerable amount of energy, therefore effective carrying out of the process is very important. Excessive grinding (overgrinding) should be avoided because of its high cost and fine grinding usually makes further upgrading difficult. Each method of separation requires optimal range of particle size. To meet this requirement the size reduction, as a rule, is coupled with either mechanical or hydraulic classification for the removal of proper size particles from comminution environment.

Screening

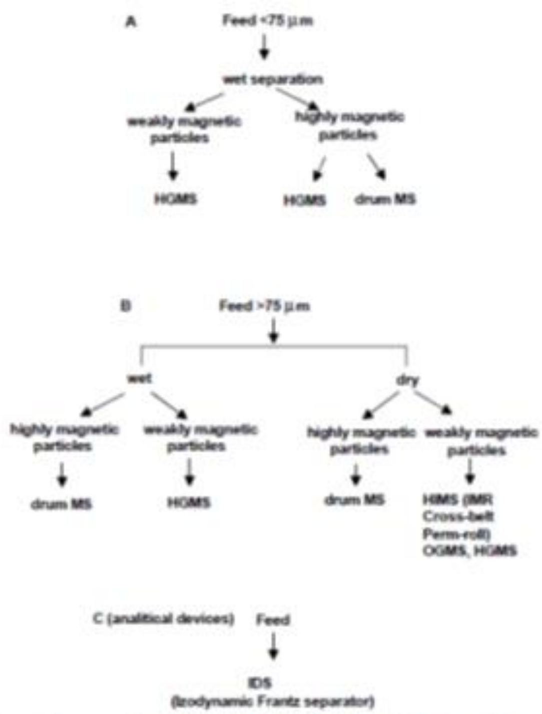
Screening, also called mechanical classification, is a separation process which utilizes the differences in particle size. The particles which are smaller than screen opening pass through the screen while larger particles either remain on the screen or fall off at a designated place. The purpose of screening is splitting the feed into two or more, differing in size, products. The main parameter, due to which separation takes place, is the particle size. Screening is a continuous process performed on a large scale while sieving is performed on sieves on a small batch laboratory scale (Kelly and Spottiswood, 1982). Each screen usually provides two products. To obtain more products it is necessary to use additional screens. Particles going through the screen form a product usually called undersize, minus, or lower product, while the ones remaining on the screen are known as oversize, plus, or upper product. Other names are also used including concentrate and waste. Intermediate product is the material passing through one and retained on a subsequent screen. Screening is frequently used as the method of separation, and is applied both as a single operation or in combination with other processes.



Screening. Main parameter of screening is particle size

Magnetic separation

The questions discussed so far involved the properties of diamagnetics and paramagenetics (true paramagnetics, ferrimagnetics, antiferromagnetics, ferromagnetics). From a practical point of view substances are divided into magnetic and non-magnetic materials. Non-magnetic particles are characterized by zero or negative value of magnetic susceptibility while magnetic particles by positive values taking into account actual magnetic properties resulting from impurities which can considerably alter magnetic susceptibility of particles. $SnO2$ or (Ca, Mg)$CO3$ can serve as an example, which as pure chemical substances are non-magnetic, while their mineral equivalents, cassiterite and dolomite, always show some positive magnetism. Magnetic impurities can cause that magnetic susceptibility of contaminated material depends on the intensity of magnetic field. It should be added that the same minerals, originating from different sources, can feature different magnetic susceptibility.

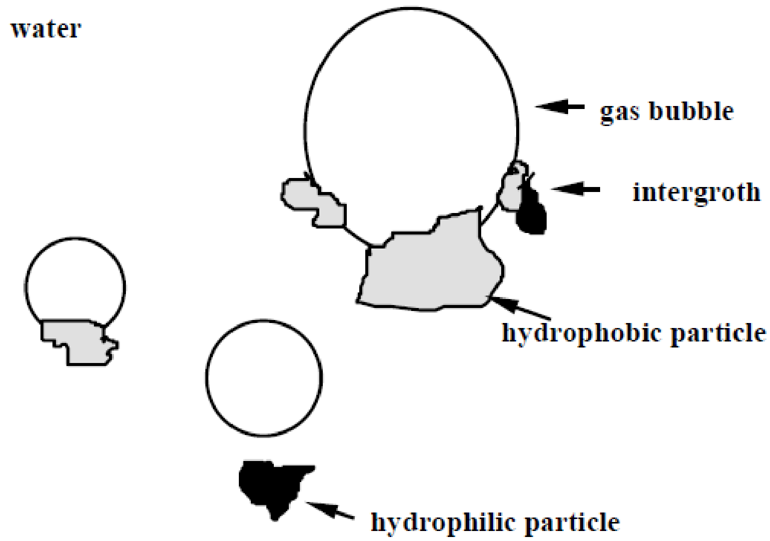


Types of magnetic separations classified according to particle size and way of separation: drum MS – separation in a field of low intensity of magnetic field (or shortly LIMS), HIMS – separation in high intensity magnetic field, e.g. IMR (induced magnetic roll), HGMS – separation in high gradient magnetic field, OGMS – separation in an open gradient field in superconducting devices, IDS – separation in isodynamic magnetic field

Flotation

Flotation is one of many methods of separation and can be used for separation of phases, for instance to remove solid particles or oil drops from water. More frequently flotation is used for separation of particles having different hydrophobicities. Hydrophobicity is a feature of material characterizing its ability to be wetted with a liquid in the presence of a gas phase. In mineral processing, solids which can be easily wetted with water are called hydrophilic, while solids with limited affinity for wetting are called hydrophobic. As a result of hydrophobicity, particles adhere to a gas bubble forming a particle-air aggregate which is lighter than water, and travels upwards to the surface of water. Hydrophilic particles do not adhere to the bubbles and fall down to the bottom of a flotation tank.

Substances can be hydrophobic to a different degree and the measure of their hydrophobicity is contact angle. The contact angle (Fig. 12.2) is determined by straight lines drawn from the point of contact between a particle, gas and water which are tangent to the solid–gas, gas–water, and solid–water interfaces. Commonly, contact angle is expressed and measured as an angle between gas and solid phases, through the water phase. The contact angle can be also defined as the angle between solid and water phases, through the gas phase. Both ways of expressing contact angle are equally


water
gas bubble
intergroth
hydrophobic particle
hydrophilic particle

Flotation