Comminution

- In order to separate the minerals from gangue (the waste minerals), it is necessary to crush and grind the rock to **unlock**, or ***liberate***, valuable minerals so that they are partially or fully exposed.
- This process of size reduction is called ***comminution***.
- The crushing and grinding process will produce a range of particles with varying degrees of ***liberation***
- The comminution process actually begins during the mining stage through the use explosives, excavators or scrapers for softer material.
- Comminution during the mining stage is necessary in order to generate a material that is transportable by haul trucks or conveyors.
- Comminution in the mineral processing plant is carried out in a sequential manner using **crushers** and screens followed by **grinding mills** and **classifiers**.

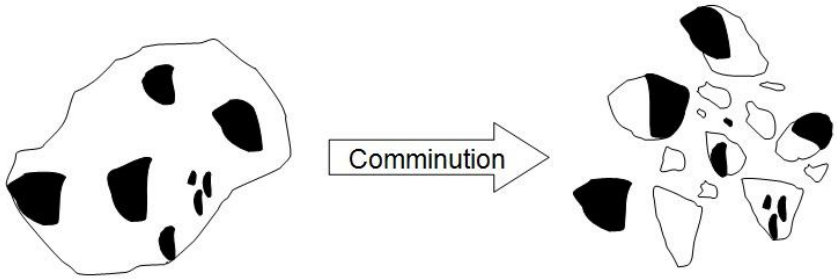


Figure . Breaking of larger material to smaller pieces result in particles with varying degrees of liberation. The darker regions represent the valuable mineral

Crushing

- Crushing is the first mechanical stage in the process of comminution, it is generally a dry operation and is usually performed in two or three stages.
- **Primary crushing;** the objective of primary crushing is to reduce the size of the rock extracted from the mine to an average diameter of 10-20 cm.

- Within the crushing circuit, a primary crusher reduces material down to a size that can be conveyed and fed to the secondary crushing circuit.
- The two most common primary crushers used for coarse run-of-mine material are the ***jaw*** and ***gyratory*** crushers.
- **Secondary crushing;** includes all operations for reclaiming the primary crusher product from ore storage to the disposal of the final crusher product, which is usually between 0.5 and 2 cm in diameter.
- The most common type of secondary crusher is the cone crusher.

Crusher can be classified to;

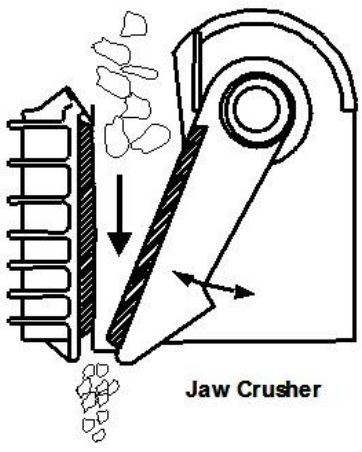
- Coarse primary crusher
- Intermediate crushing
- Fine crushing

Factors affecting the crushing process

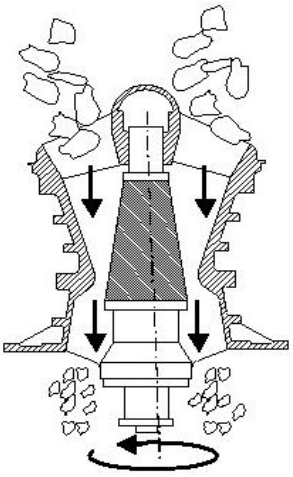
- The reduction ratio
- Speed and amplitude to strokes and movable jaw
- Size distribution of feed
- Hardness of rocks

Types of crushers

Jaw crusher; the distinctive feature of this class of crusher is the two plate which opened and shut like animal jaw. A Jaw Crusher reduces large rocks by dropping them into a flat "V" shaped space created between a fixed surface and a movable surface.

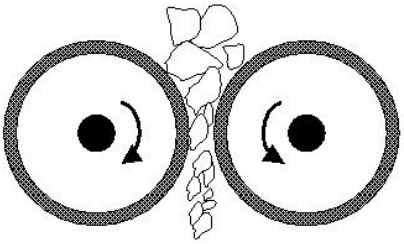

Jaw Crusher

In a **gyratory crusher**, a round moving crushing surface is located within a round hard shell which serves as the stationary surface (figure 3). The crushing action is created by the closing the gap between the hard crushing surface attached to the spindle and the concave liners (fixed) mounted on the main frame of the crusher.



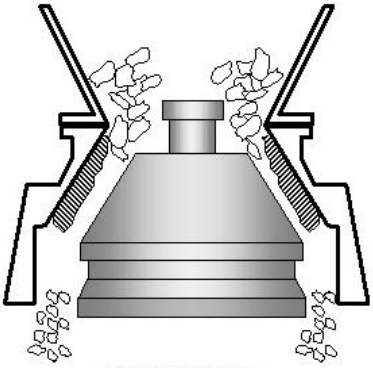
Gyratory Crusher

Roll crusher; Rolls crushers consists of a pair of horizontal cylindrical rollers through which material is passed. The two rollers rotate in opposite directions nipping and crushing material between them. These types of crushers are used in secondary or tertiary crushing applications.



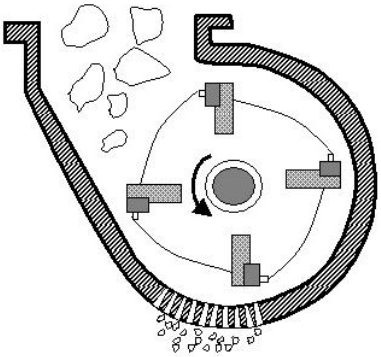
Basic Elements of a
Rolls Crusher

Cone crusher; are used for crushing all kind of ores and rocks with medium and above medium hardness in many industries. A cone crusher is very similar to the gyratory but has a much shorter spindle with a larger diameter crushing surface relative to its the vertical dimension.



Cone Crusher

Impact crusher; is used successfully for relatively nonabrasive material such as coal and limestone. Impact crushers involve the use of high speed impact rather than compresssion to crush material. These crushers are normally employed for secondary or tertiary crushing.



Basic Elements of an Impact Crusher

Grinding

Grinding, the final stage used in the comminution process, is usually conducted in ***cylindrical tumbling mills***, ***stirred mills, or vibrating mills,*** where the particle size is reduced through a combination of impact and abrasion. The main types of tumbling mills are; **ball mills**, **rod mills**, **autogenous (AG) mills**, and **semi-autogenous (SAG) mills**.

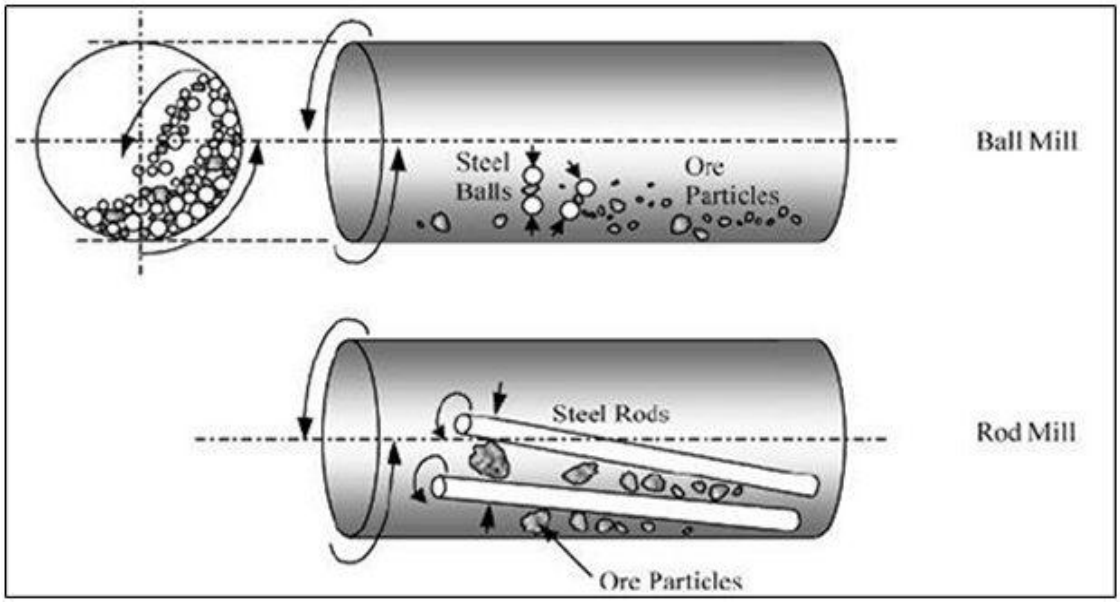


Figure : Mechanism of grinding in tumbling mills

Grinding may serve the following purposes in engineering:

- increase of the surface area of a solid
- manufacturing of a solid with a desired grain size
- pulping of resources

Grinding medium

The feed can be ***wet*** or ***dry***, depending on the subsequent process and the nature of the product.

Dry grinding is necessary with some materials due to physical or chemical changes which occur if water is added. It causes less wear on the liners and grinding media and there is a higher proportion of fines in the product, which may be desirable in some cases.

Wet grinding is generally used in mineral processing operations because of the overall economies of operation.

The advantages of wet grinding are:

1- It consumes lower power per tonne of product.

2- It has higher capacity per unit mill volume.

3- It makes possible the use of wet screening or classification for close product control.

4- It eliminates the dust problem.

5- It makes possible the use of simple handling and transport methods such as pumps, pipes, and launders.

Main factors affecting the production capacity of grinding mill

There are plenty of factors that affect the capacity of grinding mills such as:

1. The hardness of raw materials. If the hardness is high, it is difficult to grind.

2. Output size (or finished size, final size): the smaller of the output size, the lower of the production capacity.

3. The humidity of the grinding materials. If the raw materials contain high percent water, the materials will easily adhere to the surface of the grinding mill and block the grinding speed.

4. The composition of the grinding materials. If there is much powder in the raw material, it may reduce down the capacity since the powder will easily adhere.

5. The quality of quick wear parts (such as hammer mill, grinding rollers). If the quick wear parts have no good abrasive resistance, it will decrease capacity in the long run.

Selection of mills for different applications

Some of the characteristics and requirements to be considered when selecting a mill for a particular application are:

- *Mineral properties*.
- *Capacity.*
- *Reduction ratio and final size requirement*.
- *Power requirements and type of power supply*.
- *Wet or dry product*
- *Continuous or batch operation.*
- *Portable or stationary equipment required*.
- *Cost*; capital costs, running costs, and maintenance costs.

Ball mill

- A typical type of fine grinder is the ball mill.
- A slightly inclined or horizontal rotating cylinder is partially filled with balls, usually stone or metal, which grinds material to the necessary fineness by friction and impact with the tumbling balls.
- The primary differences between these mills are in the ratio of diameter to the length of the cylinder and the type of grinding media employed.

- Ball mills normally operate with an approximate ball charge of 30%.
- The feed is at one end of the cylinder and the discharge is at the other.
- Industrial ball mills can be as large as 8.5 m (28 ft) in diameter.

Screening and Classification

The size distribution of the particles must be controlled for a number of reasons at various stages of a mineral processing plant:

- To enable undersized material to bypass the crushing or grinding circuit and to retain oversized particles for further size reduction,
- To provide an optimum particle size material for efficient processing in the downstream separation and concentration systems, and
- To prepare product that meets particle size specifications required for the market place.
- There are two distinct methods for separation of particles based on size: ***screening and classification***.

Screening

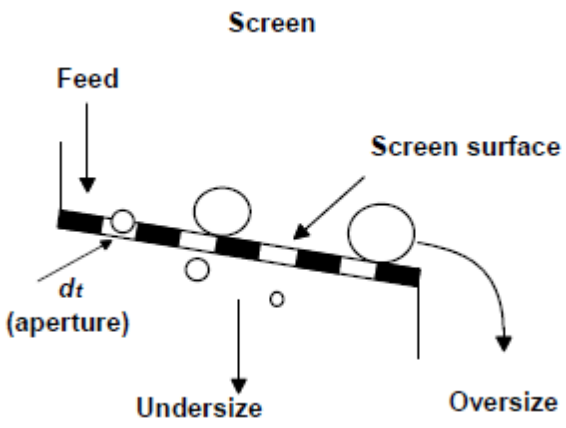
Separation of mixture of particles of various sizes into two or more fractions by a screening surface. Screening is a method of separating particles according to size alone.

In its simplest form, the screen is a surface having many apertures, or holes, usually with uniform dimensions.

Particles presented to that surface will either pass through or be retained, according to whether the particles are smaller or larger than the governing dimensions of the aperture.

Over size material; Material that retain on the screening surface is called over size material.

Under size material; Material that passes through the screening surface is called under size material.



The purposes of screening equipment are many and varied. Likewise, there are a wide range of screening objectives. The main purposes in the minerals industry are:

(a) *Sizing* or *Classifying,* to separate particles by size.

(b) *Scalping,* to remove the coarsest size fractions in the feed material, usually so that they can be crushed or removed from the process;

(c) *Grading,* to prepare a number of products within specified size ranges.

(d) *Media recovery,* for washing magnetic media from ore in dense medium circuits;

(e) *Dewatering,* to drain free moisture from a wet sand slurry;

(f) *Desliming* or *de-dusting,* to remove fine material, generally below 0.5 mm from a wet or dry feed.

Screen types

There are numerous different types of industrial screens available in wide use for both coarse and fine screening applications.

Grizzly

Grizzlies are used for rough screening of coarse materials and are most often found in crushing circuits. A grizzly is basically an inclined set of heavy bars set in a parallel manner. Coarse material slides on the inclined surface of the bars and material finer than the spacing between the bars falls through .

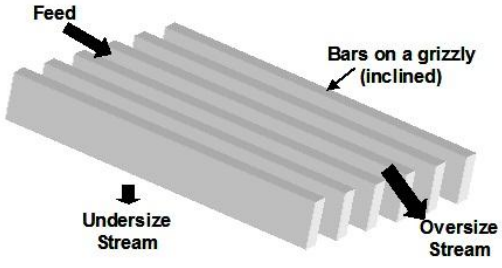
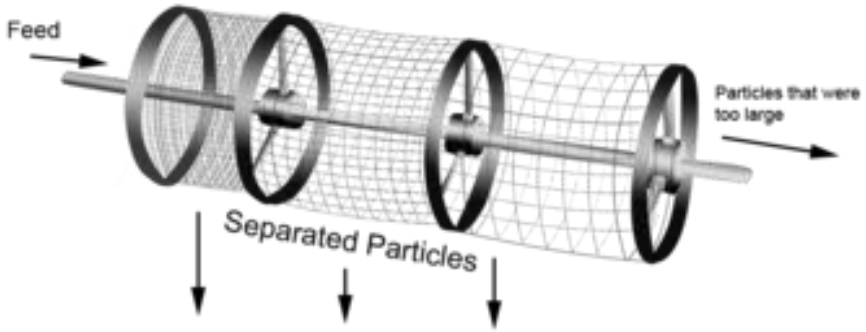


Figure - A grizzly

Revolving Screen (Trommel)

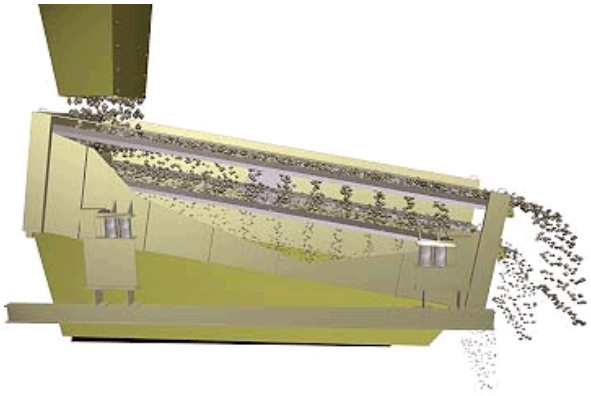
A trommel is a slightly inclined rotating cylindrical screen. The material is fed at one end of the cylinder and the undersize material falls through the screening surface while the oversize is conveyed by the rotating motion down the incline to the discharge end.



Moving Screens (vibratory and others)

There are various types of horizontally inclined screens such as the reciprocating, oscillating, vibratory or shaking screening. The basic difference in these screens is based upon the motion of the surface and the resulting action imparted on the material being screened. The vibratory screen is probably the most common screening device found in mineral processing applications.

Vibratory Screen



Classification

Classification is a method of separating mixtures of minerals into two or more products on the basis of particle size and particle specific gravity.

It is a wet process (although dry classification exists) and involves a moving fluid medium which transports the particles to separate products.

In mineral processing, the fluid medium is usually water, and wet classification is generally applied to mineral particles which are considered too fine to be sorted efficiently by screening.

Sedimentation and Hydraulic Classifiers

Free settling classifiers are essentially large pools, ponds or conical bottomed tanks with a free settling zone. The coarser particles sink and are removed from the bottom of the settling zone.

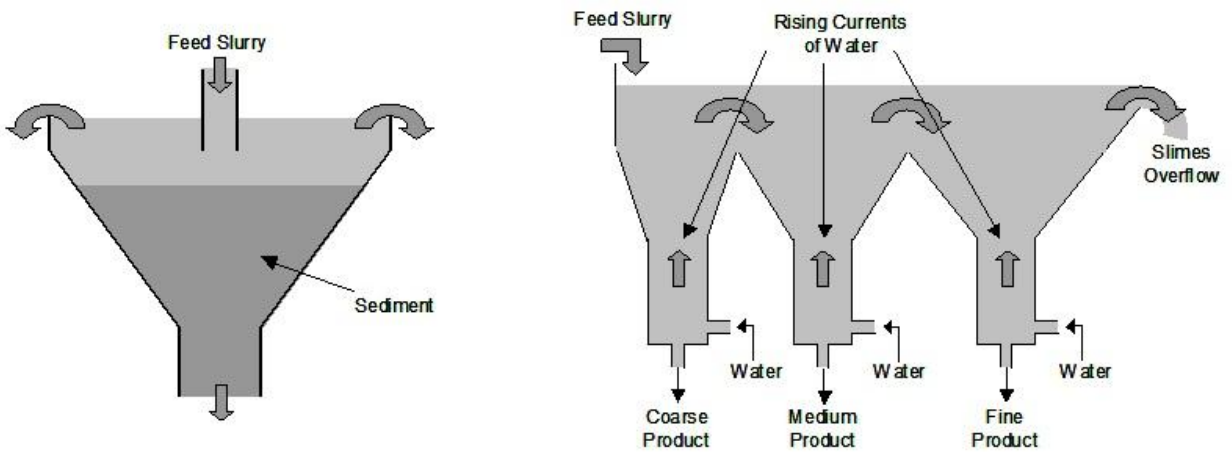


Figure Elements of a sedimentation (left) and hydraulic classifier (right)

Spiral and Rake Classifiers

Mechanical classifiers such as the spiral and rake classifiers work in a similar fashion in that both drag sediment and sand along the bottom of an inclined surface to a higher discharge point on one end of the settling chamber. The primary difference in the two

systems is the mechanism by which the settled material is moved up the inclined surface (see figure).

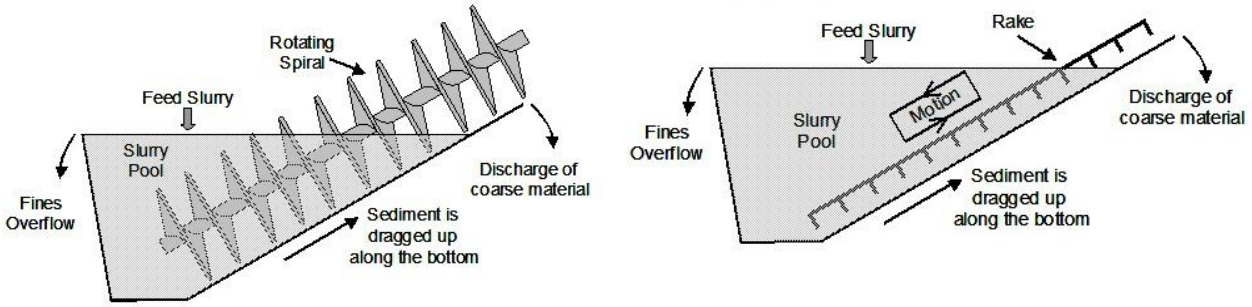


Figure Elements of spiral and rake classifier

Hydrocyclones (Cyclones)

Hydrocyclones have become one of the most important and widely used classifiers in the mineral processing industry.

They are also used for de-sliming, de-watering, de-gritting and thickening processes. They are most commonly employed in closed circuit within grinding circuits and are used to return coarse material back to the ball or rod mill for further grinding.

The main advantages of cyclones is that they have large capacities relative to their size and can separate at finer sizes than most other screening and classification equipment.

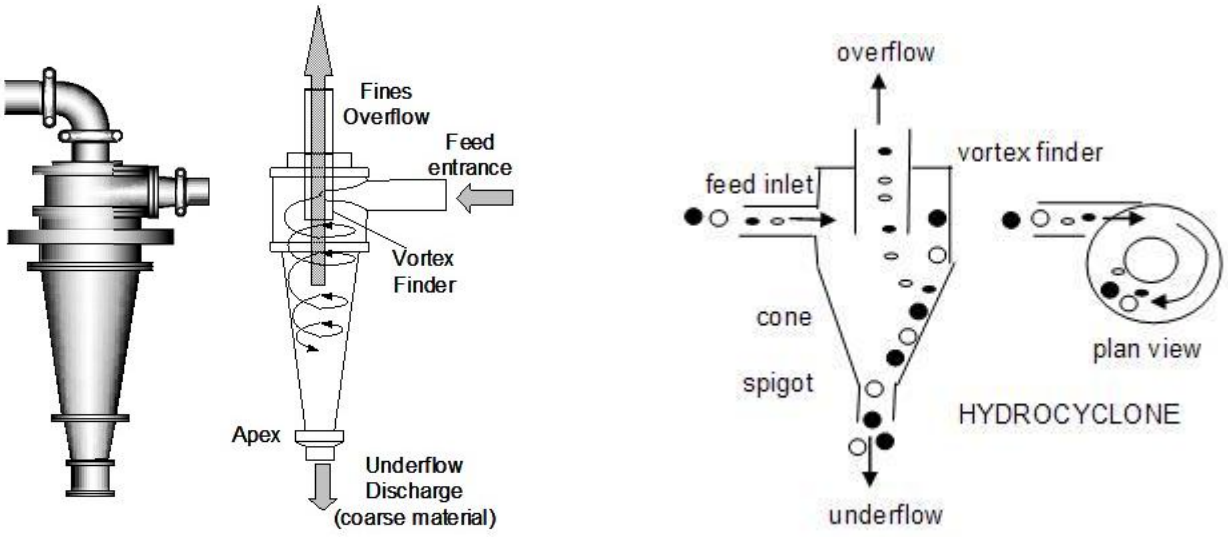


Figure . Hydrocylone pictures and elements of operation