

SYNERGY POLYTECHNIC BHUBANESWAR



(DEPARTMENT OF MINING ENGINEERING)
LECTURE NOTES ON
MINE GEOLOGY-II
(6TH SEMESTER)



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Lecture Notes of Minerals Dressing (Department of Mining Engineering)

Chapter 1- UNIT OPERATIONS

Introduction to Crushing:

Comminution is the process by which mined **ore** is reduced in size to make for easier processing. The strict definition is 'the action of taking a material, specifically mineral ore, and reducing it to minute fragments or particles. This is typically achieved in several stages of a detailed and professional **mining** operation.

Jaw Crusher

A jaw or toggle crusher consists of a set of vertical jaws, one jaw being fixed and the other being moved back and forth relative to it by a cam or pitman mechanism. The jaws are farther apart at the top than at the bottom, forming a tapered chute so that the material is crushed progressively smaller and smaller as it travels downward until it is small enough to escape from the bottom opening.

TYPES OF JAW CRUSHERS

1.Blake jaw crusher:

In the Blake or jaw crusher the moveable jaw is pivoted at top. The greatest amount of motion is at the bottom which means it has the little tendency to choke.

2.Dodge jaw crusher:

In the dodge jaw crusher the moving jaw is pivoted at the bottom. As minimum movement is at the bottom it has a greater tendency to choke.

PRINCIPLE OF JAW CRUSHER

This jaw crusher uses motor as its power. Through the motor's wheels, the eccentric shaft is driven by the triangle belt and slot wheel to make the movable jaw plate move by a regulated track. Therefore, the materials in the crushing cavity composed of fixed jaw plate, movable jaw plate and side-lee board can be crushed and discharged through the discharging opening

Purpose of Material Crushers (Size Reduction)

A **crusher** is a machine designed to reduce the size of large rocks to **smaller rocks, gravel, sand, or rock dust**; this is essential for efficient transport of the product via conveyors etc. Crushing is the first of many stages that lead to separation of the **mineral(s)** from the **waste (gangue)** material. Waste material can be discarded or recycled allowing the mineral rich product to be further processed at the main plant.

Various types of **crusher** and **mineral separator** may be employed depending upon the **throughput**, **hardness**, and **properties** of the mineral being processed. In all cases, the crushing stage is essentially achieved by transferring a mechanically amplified force (via **mechanical advantage**) to a material, to breakdown the bonds which hold the material together.

Crushing is achieved by passing the feed between two solid surfaces, then by applying sufficient force to bring the surfaces together so that the molecules of the material being crushed are **separated** from (**fracture**), or, **change alignment** in relation to (**deform**), each other.

Crushers are commonly classified by the degree to which they fragment the starting material, with **primary** and **secondary** crushers handling **coarse materials**, and **tertiary** and **quaternary crushers** reducing particles to **finer** gradations. Each crusher is designed to work with a certain maximum size of raw material, and often delivers its output to a **screening machine (screener)** which sorts and directs the product for further processing. In many cases, initial crushing stages are followed by further milling stages (if the materials need to be further reduced); see our [ball mill](#) article for further details.

Selecting crushing and grinding equipment:

- Mine operators need to choose the correct mining machinery and processing equipment based on factors such as geological conditions and ore type.
- Selecting the correct crusher depends on ore characteristics such as abrasiveness, fragility, softness or stickiness, and the desired outcome. The crushing process can include primary, secondary, tertiary and even quaternary crushing stages.
- Screens are used to separate rocks, ores and other materials by size. The crushed ore is sent to the grinding circuit to reduce the material into finer particles.

BLAKE JAW CRUSHER

The Blake jaw crusher, also known as the double toggle jaw crusher, is characterized by its heavy-duty design. It consists of a fixed jaw plate (also called a stationary or fixed jaw) and a movable jaw plate (also called a swing jaw). The movable jaw is pivoted at the top, and the motion of the swinging jaw is produced by the vertical movement of the eccentric shaft. This type of jaw crusher is ideal for crushing hard and abrasive materials, as the swinging motion of the jaw plates allows for a higher compression ratio.

What is the work of Blake jaw crusher?

Blake Crushers are Jaw Crushers with a movable jaw pivoted at the top, giving greatest movement to the smallest lumps. The throw of Blake jaw crushers is determined by the hardness of the ore as well as the size of the machine. It may vary from 4 in for hard but friable ores to 3 in for resilient material.

APPLICATIONS -

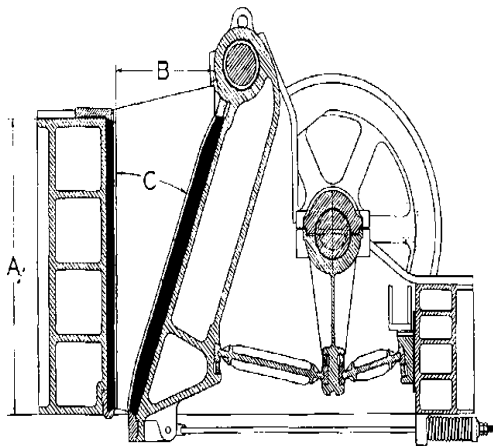
It is used for reducing run-of-mine ore or coal to a size small enough to be taken by the next crusher in the series during the first stage of crushing.

TECHNICAL SPECIFICATIONS:

1. Toggle Type: Single or double toggle
2. Feed size: 100 mm
3. Product Size: (5-15) mm
4. Capacity: 20-30 kg/hr.
5. Jaw Type: One fixed jaw and one movable jaw with Mn steel Liner. Provisions for output gap adjustment is available.
6. Feed materials: Coal, iron ore, Mn ore, Chromite ore, Rock, Mg ore, Aluminium ore etc.
7. Motor capacity: Preferably with (415-440) V/3Ph/50Hz electric supply, and onsite isolator switch.

STANDARD OPERATING PROCEDURE:

1. Switch 'ON' the Main supply.
2. Switch on the machine followed by MCB.
3. Before charging the feed material, note down the following points
 - o Properly check the nuts & bolts at the joints.
 - o Proper placement of product collector bath.
 - o Check the contact points for any wear, & friction.
4. After completion of the crushing operation, Switch 'OFF' the machine along with MCB connection, then cut the main supply.
5. Before leaving, clean the equipment properly



WORKING PRINCIPLE OF BLAKE JAW CRUSHER-

The working principle of jaw crushers is based on the reciprocating movement of the movable jaw that compresses and crushes the rock or ore between itself and the fixed jaw, as the material enters the zone between the jaws.

DODGE JAW CRUSHER

What is Dodge jaw crusher?

The Dodge jaw crusher, also known as the single toggle jaw crusher, is distinguished by the presence of a single swing jaw. It utilizes a movable jaw that is pivoted at the bottom and is operated by an eccentric shaft located at the top of the crusher. The material is crushed between the fixed and movable jaw plates, with the latter exerting force on the material as it moves towards the fixed jaw. Dodge jaw crushers are commonly used for softer materials and can handle larger feed sizes compared to Blake jaw crushers.

In the Dodge type jaw crushers, the jaws are farther apart at the top than at the bottom, forming a tapered chute so that the material is crushed progressively smaller and smaller as it travels downward until it is small enough to escape from the bottom opening.

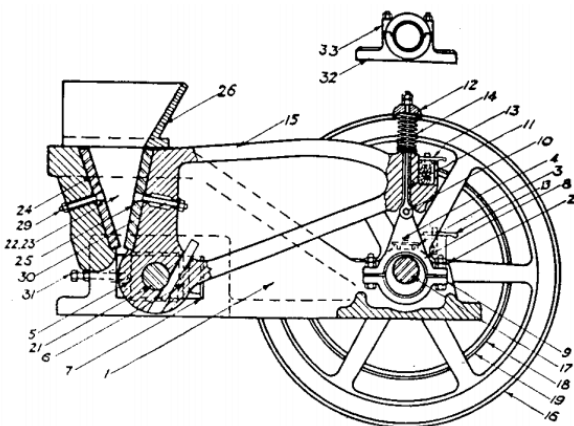


DIAGRAM OF DODGE JAW CRUSHERS

What is the working principle of crusher?

The working principle of jaw crushers is based on the reciprocating movement of the movable jaw that compresses and crushes the rock or ore between itself and the fixed jaw, as the material enters the zone between the jaws.

Dodge jaw crusher-

- movable jaw is pivoted at the top.
- Maximum movements is at the top
- Tendency to choke/clog
- Suitable for low production rate.
- Large reduction ratio is possible
- Highly maintenance
- Comparative made in smaller size

ROLL CRUSHER

What is a roll crusher?

- A type of secondary or reduction crusher consisting of a heavy frame on which two rolls are mounted. These are driven so that they rotate toward one another. Rock fed in from above is nipped between the moving rolls, crushed, and discharged at the bottom.
- Roller crushers are machines that are designed to reduce large rocks or other materials into smaller pieces. These machines use two or more rollers to crush the material, often in a continuous process. Roller crushers are commonly used in the mining and construction industries, as well as in other industries such as food processing and recycling.
- The basic structure of a roller crusher consists of two parallel rollers, each with a separate motor and gear system. The rollers rotate in opposite directions, and the material to be crushed is fed into the gap between the rollers. As the rollers rotate, the material is compressed and crushed, with the final size of the crushed material determined by the gap between the rollers.
- One of the primary advantages of roller crushers is their ability to produce a uniform product size distribution. This is because the size of the crushed material is determined by the gap between the rollers, which can be adjusted to produce a specific product size. Roller crushers can also be used to crush materials that are relatively hard, such as ores and minerals.
- Another advantage of roller crusher is their relatively low operating costs. This is because roller crushers are typically more efficient than other types of crushers, such as jaw crushers or cone crushers. Roller crushers also have a lower energy consumption compared to other types of crushers, which can lead to significant cost savings over time.

What is the principal of roll crusher?

In a roll crusher comminution primarily involves individual particles nipped between converging roller surfaces. The forces of compression and friction between the rolls and particles are responsible for size reduction, provided the combined forces exceed the compressive strength of the particle.

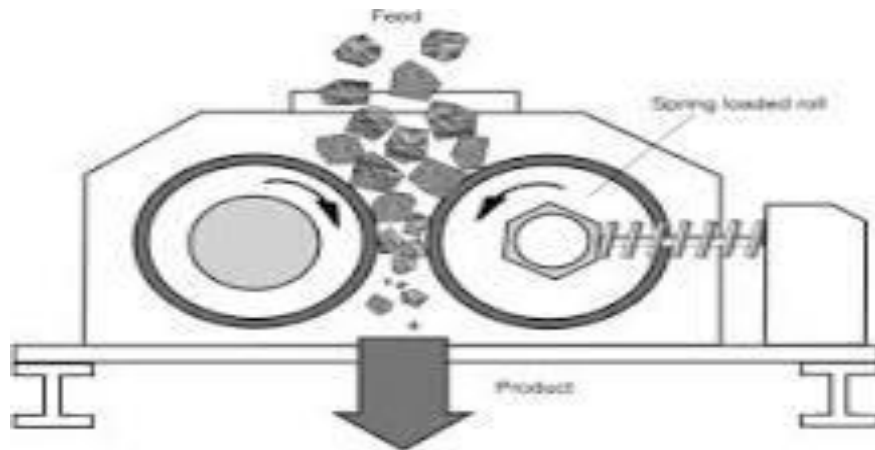


Diagram of roll crusher

Type of roll Crusher are:

- Single roll Crusher
- Double Roll Crusher
- Four roll crusher structure
- Three roll and four roll crushers

Working Mechanism

Rolls Crusher consist of two parallel rotating rolls turning together (in opposite direction) with feed being directed through the moving gap between them. One roll is fixed and the other movable using hydraulic pressure. As the ore moves through the gap the hydraulic force behind the movable roll acts to crush the particles as they are forced together into a crushed particle bed. Each roll is equipped with its own motor. One single crusher can process up to 2000 TPH of ore being fed to it. Operating with high pressure normally results in a product that contains a significant amounts of ultrafine which provides a favorable ore size distribution for ball mill.

GYRATORY CRUSHER

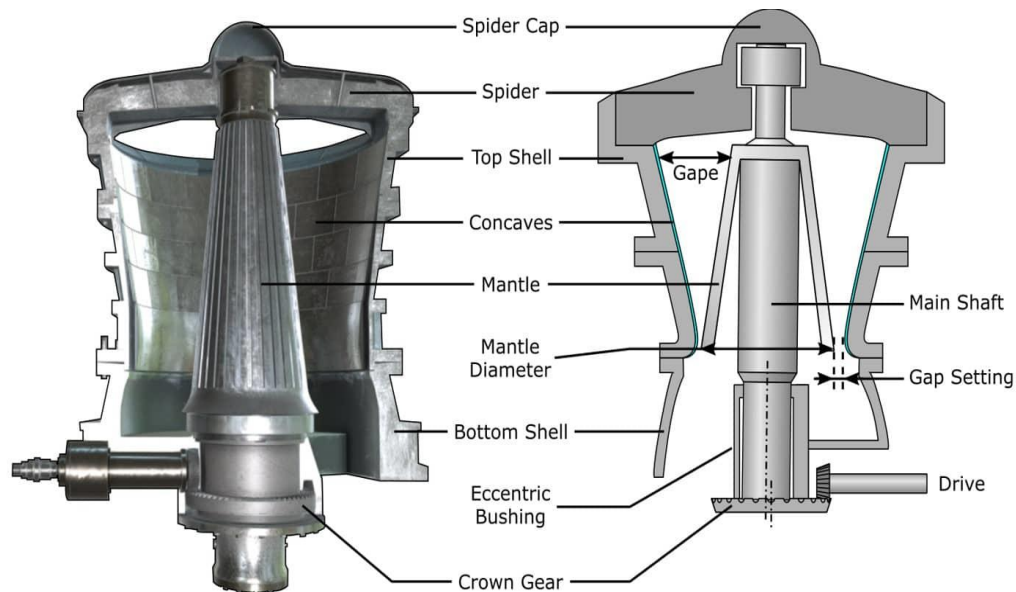
Gyratory Crusher Components

Gyratory crushers were invented by Charles Brown in 1877 and further developed by Gates in 1881 (they were commonly referred to as a 'Gate's crushers' in the early years). A primary crusher is designed to receive run-on-mine (ROM) rocks directly from the mines. Gyratory crushers typically crush to reduce the size of **aggregate** to a

maximum of about **one-tenth** of its original size. Gyratory crushers are always installed **vertically orientated**.

A gyratory crusher's size is classified by:

- Its **gape** and **mantle diameter**.
- The diameter of the **receiving opening**.



Key components of a gyratory crusher are:

- **Spider Assembly & Bushing**
- **Top & Bottom Shell Assemblies**
- **Main Shaft**
- **Mantle & Concaves**
- **Eccentric Drive & Bushing**
- **Pinion & Countershaft Assembly**
- **Hydroset Assembly (Hydraulic Support)**

Gyratory Crusher Operation:-

- **Crushing** action is produced by the oscillation or '**throw**' (opening & closing) of the gap between the moving mantle liner, mounted on the **central vertical shaft (spindle)**, and the fixed concave liners mounted on the **mainframe (top shell)** of the crusher. The **mantle** and **concaves** form the working surfaces of the crusher, producing the force required to crush the ore.
- **Eccentric motion** is achieved by the **lower eccentric bushing** and **drive arrangement** on the bottom of the **main shaft**. The input **pinion drive countershaft** is supported by **pinion bearings** and powered by an **electric motor**. An external **gearbox** or **belt drive** arrangement reduces the motor speed to approximately **100-200 RPM** at the crusher. In some cases, a **clutch system** may also be used to absorb shocks. The **pinion** on

the **countershaft** meshes with and turns the **eccentric gear drive** or **crown gear**.

What is a gyratory crusher?

A gyratory crusher is an ore processing machine that crushes large rocks into smaller ones. It works by applying pressure to the rocks as they enter the crushing chamber. To work a gyratory crusher, you will need to adjust the size of the opening at the bottom of the crusher to allow for the right sized rocks to enter.

What are the uses of gyratory crushers?

Gyratory crushers are heavy-duty machines used in mining and aggregate processing to crush rocks and ores. They have a conical shape and consist of a concave surface and a conical head that gyrates around an axis to break materials into smaller pieces by compression.

CONE CRUSHER

What is a cone crusher?

A Cone Crusher is a compression type of machine that reduces material by squeezing or compressing the feed material between a moving piece of steel and a stationary piece of steel. Applications

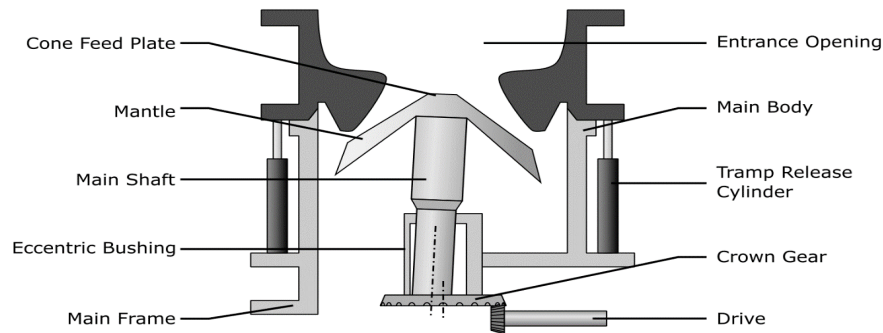
What are the principles of cone crusher?

Crushing Principles: Cone crushers operate on the principle of compression crushing. The material is squeezed or compressed between the mantle and the concave, which leads to size reduction. This is different from impact crushers that use impact forces to crush material.

There are three main types of cone crushers:

- Standard Cone
 - Short Head Cone
 - Hydrocone
-
- **STANDARD CONE CRUSHER-** The Standard Cone crusher typically has a medium-sized feed opening, allowing it to accept relatively large feed sizes while producing relatively fine discharge sizes.
 - **SHORT HEAD CONE CRUSHER-** The Short Head Cone crusher has a steeper angle in its crushing chamber, allowing it to accept smaller particles at higher capacities than a Standard Cone crusher.

- **HYDROCONE CRUSHER**- The Hydrocone crusher is designed to be a superior secondary crusher for fine reduction applications. It has the added benefit of low operating costs due to its ability to be adjusted for varying size ranges of feed.



CHAPTER 3: GRINDING

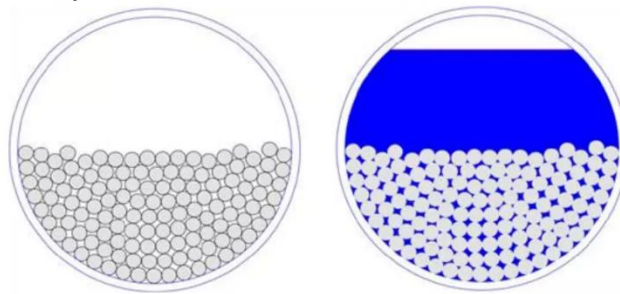
BALL MILL

- ❖ **A ball mill** is a type of grinder used to grind, blend and sometimes for mixing of materials for use in mineral dressing processes, paints, pyrotechnics, ceramics and selective laser sintering.
- ❖ It is efficient tool for grinding many materials into fine powder.
- ❖ A ball mill consists of a hollow cylindrical shell rotating about its axis.
- ❖ The axis of the shell may be either horizontal or at a small angle to the horizontal.
- ❖ It is partially filled with balls.

- ❖ Most ball mills are batch operated, however there are continuous ball millers available nowadays with continuous milling action.



- ❖ The **ball mill** can be divided into wet ball mill and dry ball mill according to the use environment.
- ❖ The difference is that the structure of the **dry ball mill** is more complicated than that of the wet ball mill. The discharge port of the dry ball mill is straight and equipped with an air induction device, a dust exhaust pipe and a dust collector. The structure of the **wet ball mill** is relatively simple, there is no need to add too many auxiliary accessories, the discharge port is flared, and the built-in spiral device is more convenient for ore discharge.
- ❖ The **wet ball mill** has better performance, higher grinding efficiency, and lower requirements for the moisture content of the ore. In addition, its auxiliary equipment is less and the material transportation device is simple. Therefore, the investment is about 5% -10% lower than that of the dry ball mill.



The degree of milling in a ball mill is influenced by:

- 1) Residence time of the material in the mill chamber.
- 2) The size, density and number of the balls.
- 3) The nature of the balls (hardness of the grinding material).
- 4) Feed rate and feed level in the vessel.
- 5) Rotation speed of the cylinder.

Types of Ball Mills:

1) Horizontal Ball Mill

- ✓ Are the most common type in the industry.
- ✓ Some horizontal ball mills have the timers to view the processed materials contained in it.
- ✓ Some have timers, to check the materials within the time period.



2) Industrial Ball Mill

- ✓ Larger in size than the other types.
- ✓ Size varies from the size of a refrigerator to the bus.
- ✓ The main difference is the number of chambers.
- ✓ Another difference is its forced-air system.



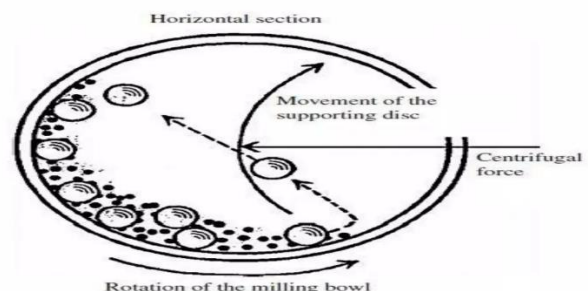
3) Planetary Ball Mill

- ✓ These are most commonly used for laboratory use.
- ✓ Used for small applications, and fits in lab table or workbenches.
- ✓ Different ball sizes for different uses.



Principle

- ❖ A ball mill works on the principle of impact and attrition.
- ❖ size reduction is done by impact as the balls drop from near the top of the shell.
- ❖ Ball mills rotate around a horizontal axis, partially filled with the material to be refined plus the grinding medium. An internal cascading effect reduces the material to a fine powder.



- ❖ Ball mill principle work on Impact and Attrition. Both are responsible for size reduction, rapidly moving balls are used for reducing the size of brittle materials.

- Impact: Impact mean pressure exerted by two heavy objects.
- Attrition: Reduced the size of the materials when they colloid by heavy weight (Ball).

Construction:

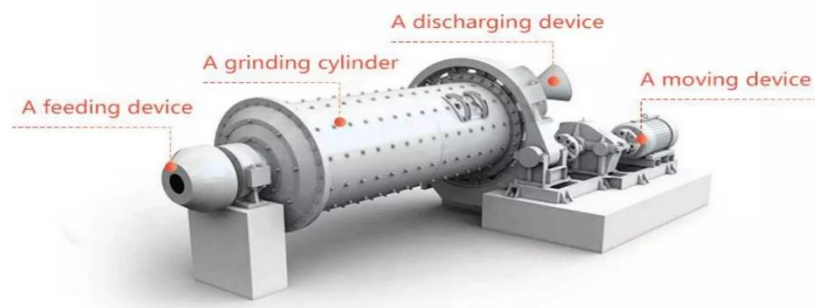
The ball mill grinder consists following Parts:

- Cylinder: cylinder is made of a hollow metal that moves about its horizontal axis. the cylinder can be made of porcelain, metal, and rubber. the length of the cylinder slightly higher than its diameter.
- Ball: The ball lies in cylinders, which are made up of stainless steel, the size of the ball depends on the cylinder diameter. The ball covers 30 to 50% area in the cylinder.

Components

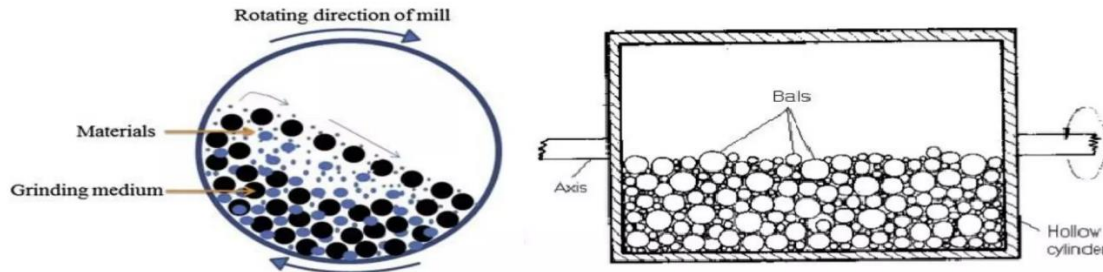
ball mill grinding machine consists of following parts:

- Feeding part
- Discharging part
- Turning and driving part(gear, motor.. etc)
- Rotating balls

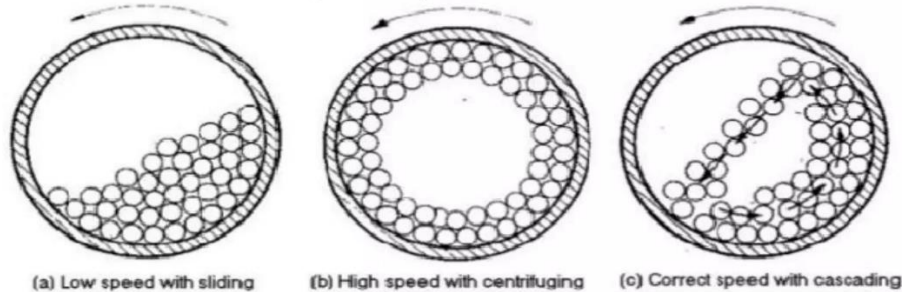


Working:

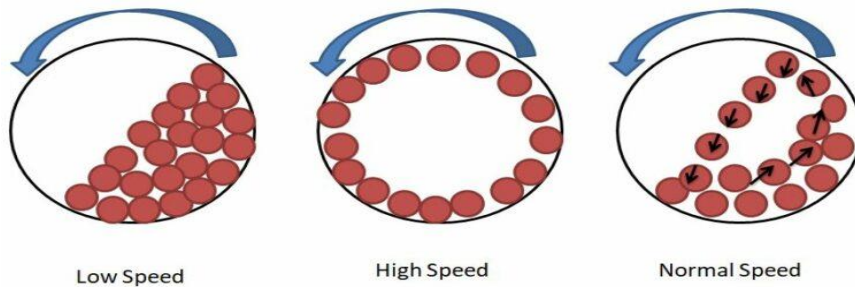
- Open the lid and Feed the materials into the cylinder
- Introduced the fixed numbers of balls and closed the lid
- Run the machine and adjust the speed as per required.
- After achieving the desired particle size, stop the machine and remove the materials.



- At low speeds, the mass of balls will slide or roll over each other and negligible size reduction will occur.
- At high speeds, the balls will be thrown out to the wall by centrifugal force and no grinding will occur.
- At about two-thirds of the speed at which centrifuging just occurs, movement takes place as shown, that is, the balls are carried almost to the top of the mill and then fall in a cascade (tumble) across the diameter of the mill.



Ball mill Speed Impact on Size Reduction



- Low speed: At low speed, the mass of balls will slide or roll up one over another and will not produce a significant amount of size reduction.
- High Speed: At high-speed balls are thrown to the cylinder wall due to centrifugal force and no grinding will occur.
- Normal speed: At Normal speed balls are carried almost to the top of the mill and then fall into a cascade across the diameter of the mill, in this way maximum size reduction is obtained.

Advantage:

- Minimum loss of materials
- suitable for the wet and dry grinding process
- Sterility can be maintained due to a close container system, hence useful in the manufacturing of parenteral and ophthalmic products.
- Particles size is easy to reduce
- Less energy consumed
- Easy to clean
- Required less space to install
- low maintenance cost

Disadvantage:

- It is a slow process
- Produced strong vibration and sound and less in case of rubber ball usage.
- Cannot reduce soft, tacky, and fibers materials
- Wear occurs inside the cylinders hence chances of possible contamination are high.
- Less capacity, do not handle the large quantity