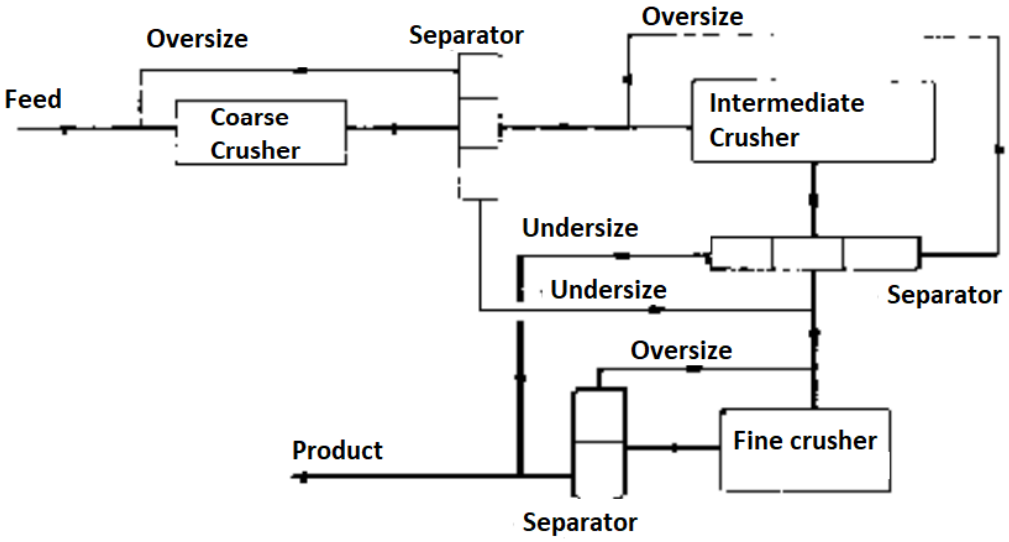
Closed and Open circuit grinding

Open circuit grinding

If a plant is separated in such a way that the material passed only once through the equipment.

Closed circuit grinding

As shown in figure , The product obtain from a grinding or crusher contains material of insuffiently crushed it may be necessary to separate the product and return the o/s material for second crushing. This system is generally preferred and it is known as closed circuits. Energy consumption is less when compared to open circuit grinding.



Critical speed of a ball mill

The speed at which the outermost ball lesser the contact with the wall of the mill depends on the balance between the gravitational force and centrifugal force.

Consider a ball at point 'A' on the periphery of the mill wall. Let the radius of mill and ball be 'R' and 'r' . Let OA makes an angle α with vertical. Let R-r be the distance between the center of ball and mill.

Two forces acting on the mill are

1) Gravitational force mg

m- mass of ball and g-acceleration due to gravity

2) Centrifugal force acting on the mills $=mu^2/R-r$

3) Centripetal Component of force opposing the ball fall$=mg\cos\alpha$

As long as centrifugal force exceed the centripetal force , the ball will not fall from the mill wall . As the mill reaches a certain speed for the ball to fall from the mill wall, two opposing forces are equal

$mg\cos\alpha = mu^2/R-r$

Where $u=2\pi(R-r)N$

N=Number of rotation of the mill

$mg\cos\alpha = m[2\pi(R-r)N]^2/R-r$

$\alpha=0$, at critical speed then $N=N_c$

$mg=m4\pi(R-r)^2N_c^2/R-r$

$g=4(R-r)N_c^2$

$N_c^2=g/[4\pi^2(R-r)]$

Centrifuging and Critical speed

Faster the mill rotated the balls are carried along the mill wall and hence the greater power is consumed. When they are released impact on the mill is greater and we need a larger protecting capacity for mill wall. At a very high speed the balls are carried along the mill wall, it is said to be centrifuging. The speed of which a centrifuging is called critical speed. Operating speed will be less that the critical speed. 65 to 80% of N_c. Little or no grinding takes place during centrifuging.

Cascading and cataracting

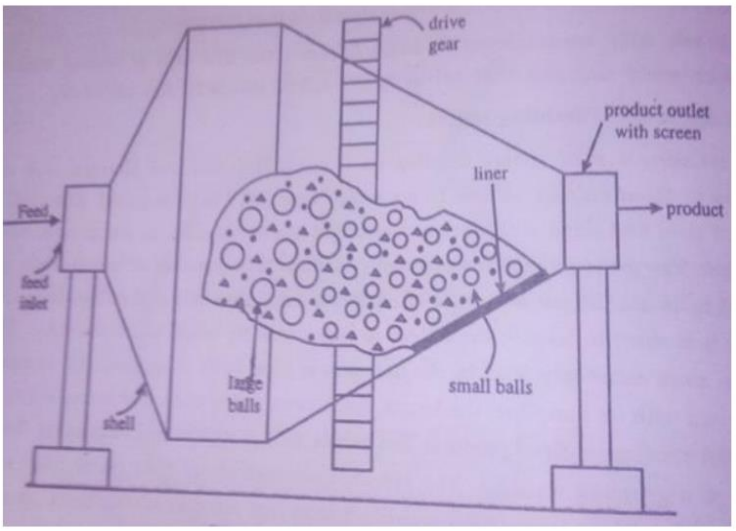
- Cascading refers the rolling of balls or pebbles from top to bottom of the trap.
- Cataracting refers throwing of balls through the air to the toe of the trap.

Ball Mill

Construction

Ball mill consist of a hollow cylindrical shell rotating about its axis. Axis of the shell horizontal or at small angle to the horizontal. It is partially filled with balls made up of Steel,

Stainless steel or rubber. Inner surface of the shell is lined with abrasion resistant materials such as Manganese, Steel or rubber Length of the mill is approximately equal to its diameter Balls occupy about 30-50% of the volume.dia of the ball 12 mm-125 mm Shell is rotated through a drive gear (60-100 rpm) and large mills, shell might be in 3m in dia and 4.25 m in length. Operation may be batch or continuous, wet or dry in a continuously operated ball mill outlet is normally covered with coarse screen to prevent the escape of the balls.



Working

Material to be ground is fed from the left through a 60 cone and product is discharged through a 30 cone to the right. As the shell rotates the balls are lifted up on the rising side of the shell and they cascade down from near the top of the shell. The solid particles in between balls are ground and reduced in size by impact. As the shell rotates the large balls segregate near the feed end and small balls segregate near the product end If the rate of feed is increased, coarser product will be obtained and if the speed of rotation is increased the fineness for a given capacity increases. During grinding, balls themselves wear and are continuously replaced by new ones so that mill contain balls of various ages and thus of various ages and thus of various sizes.

Applications

- The ball mill is used for grinding materials such as coal, pigments and feldspar for pottery.
- Grinding can be carried out in either wet or dry but the former is carried out at low speeds.

The advantages of wet grinding are less power consumption, increased capacity, no dust formation etc and dis advantages are high wear on the grinding medium and necessity to dry the product.

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

Blake jaw crusher

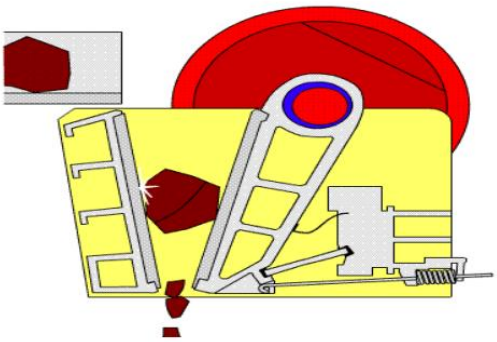
In the Blake or jaw crusher the moveable jaw is pivoted at top. The greatest amount of motion is at the bottom which means it has the little tendency to choke.

Dodge jaw crusher

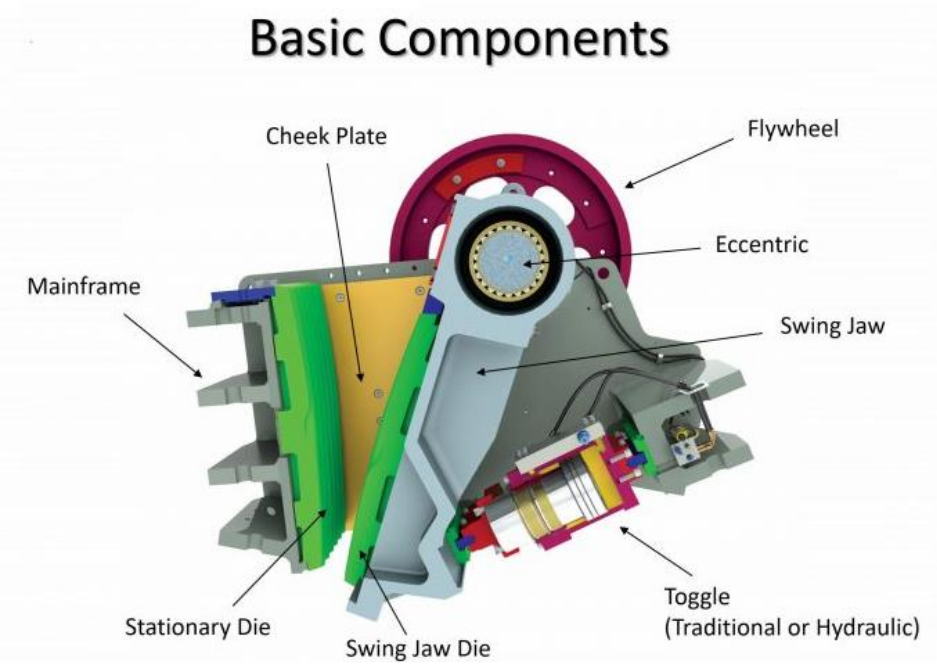
In the dodge jaw crusher the moving jaw is pivoted at the bottom. As minimum movement is at the bottom it has a greater tendency to choke.

Working

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.



The picture above is the sketch of the Jaw Crusher and the picture below lists the basic components



Applications

- Jaw Crusher can be used in mining, metallurgical industry, construction, road and railway building, chemistry etc.
- Simple structure easy maintenance.
- Stable performance.
- Even final particles and high crushing ratio.

So, what is really the crushing process?

In order to make use of the rocks or ores obtained through quarrying/explosion in the Mining and Construction sectors, the materials need to be crushed to reduce them to a smaller size. This process can also be referred to as Size reduction or Crushing**.**

The goals of the size reduction are as follows:

1.) Obtaining the size or surface area required for the use of the ore or material
2.) Allowing ease of transportation and storage
3.) Separating the different minerals contained within the ore and to release them from one another
4.) Obtaining the size or surface area required for the enrichment stage.

In general, crushing is carried out in three stages, depending on the desired size of the material.

Primary Crushing

This is the first stage of the crushing process. In general, the size of the feed material, which is between 800 and 1500 mm, is reduced to between 150 and 300 mm.

Secondary Crushing

This is the second stage of crushing. Feed size, which is around 150 to 300 mm, of the rock or ore from the primary crushing process is reduced to between **50 and 80 mm.**

Tertiary Crushing

This is the third stage of crushing. The size, which is around **50–80 mm,** of the ore or rock from the secondary crushing process is reduced to between **5 and 12 mm.**

We call the machine that performs the CRUSHING process a Crushing machine or a crusher**.**

All jaw crushers feature two jaws: one of which is fixed while the other moves. 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.

The moving jaw moves back and forward against the fixed jaw, and material fed from the top of the machine is compressed between the two, breaking it into smaller pieces. As the moving jaw moves away from the fixed jaw, the crushed material is discharged from the crusher at the bottom, with the size of the ejected material determined by the gap between the jaws.

Main classification of Jaw crushers

There are two main groups of jaw crushers, categorized according to their jaw movement mechanism.

- Single-toggle jaw crushers
- Double-toggle jaw crushers

In single-toggle jaw crushers, the movable jaw is supported by the bearing on an eccentric shaft driven by the pitman to which it is attached. The pitman is supported by a toggle plate at the bottom of the moveable jaw. Toggle plate compressed between moveable jaw and main body. This mechanism ensures that any point on the moving jaw moves in an elliptical orbit. This mechanism makes a movement aka four bar linkage movement. Through this movement, the movable jaw applies both pressure and friction forces to the material to be crushed.

In double-toggle jaw crushers, the pitman is mounted on fixed non-eccentric shaft that situated at the top of the crusher. There are two toggle plates, one on the left and one on the right, are linked to the pitman that is hinged to the driven camshaft. The toggle plate on the left is linked to the jaw-supporting block, while the one on the right is linked to the main

body. The mechanism of double-toggle jaw crushers allows applying only pressure on the material.

A comparison of jaw crushers with the same capacity reveals that double-toggle jaw crushers are more expensive than ordinary jaw crushers. For this reason, mostly single-toggle jaw crushers are used in the aggregate sector, while double-toggle jaw crushers are used mostly for crushing very hard and highly abrasive materials. The lifecycle of double-toggle jaw crushers is longer since they do not apply friction force.

REFERENCES:

- WHO Regional Office for Europe "Health Aspects of Air Pollution" (2003), Particulate matter (PM), Section 5.1 Introduction

- Mechanical Eng. Msc Suphi Yavuz, Başak Yavuz Makine, Technical Notes

- Mining Eng. Msc Necati Yıldız, Ore Dressing and Enrichment Book

- R. Hogg, H. Cho, in Encyclopedia of Materials: Science and Technology, 2001

- Mohamed Rahaman; Mohamed N. Rahaman (7 August 2006). Ceramic Processing. CRC Press. pp. 41–. ISBN 978-0-8493-7285-8.

- John B. Wachtman (28 September 2009). Materials and Equipment - Whitewares Manufacturing: Ceramic Engineering and Science Proceedings, Volume 14. John Wiley & Sons. pp. 264–. ISBN 978-0-470-31618-4.

- Hammer Milling and Jet Milling fundamentals, Gary Liu, CEP, 2017

- Air jet Milling, Chamayou, Elsevier, 2007