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Influence of Crusher Machinery & It's Working Principle

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Abstract – *Coal, mechanical, and other industries that use crushers frequently are among the most important converters of size. They occur in many sizes and capacities which vary from 0.1 ton/hr. to 250 ton/hr. They can be categorized on the mechanism used. Equipment has been purchased by quarries to increase production and increase the quality of their products. Crushers are mainly of three categories i.e. Cone crusher, Jaw crusher and Impact crusher. However, there are few studies about the influence of crushers mechanism like jaw crusher, horizontal shaft impactor and vertical shaft impactor.*

Key Words: comminution, crushing principle, reduction ratio, type of crusher, Effective circuits of crushing

1. INTRODUCTION

This document is an investigation aimed at studying and optimizing the secondary and tertiary crushing circuit. Crusher is a machine designed to reduce large rocks into smaller rocks, gravel, or rock dust. First, crush rocks by blasting and then breaking them into crushable lumps by breaking oversize rocks. The reduction of chunks of rocks or ores into smaller sizes [1] is known as size reduction.

The type of crusher to be used for a given job is dependent on the [2]:

- Nature of material to be crushed
- Area of application of the material
- Maintenance and Operational costs
- Power consumption
- Vibration, Noise
- Environmental issues etc.

Each crusher is designed to work with a certain maximum size of raw material, and often delivers its output to screening machine and tertiary and Quaternary crushers reducing ore 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 which sorts and directs the product for further processing.

These units can move with the large infeed machinery (mainly shovels) to produce a greater amount of tonnage. Several types of crushers are capable of crushing rocks up to 1.5 m (60 inches).

1.1 Basic principles of crusher selection [3]

- The period of operation
- The specification of stone materials
- The nature of stone materials

1.2 Factors to consider when choosing a crushing equipment [3]

1. Economic indicator
2. Technology indicator
3. Product indicator
4. Installation site
5. Foundation and pillar
6. Supply of material
7. Maintainability of equipment
8. Compatibility of equipment
9. Relationship between worker and machine
10. Environmental requirement

2. Comminution

Comminution of solid materials involves reducing their particle sizes by crushing, grinding, cutting, vibrating, etc. Solid materials are generally broken up into smaller pieces by beating, crushing, cutting, vibrating, or other processes. The comminution energy can be estimated by following laws.

2.1. Rittinger Law [4]

Richter (1867) hypothesized that the energy needed for size reduction is proportional to the new surface area created as a result of size reduction. In view of the fact that particle size is inversely proportional to specific surface area, Rittinger hypothesis is as follows:

$$E = K_1\left(\frac{1}{x_p} - \frac{1}{x_f}\right)$$

Formula 1.: Rittinger law for comminution.

Where,

E is the net specific energy;

xf and xp are the feed and product size indices, respectively

K1 is a constant.

Application of Rittinger law

- Where surface area created is significant – fine grinding
- Particle size less than 0.05mm
- Energy input is not very high

2.2. Kick Law [4]

Kick (1885) proposed the hypothesis that identical relative size reductions require the same amount of energy. Kick's equation is,

$$E = K_2 \ln\left(\frac{x_f}{x_p}\right)$$

Formula 2.: Kick law for comminution.

Where,

E is the net specific energy;

xf and xp are the feed and product size indices, respectively

K2 is a constant.

Application of Kick law

- based on stress analysis if plastic deformation occurs within the elastic limit
- More accurate than Rittinger law for course crushing.
- Suitable for feeds with a diameter of more than 50mm.

2.3. Bond Law [4]

The 'Third Law' of grinding was proposed by Bond (1952). According to the Third Law, the total length of new cracks created is proportionate to the net energy consumed in comminution. The following is the resultant equation:

$$E = K_3\left(\frac{1}{\sqrt{x_p}} - \frac{1}{\sqrt{x_f}}\right)$$

Formula 3.: Bond law for comminution.

Where,

E is the net specific energy;

xf and xp are the feed and product size indices, respectively

K3 is a constant.

3. Crushing Principle

They are typically separated into three forces: impact, shear, and compression. When analyzing a crushing machine, it is vital to know what types of breakage that are occurring in the machine. In order to examine a crushing machine's characteristics, input, output, and performance, it's necessary to understand the different forms of breaking that occur in the machine. Different types of breakage have been studied by several authors [5, 6].

Form conditioned crushing and energy conditioned crushing are two different types of crushing. The particle is crushed in form conditioned crushing, and the overall deciding element for size reduction is the size of the end gap between the surfaces. The power used can often be used to measure and record the force utilized during compression. This will not provide an accurate energy calculation for each individual particle, but rather an average of the particles that are being given out. For various types of form-conditioned crushers, many predictive models have been developed [7].

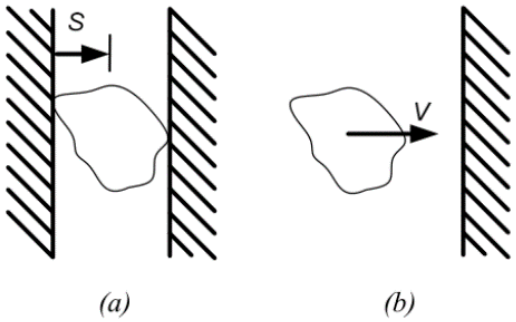

Figure 1. An image of a) a rock particle being subjected to compressive crushing and b) energy conditioned crushing from

When particles and geometry collide, energy conditioned crushing transforms their kinetic energy into potential energy. This is frequently accomplished by accelerating particles to high speeds and then driving them against metal anvils, or by spinning solid metal rods at high speeds in particle showers. In order to anticipate how much energy will be transformed, the angle of impact and the magnitude of kinetic energy are critical.

Attrition is a phenomenon that occurs when a particle travels along a surface and makes intermittent contact with it. The sharp corners of the particle will fall off as a result of repeated hits. Because impact rarely happens completely perpendicular to the surface, attrition is

common in most energy-conditioned crushing and even to a lesser amount in form-conditioned crushing. This blend of energy and collision patterns produces a variety of breaking effects with distinct names and criteria. These breakage effects can be observed in Table 1 as a result of an attempt to map them and develop a framework.

Table -1: Comminution effects on particles subjected to loading events

effect	feed	loaded particle	product
weakening			
cracking			
breaking			
crumbling			
chipping			
splitting			
disintegrating			

The process of converting the object from ore physical dimension of higher order to another dimension of smaller order. It is the operation carried out for reducing the size of bigger particle into smaller one of desired size and shape with the help of certain external forces. Comminution is some other term used for size reduction.

4.1. Factor Affecting Size Reduction Process:

1. presence of moisture and sticky material in equipment feed.
2. Presence of fine in the feed.
3. Segregation of feed partial in the crushing chamber.
4. Lack of feed control
5. Wrong Motor size
6. Insufficient crusher discharge area
7. Insufficient capacity of the crusher's discharge conveyor.
8. Material being extremely hard to crush.
9. Surface energy of solids
10. Power consumption
11. Selection of an appropriate crushing chamber.

5. Comminution / Crushing machines

5.1. Compressive crushing (Jaw Crusher)

Jaw crusher makes use of compressive force for breaking of particle. A jaw or toggle crusher includes a set of vertical jaws, one jaw being fixed and the alternative being moved backward and forward relative to it through a cam or pitman mechanism. The jaws are attached apart at the top than at the lowest, forming a tapered chute in order that the material is beaten to smaller length as it travels downward till it escapes from the hole at downside. The motion of the jaw may be pretty small, considering the fact that entire crushing is not achieved in one stroke. The inertia required to overwhelm the material is provided with the aid of a weighted flywheel that movements a shaft creating an eccentric movement that causes the closing of the gap. Jaw crusher functions and parts shown in figure 2. [8]

There are a set of different Jaw crushers classifications that are based on where the position of the pivoting of the swing jaw is. These are Blake, dodge and prevalent crushers with upper, decrease and intermediate position of the pivot respectively. The jaw crusher gives high size reduction but also tend to make very sharp particles. [9]

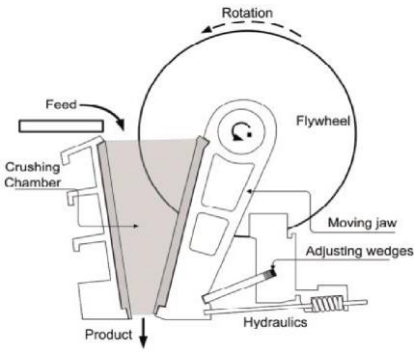

Figure 2. Mechanism of Jaw Crusher

5.2. Impact crushing (impactor)

5.2.1. Horizontal Shaft Impactor

Hammers are constant onto the outer edge of a spinning rotor. material is fed onto the upwards swinging hammers

which accelerate them into the anvils attached to the partition ensuing in breakage. particles are regularly flung multiple times and as a consequence ensure one of the maximum discount ratios for crushing machines.

Horizontal shaft impactor break rock by impacting the rock with hammers/blow bars that are fixed upon the outer edge of a spinning rotor. here the rotor shaft is aligned alongside the horizontal axis. The enter feeder material hits the rotating hammers of the rotor and due to this sudden effect it breaks the cloth and in addition breaks the fabric via throwing it directly to the breaking bar/anvils.

the difficulty with the usage of anvils as a way to instigate particle breakage is that the wear and tear may be very excessive and high-priced. that is one of the motives to why soft rock material and recycled goods are more normally used than hard rock material because the tougher the material the faster the wear will be. The Horizontal Shaft impact crusher can be used as primary, secondary or maybe tertiary crusher and typically creates particles of a rounder high-quality. [9]

5.2.2. **Vertical Shaft Impactor**

VSI crushers use a distinctive method related to a high velocity rotor with wear resistant tips and a crushing chamber designed to 'throw' the rock towards. The VSI crushers make use of velocity in preference to surface force as the main force to break rock.

A VSI crusher is a common comminution machine for crushing particles and enhancing the shape of particles. There are some unique configurations of VSI crusher but the focus might be on describing the general flow of the material that is going via all the crusher, no matter how they're installation. There may also be a generalization of the unique sections of the crusher and how they relate to the operation. by way of dividing up the crusher in special sections, A thru E, it's far less difficult to speak about behaviors in unique interaction fields. These areas can be seen in Figure 4 which shows the cross-section of a principal VSI.

Section C is in which the feed tube connects with the center of the rotor. particles fall in and onto the bottom of the rotor, that's geared up with a spread plate to shield the rotor and make the particles go with the flow outwards, in the direction of the rotors exhaust ports. [9]

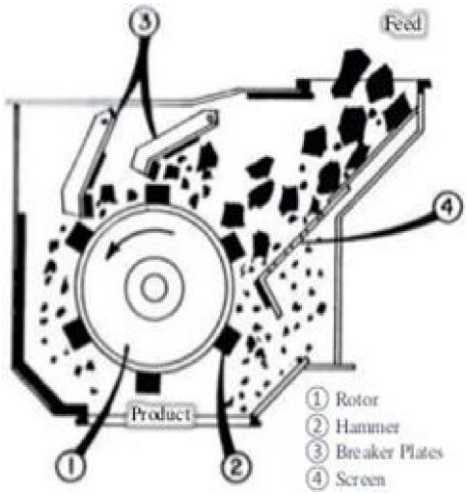

Figure 3. Mechanism of Horizontal Shaft Impactor

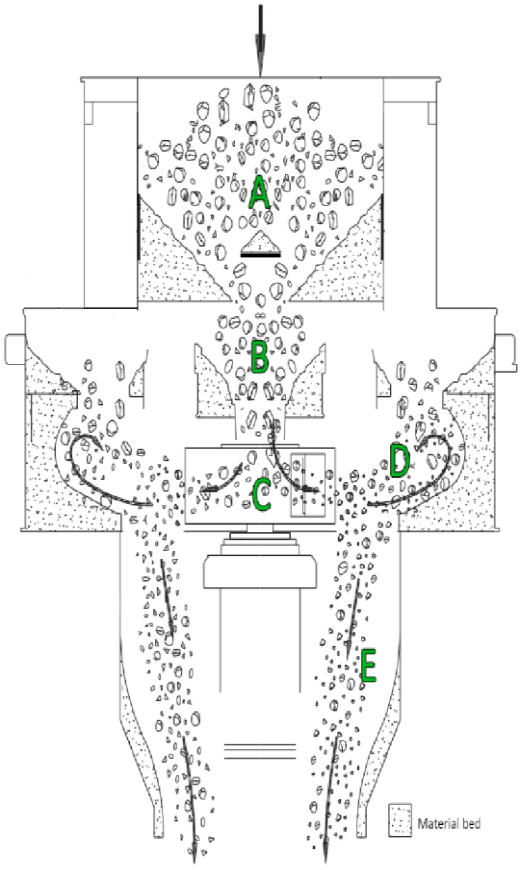

Figure 4. Mechanism of Vertical Shaft Impactor

6. Most Effective Crushing Circuit

The following circuit is belonging to Singh Crusher Pvt. Ltd. Satpur, Nashik, Maharashtra, India

6.1. PJC-SJC-VSI Circuit

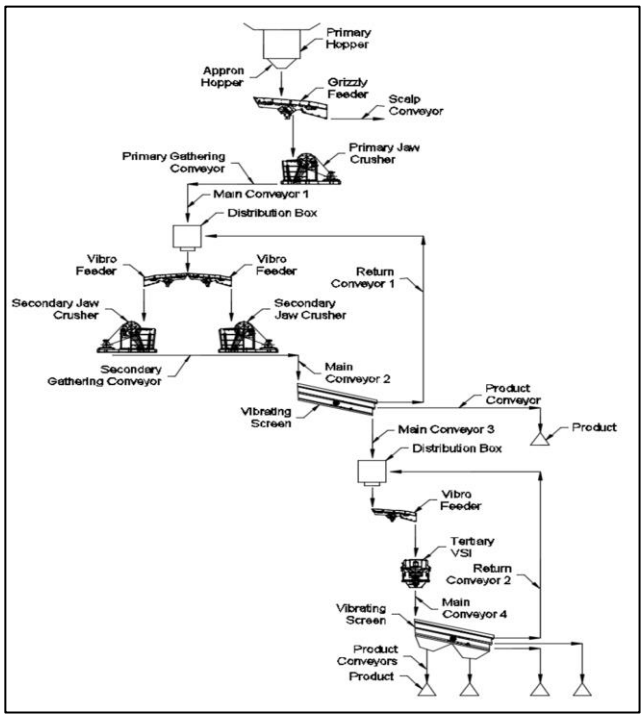

Figure 5. PJC-SJC-VSI Circuit

Primary Stage: In That Circuit Jaw Crushers used as Primary as well as Secondary. It will Depend on Crushers Output (TPH). The Material Passes from Primary Hopper to Appron Hopper. The Capacity of Hopper will be decided by Material required to run Primary Jaw Crusher for 1 hr. Appron Hopper is connected with Grizzly Feeder. Use of Grizzly Feeder are to remove soil from material which is present in input material. Grizzly feeder is connected with chute which gives path to material into Primary Jaw Crusher. Primary crusher will reduce material and continue forward on Primary Gathering Conveyor to Main Conveyor 1.

Secondary Stage: Main Conveyor is Feeds Distribution Box which has connection with two Grizzly Feeders. Grizzly Feeder Pass Material to Secondary Jaw Crusher with the help of Chute. Secondary Jaw Crusher reduce Material in Desire sizes. Both Secondary Jaw Crusher have single Secondary Gathering Conveyor. Vibrating screen have input from Main conveyor 2 Which is having material of Secondary Gathering Conveyor. In Vibrating Screen, the upper Deck is sort uncrushed Material and send for re crush with the help of Return Conveyor. It has option to remove primary product if required.

Tertiary Stage: This Stage mostly used for Formulation of Artificial Sand. The main component of this stage is vertical shaft impactor. The output of tertiary stage is in spherical shape.

6.2. PJC-SHSI-VSI Circuit

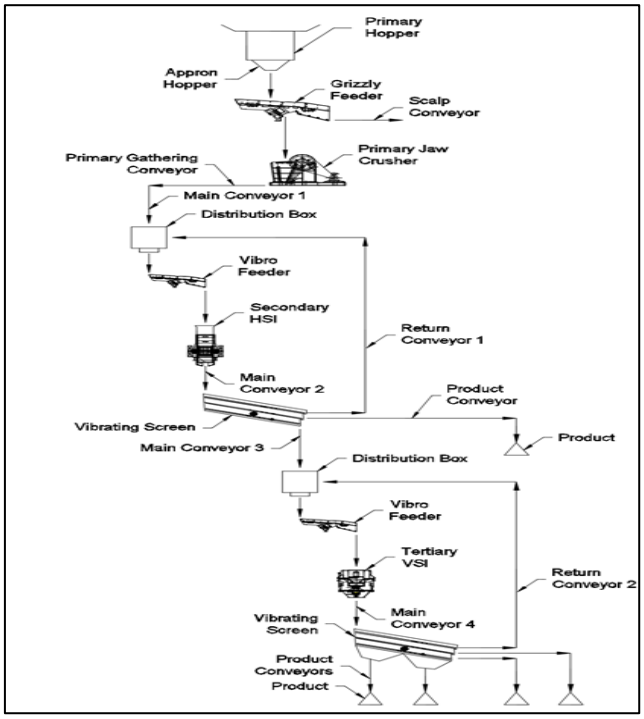

Figure 6. PJC-SHSI-VSI Circuit

Primary Stage: In That Circuit Jaw Crushers used as Primary crusher only. The Material Passes from Primary Hopper to Appron Hopper. The Capacity of Hopper will be decided by Material required to run Primary Jaw Crusher for 1 hr. Appron Hopper is connected with Grizzly Feeder. Use of Grizzly Feeder are to remove soil from material which is present in input material. Grizzly feeder is connected with chute which gives path to material into Primary Jaw Crusher. Primary crusher will reduce material and continue forward on Primary Gathering Conveyor to Main Conveyor 1.

Secondary Stage: Main Conveyor is Feeds Distribution Box which has connection with two Grizzly Feeders. Grizzly Feeder Pass Material to Secondary horizontal shaft impactor with the help of Chute. Secondary horizontal shaft impactor reduces Material in Desire sizes. Vibrating screen have input from Main conveyor 2 which is output of

horizontal shaft impactor. In Vibrating Screen, the upper Deck is sort uncrushed Material and send for re crush with the help of Return Conveyor. It has option to remove primary product if required.

Tertiary Stage: This Stage mostly used for Formulation of Artificial Sand. The main component of this stage is vertical shaft impactor. The output of tertiary stage is in spherical shape.

These are two type of circuit used for crushing of graphite stone. These circuit are most effective and most economical suitable for plant.

7. Conclusion

The purpose of these paper is to invest financial in proper and effective manner without wasting of money in inappropriate machine. Above two circuit is useful for planning for crusher plant. If we are aware about that then it will be very helpful to you and your growth.

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