MECHANICAL OPERATIONS LAB REPORT

Experiment 2: Roll Crusher

S.S.S.Vardhan

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AIM

- Calculate the Size Reduction Ratio of the Roll Crusher
- Derive theoretical and experimental Capacities of the Roll Crusher

APPARATUS

1) Smooth Double Roll Crusher 2) Sieve Shaker Machine 3) British Standard Sieves 4) Feed Particles 5) Collecting Bin 6) Weighing Machine 7) Stopwatch

THEORY

A roll crusher is a type of secondary or reduction crusher consisting of a heavy frame on which two rolls are mounted. Rock fed in from above is nipped between the moving rolls, crushed, and discharged at the bottom. The forces necessary to perform the crushing in a roll crusher are a combination of impact, shear and compression. Shear and compression forces occur as the feed material is pulled between the crushing plate and/or crushing rolls. The particles are drawn into the gap between the rolls by their rotating motion and the friction angle formed between the roll and the particle called the nip angle.

Theoretical Capacity: The theoretical capacity of a roll crusher is given by

$$TC = 60\pi D(S)B\varrho N$$

where, D = Diameter of roll (m) S = Spacing between rolls (m) B = breadth of the rolls (m) N = Speed of rotation (rpm) ρ = Density of material

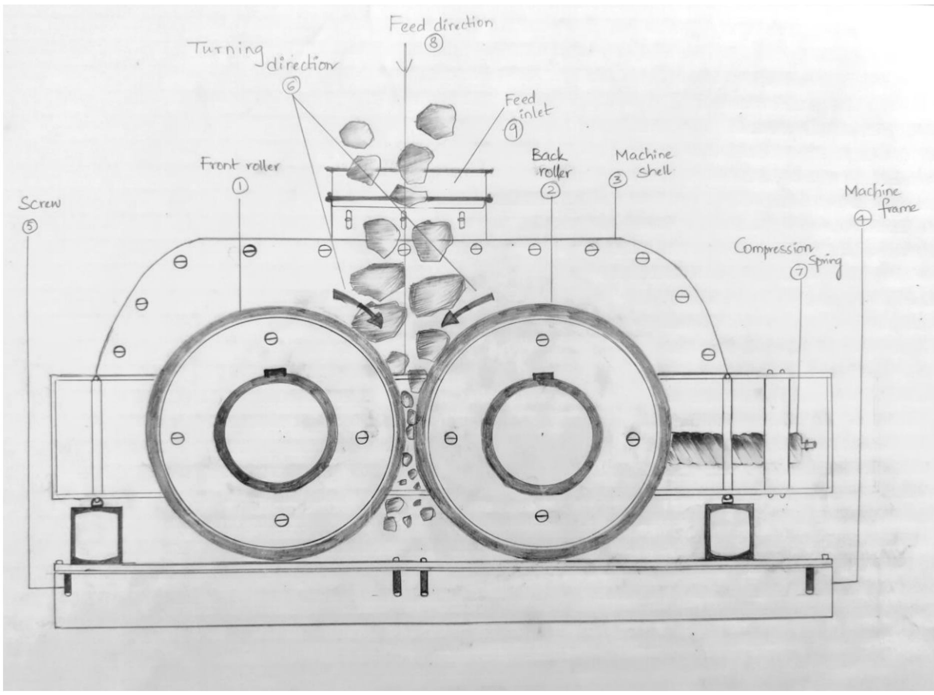
Actual Capacity: The actual capacity is obtained by dividing the amount of material crushed by the time taken for crushing. Mathematically it is given as,

$$Actual\ capacity = mass\ taken\ /total\ time, \text{ for crushing}$$

Reduction Ratio: It is the ratio of feed size to the product size. It is always greater than one. For roll crusher. Mathematically it is given by,

$$R = avg.\ feed\ size/\ avg.\ product\ size$$

EXPERIMENTAL SET-UP



Hand drew Schematic of the Roll Crusher

Observations

Size	Mass (gm)	Crushing TIme
+0.25", -1.5"	500	23s

Mesh No.	Sieve opening Di(gm)	Mass(gm)	Mass Fraction Xi	XiDi
10	1.676	469.5	0.964	1.612794
22	0.699	10.5	0.0216	0.015043
30	0.5	3.5	0.0072	0.003587
52	0.295	1.5	0.003	0.000907
72	0.211	0.9	0.0018	0.000389
Pan	0	2	0.004	0
				Average Product Size: $\sum Xid$ = 1.632719615mm

Consider the following case,
For Mesh Number = 30
d_i = 0.5mm
m_i = 3.5 g

Total Output Mass = Σm_i = 487.9g

$$\therefore\ x_i = \frac{3.5}{487.9} = 0.007174$$

$$x_i d_i = 0.007174 \times 0.5\text{mm}$$
$$= 0.003587\text{ mm}$$

On performing similar calculation on others,

$$\Sigma x_i d_i = 1.632719615\text{ mm}$$

CALCULATIONS

$$\text{Reduction Ratio} = \frac{\text{Avg. size of particles in Feed}}{\text{Avg. size of particles in Output}}$$

$$= \frac{9.525}{1.632719615} = 5.822$$

$$\text{Actual Capacity} = \frac{\text{Mass of feed particles}}{\text{Crushing Time}}$$

$$= \frac{500}{23} = 21.7391 \text{ g/s}$$

$\therefore$ Actual Capacity = 21.7391 g/s
= 78.2608 kg/hr

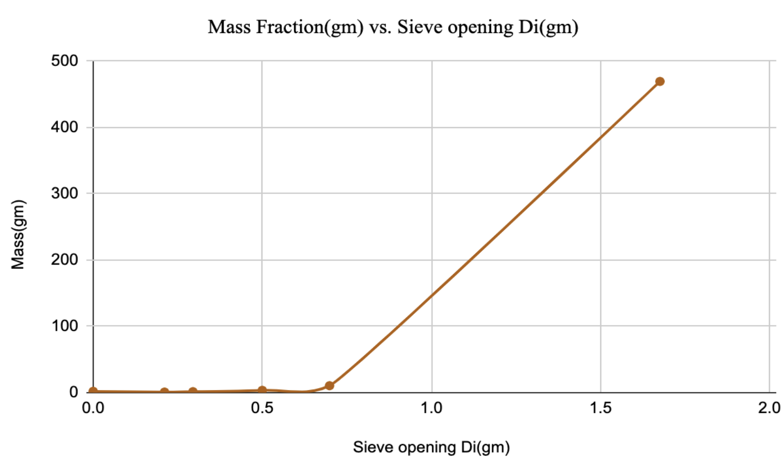
Theoretical Capacity (Given) = 1521.1 kg/hr

$\therefore$ Actual capacity is only 5.15% of theoretical capacity

RESULTS

- Reduction Ratio: 5.822, Actual Capacity: 78.2608 kg/hr,
- Theoretical Capacity: 1521.1 kg/hr
- The actual capacity is only 5.15% of the theoretical capacity

GRAPH



DISCUSSION

The working principle of the roll crusher is driven majorly by the Impact forces (when the feed particle hits Rolls or other feed particles), and Compressive forces (normal interaction between the opposite rotating Rolls). Friction forces between the surface of the particle and the rotating motion of rolls force the particle to fracture into the gap present between the Rolls, leading to the crushing of the particle. Roll crushers are predominantly used in Minerals, Abrasive metal ore crushing, Coal plants, Cement, Pisolite and construction Industries. Theoretical Capacity is found by multiplying density to the Volumetric Flowrate, where Volumetric Flowrate is a product of Area of Gap cross-section between Rolls (and) tangential speed of the roll.

We have an error in the Total mass between Feed and Output of 12.1g (500- 487.9). This is greater than any mass collected from the 2nd Sieve plate to the pan, so the major contributing factor for this error is the Larger Particles. While performing the experiment, the source of losing such particles is while pouring the feed, where some of them might shoot back because of the strong impulsive forces given by the rotating Rolls. Hence, we should gently pour the feed instead of flipping the entire plate containing feed.

The roll diameter should be of the correct size to provide an adequate angle of nip which ensures that the crusher has the ability to grab the feed material and pull it into the crushing zone without delay. The crusher shouldn't have too narrow a width compared to the size of the incoming feed as it can result in the bridging of the feed material across the crusher opening.

The reason for the huge difference in the orders of Theoretical Capacity given and Actual Capacity obtained, for defining theoretical capacity we take a major assumption that particles' falling motion is similar to that of a ribbon. Because of this, we multiply the gap area cross-section with rolls tangential speed. However, in reality, effective Area will not be the total area because of the spaces between the particles in a mixture. So, to incur this effect, we need to multiply the theoretical volumetric flowrate with a solid fraction. Also, the actual flow pattern of feed would be of a conical shape, and the shear velocity applicable on a particle is not only due to the angular rotation of Rolls but also the friction between the particles. Hence, the factors affecting Capacity are - Size of the rolls, Particles Size, Rotating speed of Rolls, Porosity of particles, Machine Run Time.