

# Estimating Crushing Force of Cone Crusher using Analytical Method

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**Abstract** - Cone crushers are widely used in Aggregate and Mineral processing industries as Secondary or Tertiary stage crusher to crush blasted rock material. In this work to calculate the output from a cone crusher, models for size reduction and flow are needed. The interaction between these two models & quite complex as the overall size reduction in a cone crusher is a result of a repeated consecutive comminution process. The flow model & important since it describes how the rock material moves through the crusher chamber. Thereby the flow model provides input to the size reduction model. In turn, the size reduction model predicts the size distribution after compressing the rock material. In this work a simplified methodology for estimating crushing force of cone crusher is presented.

**Key Words:** (Cone Crusher, Crushing chamber, crushing force, analytical method)

## 1. INTRODUCTION

The objective of crushing in any industry is to liberate valuable minerals from crushed material or to produce aggregate which is used as construction materials. Cone crushers is commonly used in aggregate producing and mineral processing industries. Crushing chamber is considered as heart of cone crusher as it decides the performance of crusher by affecting capacity, product size and product shape.

Cone crusher is the main material crushing to a certain degree of particles and plays a key role in the corresponding production process. For optimizing the sizing of cone crusher components it is first step to evaluate crushing force.

The aim of this paper is to look inside the crushing chamber and examines the crushing force which is the important parameter based on which sizing of cone crusher components needs to be decided.

### 1.1 CONE CRUSHER BASICS

#### A. Construction

In cone crusher components Concave & Mantel forms the crushing chamber geometry. The Core and Mantel is shrink fitted on shaft. Shaft is pivoted in bush bearing which gyrates at constant speed with Mantel as shown in Fig. 1. The nutational motion is achieved using eccentric sleeves which turns main shaft using V-belt drive thru gear mechanism.

#### B. Working

In a cone crusher the rock material is crushed between rigid surfaces. The motion of the moving surface is independent of the loading of the crusher. Therefore, the explored comminution principle is form conditioned compressive crushing.

Particles are nipped, compressed and crushed between mantle and concave. Breakage of particles can be both single particle (particles are broken between cone and mantle) and inter particle (between other particles). The mantle and the concave must be replaced regularly as they are continuously subjected to wear.

Crushing takes place continuously and is inter-particle to a great extent. Inter-particle crushing is achieved when a particle is stressed and broken between other particles. Inter-particle breakage is desirable from the point of view of wear and service life. Inter-particle breakage is also considered to give the best shape of the produced particles.

To achieve inter-particle breakage choke fed conditions are normally recommended. Choke fed conditions imply that the inlet of the crusher is covered with feed material. The feed material is then fed into the crusher by the influence of gravity.

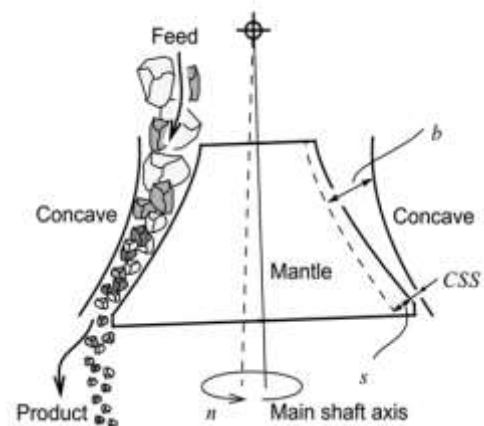


Fig -1: Basic principle of cone crusher working

The basic operating principle of a cone crusher is shown in Figure 1 The properties, i.e. size distribution and quality parameters, of the product leaving the crusher are a result of the interaction between crusher and rock material. In turn, the interaction is dependent on chamber geometry, crusher dynamics and rock material characteristics.

Concave, mantle, eccentricity and location of the pivot point together form the chamber geometry of the cone crusher. Like a crank, the eccentricity turns the main shaft with constant speed. At the top the main shaft is journal led in a pivot point. For some designs, the pivot point is just virtual. The mantle is fixed to the main shaft and the concave to the crusher frame. The resulting motion of the mantle and main shaft will be a nutating motion.

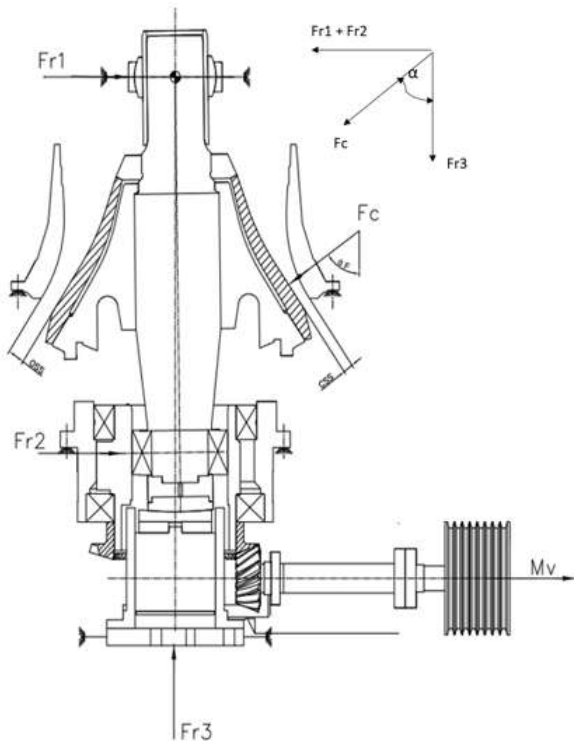


Fig -2: Free body force diagram cone crusher

If a vertical cross-section of the crusher is considered, the mantle will move cyclically forwards and backwards relatively to the fixed concave. During the squeezing motion the intervening rock material will be subjected to a compressive stress field and thereby comminuted. During the releasing motion the material is able to flow down through the chamber. The motion is driven by the influence of gravity and is governed by the motion of the mantle.

At a fixed point of location somewhere in the crusher chamber, the distance between mantle and concave will vary between open and closed position, as shown in Figure 2. The motion can be described with a cyclic function of the eccentric angle. The eccentric angle corresponds to the position of the eccentricity and therefore also to the position of the main shaft.

Schematic representation of Cone crusher & forces acting on it

## 2. CRUSHING FORCE ESTIMATION ANALYTICAL METHOD

Under normal working state, the size of the force of cone crusher are influenced by the physical and chemical properties such as ore, hardness, mechanical properties, breaking method and ore crushing cavity in the distribution and so on many factors. If using a theoretical formula to calculate the crushing force is a difficult, so using by crusher work normally when the hydraulic cylinder pressure to calculate crushing force. Crushing force calculation formula as shown in formula 1.

All parameters of the cone crusher are shown in table 1. To break into the various parameters in table 1 generation force calculation formula, to calculate maximum crushing force of cone crusher. Due to the crushing force is perpendicular to the moving cone lining board, we can undertake decomposition for crushing the biggest force Fc.

Table -1: Input parameters used to construct crushing chamber

D	CSS	D1	$\alpha$	P	$\gamma$
[mm]	[mm]	[mm]	[deg]	[bar]	[deg]
1300	25	380	56	45	0.98

Fc : The biggest crushing force

D1 : The hydraulic cylinder piston diameter = 380 mm

P : Normal Operating pressure = 45 bar

Pu: Pressure during Uncrushable= 55 bar

n : The number of hydraulic cylinder = 1

$\alpha$  : Dynamic cone Angle on the conical bottom(degree)

$\gamma$  : Precession Angle ( degree)

G : The moving cone weight= 29920 N

$$F_c = \frac{0.78D1^2.n.P - G}{\cos(a - g)} \quad (1)$$

Cylindrical roller bearing radial force

$$F1 = Fr1 + Fr2 = Fc \cdot \cos(90 - a) \quad (2)$$

## 3. RESULTS AND DISCUSSION

During normal operating condition, considering duty conditions based on industrial trials it is observed that at 45 bar the crusher operates in normal condition for this size.

Accordingly using equations 1 & 2

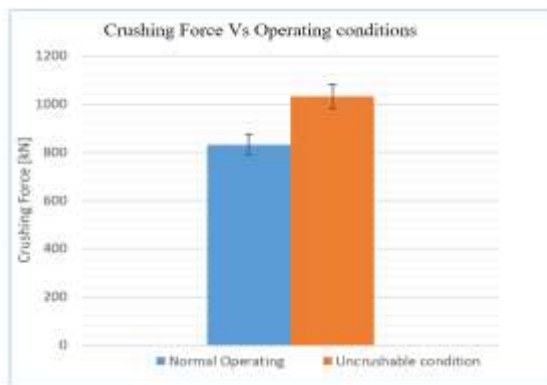
Crushing force operating Fco1 = 832 kN

When uncrushable item comes in crushing chamber based on past industrial data it is observed that the pressure rises upto 55 bar hence the maximum crushing force value due to uncrushable is calculated as

Crushing force Uncrushable  $F_{cu1} = 1028 \text{ kN}$

#### 4. CONCLUSIONS

The crushing force values obtained from simplified equations are shown using graphical method in fig. 3.



**Fig -3:** Comparison of crushing force

Percentage of error between two methods is approximate 24%. Is due to difference in pressure when uncrushable material arrives in crushing chamber. Hence during design of crusher components it is important to consider the condition of uncrushable.

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