

Development Design for Jaw Crusher Used in Cement Factories

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Abstract—Crushers are machines which use a metal surface to break or compress materials mining operations use crushers, 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 ore particles to finer gradations. Due to their simple design and easy maintainability jaw crushers are widely used as primary size reduction equipment in mechanical and mining industries. As jaw crushers break minerals & ores of high strength and the economy of many industries depends on its performance, it is essential to improve the efficiency of the present design. This paper focuses on review of a work carried out by researchers in the field of kinematic & dynamic analysis of the jaw crusher attachment. Kinematic & Dynamic analysis is helpful for understanding and improving the design quality of jaw crusher. There are many researcher work done by researcher in the same field but still there is a scope to develop Kinematic & dynamic analysis to jaw crusher attachment. This paper include design and manufacturing of all elements of jaw crusher by using equations, mathematic formulation, and determining to all parts of crusher dimensions, and testing at different distance of the lower gap to determine mass of product materials per different times.

Keywords—Jaw Crushers, Cement Factories, Manufacturing and Design.

1. INTRODUCTION

A crusher is a machine designed to reduce large rocks into smaller rocks, gravel, or rock dust. Crushers may be used to reduce the size, or change the form, of waste materials so they can be more easily disposed of or recycled, or to reduce the size of a solid mix of raw materials (as in rock ore), so that pieces of different composition can be differentiated. Crushing is the process of transferring a force amplified by mechanical advantage through a material made of molecules that bond together more strongly, and resist deformation more, than those in the material being crushed do [1]. Crushing is the essential function in the treatment of all rocks and minerals, whatever is their and use. The primary crushing of rocks does not appear compatible with high tech engineering of 21 Century. However, we have come a long way from the beginning of the 1800's when crushing was carried out by hundreds of men and women equipped with sledgehammers.

Even the largest commercial crushed stone-plants were small, consisting of one crusher, either jaw or gyratory, one elevator and one screen. When demand grew beyond the capabilities of one crusher, it was generally a simple matter to add a second machine. When the business outgrew the capacity of this sort of plant, it was not unusual to double up, either in the same building, or by erecting an entirely separate plant adjacent to the original one. The jaw crusher has developed for many years. Now it is widely used in many industries and has a very advanced technology.

Jaw crusher has experienced more than 100 years, although nothing groundbreaking changes in the structure, but because it has a simple structure, easy to produce, easy maintenance, equipment and production costs low, so until now Jaw crusher is still widely used in the production of mineral processing, building materials, silicate and chemical industry. It is generally used in the mineral processing industry production thick, hard and medium hard ore crushed, sometimes in the production of other industrial sectors and small ore crushing role.

Jaw crusher production is only a few decades old. The early years of the People's Republic of China, mainly due to the

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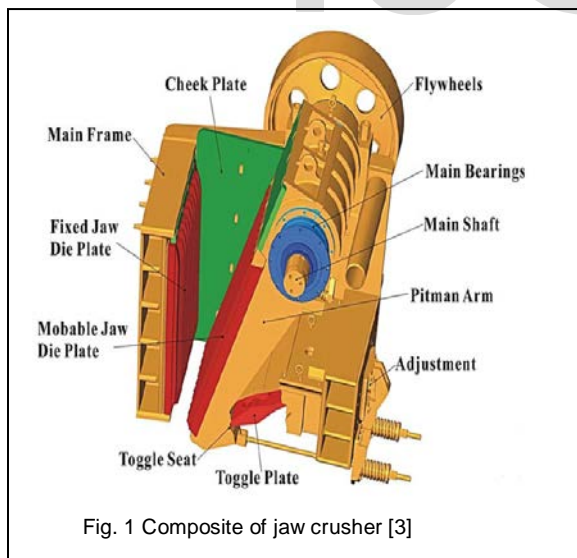
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weak foundation of Machinery Industry, the imitation of small and medium-sized jaw crusher, the end of the 1950s, due to the development needs of our mines and building materials industry, promote on the large elbows board Jaw crusher design and manufacturing. 1970s, our jaw crusher production has begun to take shape gradually complete specifications, can basically meet the needs of national economic construction. In the 1980s, due to the introduction of new technology, so that our jaw crusher production reached a high level, not only to meet domestic needs, but also are exported to Southeast Asia, but compared with foreign advanced level, domestic jaw crusher structure and crushing cavity is still relatively backward. Over the past 10 years, with the jaw crusher, continuous innovation and transformation, an increase of varieties and specifications, has gradually approaches the advanced level. At present, China's production of the most widely used jaw crusher there are two types: the moving jaw to do simple swing jaw crusher crank double rocker mechanism - simple pendulum-type jaw crusher; movable jaw complex swing crank rocker mechanism jaw crusher - compound pendulum type jaw crusher [2].

the material is crushed progressively smaller and smaller as it travels downward until it is small enough to escape from the bottom opening. The movement of the jaw can be quite small, since complete crushing is not performed in one stroke. The inertia required to crush the material is provided by a weighted flywheel that moves a shaft creating an eccentric motion that causes the closing of the gap [4]. A jaw crusher is generally used as a primary crusher in a crushing circuit. Product is fed into the top of the jaw crusher by an vibrating grizzly feeder. The eccentric rotating drive shaft causes the movable jaw to oscillate crushing the aggregate against a fixed jaw. Jaw crushers are run on belt drives driven by an electric motor or diesel engine. Jaw crushers are used extensively throughout the aggregate and mineral processing industry.

1.2 Working of Crusher

Crushing is the process of reducing the size of the lump of ore or over size rock into definite smaller sizes. Based on the mechanism used crushers are of three types namely Cone crusher, Jaw crusher and Impact crusher. The first stage of size reduction of hard and large lumps of run-of-mine (ROM) ore is to crush and reduce their size. The mechanism of crushing is either by applying impact force, pressure or a combination of both. The jaw crusher is primarily a compression crusher while the others operate primarily by the application of impact. The crusher crushes the feed by some moving units against a stationary unit or against another moving unit by the applied pressure, impact, and shearing or combine action on them [3]. they are available in various sizes and capacities ranging from 0.3 ton/hr to 50 ton/hr. They are classified based on different factors like product size and mechanism used. Based on the mechanism used crushers are of three types namely Cone Crusher, Jaw Crusher and Impact Crusher. Fracture occurs in the feed material when the strain developed in it due to sufficiently applied impact forces, pressure or shearing effect exceeds the elastic limit. Generally crushers are very rugged, massive and heavy in design. The contact surfaces are equipped with replaceable liners made from high tensile manganese or other alloy steel sheet having either flat or cor-



Rapidly growing rate of industry crushing machinery. 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

rugated surfaces. Shearing pins or nest in heavy coiled springs are provided in the crusher to guard against shock and overload. A crusher may be considered as primary, secondary or fine crusher depending on the size reduction factor.

- a) Primary crusher - The raw material from mines is processed first in primary crushers..

The input of such crushers is relatively wider and the output products are coarser in size.

Example - Jaw crusher, Gyrotory crusher.

- b) Secondary crusher- The crushed rocks from primary crusher are sent to secondary crusher for further size reduction. Example - Cone crusher, reduction gyrotory crusher, spring rolls, disk crushers etc.
- c) Fine crushers- Fine crushers have relatively small openings, and are used to crush the feed material into more uniform and finer product. Example - Gravity stamp.

The material to be crushed is dropped between two rigid pieces of metal, one of which then move inwards towards the rock, and the rock is crushed as it has a lower breaking point than the opposing metal piece. Jaw crusher movement is guided by pivoting one end of the swinging jaw. and an eccentric motion located at the opposite end [4].

1.3 Different Types of Jaw Crusher

According to the amplitude of motion of the moving face; Jaw crusher are classified as follows:-

1.3.1 Blake Type Jaw Crusher

Blake type jaw crusher, primary crushers in the mineral industry; attains maximum amplitude at the bottom of the crushing jaws as the swinging jaw is hinged at the top of the frame. These crushers are operated by and controlled by a pitman and a toggle. The feed opening is called gape and opening at the discharge end termed as the set. The Blake crushers may have single or double toggles. The toggle is used to guide the moving jaw. The retrieving motion of the jaw from its furthest end of travel is by springs for small crushers or by a pitman for larger crushers. During the reciprocating

action, when the swinging jaw moves away from the fixed jaw the broken rock particles slip down and are again caught at the next movement of the pitman and are crushed again to even smaller size. This process continued till the particle sizes becomes smaller than set; the smallest opening at the bottom. For a smooth movement of the moving jaws, heavy flywheels are used.

Blake type jaw crusher may be divided into two types:

(i) Single toggle type: - A single toggle bar is used in this type of crushers. Comparatively lighter jaw crushers use single toggle as they are cheap.

(ii) Double toggle type: - One extra toggle bar is attached here. Commonly used in mines as ability to crush materials is excellent, including tough and abrasive minerals.

To crush larger material, Blake type jaw crushers are preferred. The characteristics of such crusher are:

1. Larger, rough, massive and sticky rocks can be crushed.
2. They are easy to maintain
3. It is very simple to adjust and prevent much of wear and are easy to repair,
4. Moving jaw can be reinforced with high tensile manganese to crush very hard rock.

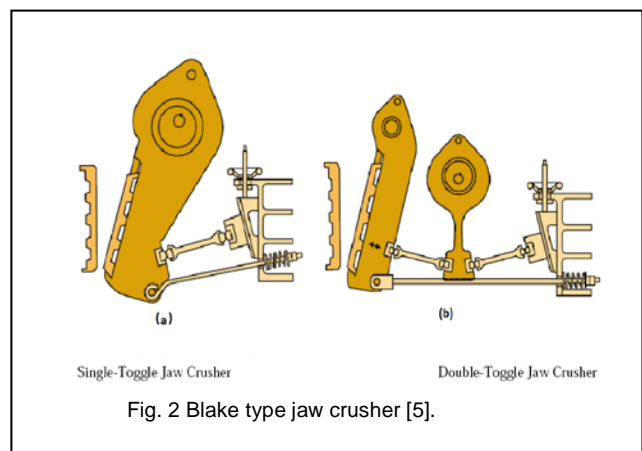


Fig. 2 Blake type jaw crusher [5].

1.3.2 Dodge Type Jaw Crusher

The movable jaw is pivoted at the bottom and connected to an eccentric shaft. The universal crushers are pivoted in the middle so that the jaw can swing at the top and the bottom as well. Maximum amplitude of motion is obtained at the top of

the crushing plates. Dodge type crushers are not used for heavy duty and commonly found in laboratories. [4].

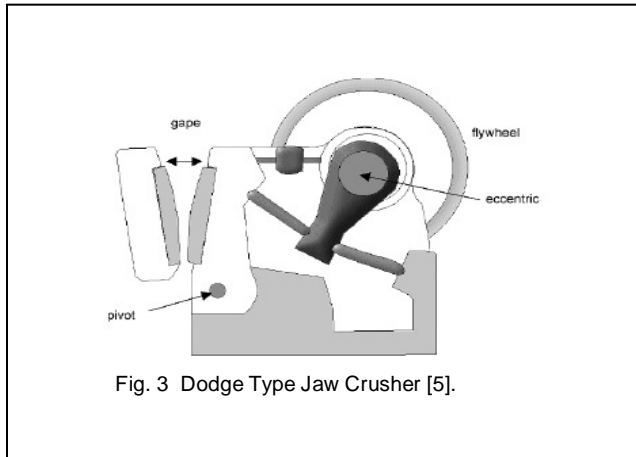


Fig. 3 Dodge Type Jaw Crusher [5].

Advantage and disadvantage of Jaw crushers

Main advantages:

- Heavy Duty Jaw Crusher Design.
- Long Life.
- Cost Effective.
- Standard Replacement Parts.
- High Productivity [3].

Main disadvantages

- lower power consumption
- bigger vibration
- small crushing ratio [6]

Application of jaw crushers:

- Mining.
- Aggregate.
- Demolition
- Industrial.
- Construction.
- Environmental [5].

2 WORKING PRINCIPLE

The mechanism of jaw crusher is based on the concept “crushing without rubbing”. Jaw crushers consist of two jaws. One fixed and the other reciprocating. The opening between them is largest at the top and decreases towards the bottom. The pitman moves on an eccentric shaft and swing lever swings on center pin. The rock is thrown between two jaws and crushed by mechanical pressure. A belt pulley; which is driven by a motor drives the eccentric shaft to rotate. This makes the attached jaw to approach and leave the other jaw repeatedly, to crush, rub and grind the feed. Hence the material moves gradually towards the bottom and finally discharges from the discharge end. The fixed jaw mounted in a “V” alignment is the stationary breaking surface. The swinging jaw exerts impact force on the material by forcing it against the stationary plate. The space at the bottom of the “V” aligned jaw plates is the crusher product size gap or size of the crushed product from the jaw crusher. The remains until it is small enough to pass through the gap at the bottom of the jaws. [7].

When the movable jaw goes downward, the angle between movable jaw and bracket turns small. Under the force of spring and connecting bars, the movable jaw plate leaves fixed jaw plate, and the crushed materials with qualified size are discharged from the crushing cavity. With the continuous rotation of the motor, the movable jaw crushes and discharges materials, which, in turn, realizes the goal of mass production. [8].

3 DESIGN PARTS OF JAW CRUSHER

3.1 Determination of Crusher Dimensions

A jaw crusher uses compressive force for breaking of particle. This mechanical pressure is achieved by the two jaws of the crusher of which one is fixed while the other reciprocates. A jaw or toggle crusher consists one jaw is kept stationary and is called a fixed of a set of vertical jaws ,jaw while the other jaw called a swing jaw, moves back and forth relative The volume or cavity between the mechanism. pitman or cam to it, by at two jaws is called the crushing chamber. The movement of the swing jaw can be quite small, since complete crushing is

not performed in one he material is provided by a stroke. The inertia required to crush tweighted flywheel that moves a shaft creating an eccentric motion that .causes the closing of the gap Jaw crushers are heavy duty machines and hence need to be robustly n or steel.The constructed. The outer frame is generally made of cast iron jaws themselves are usually constructed from cast steel. They are fitted hard (a -with replaceable liners which are made of manganese steel, or Ni Cr alloyed cast iron). Jaw crushers are usually constructed in sections - Nitransportation if they are to be taken underground for to ease the process carrying out the operations.

Where L_T = length of throw.

For reduction ratio, $R = 5: 1$ we set the gape as, 0.3m and a set of 0.06m.

Therefore, $L_{min} = 54mm$, $L_{max} = 66mm$

The rule of the thumb relating the gape and width of the jaw is;

$$1.3 G < W < 3 G$$

Where, G = gape, W = length of jaw.

We set the width of the crusher to be twice the gape. Hence, $W = 2G$, = length of jaw =0.6m.

3.2 Determination of Critical Velocity

There exists a speed for a crusher, where the conditions are optimum. The output and power consumption are optimized at that speed. This speed is known as critical velocity.

For the above dimensions, the critical speed in R.P.M is given by the following formula (Rose and English),

$$V_c = 47(1/(L_T^{0.5})) * ((R - 1)/R)^{0.5} \quad (1)$$

R = Reduction ratio.

V_c = critical velocity.

$$V_c = 47(1/(0.012)^{0.5}) (5/4)^{0.5} \quad (2)$$

= 384 R . P . M

3.3 Determination of Crusher Capacity, Q

a) From Rose and English,

$$Q = 2820L_T^{0.5}W(2L_{min} + L_T) * \quad (3)$$

$$(R/(R - 1))^{0.5} \rho_s f(p_k) f(\beta) S_c \quad (3)$$

Where,

ρ_s = density of stones or rocks

$f(p_k)$ = packing factor

$f(\beta) = 1$

S_c = surface characteristic of roks

Substituting for values in the above equation

$$Q = 2820 * (0.012)^{0.5} * 0.6 * (2 * 0.054 + 0.012) * (5/4)^{0.5} * 2.65 * 0.4 * 0.5$$

$Q = 13.17962$ tones /hour

b) From Michelson equation,

$$Q = 7.037 * [10]^5 WK_X ((L_{min} + L_T)/V_C) \quad (4)$$

$K_X = 0.18$ to 0.3

$$Q = 7.07 * [10]^5 * 0.6 * 0.2((0.054 + 0.012)/384)$$

$Q = 14.5137$ tonnes /hour

From the two methods, it is clear that for the given dimensions of the crusher, the average crusher capacity, Q is 14 tones/hour.

3.4 Power Consumption

The jaw crusher is driven by a motor or a diesel engine. The power that the engine or motor should avail to the jaw crusher drive shaft is given by;

$$\text{Power, } P = Q0.3162w_i (1/\sqrt{DP_b}) - 1/\sqrt{Dpa}) * \text{safety factor} \quad (5)$$

Where,

DP_b = mean product size, Dp_a = mean feed size

w_i = work index ,wich is 16 for granite

Q = crusher capacity

3.5 Design of Flyweel

A flywheel is a device used in machines as a reservoir which stores energy during the period when the supply of energy is more than the requirement and releases it during the period when requirement of energy is more than the supply. In order to understand the design of a flywheel, we have a look at some terms concerning the operation of a flywheel.

3.6 Coefficeent of Fluctuation of Energy, K

This is the ratio of maximum fluctuation of energy to the indicated work done by the engine during one revolution of

$$K_e = \Delta E / (T_m * \theta) \quad (6)$$

$$\Delta E = E_{max} - E_{min} \quad (7)$$

Where,

ΔE = maximum location of energy

$T_m \theta$ = work done per cycle.

T_m = mean torque.

θ = angle turned in one revolution of the crank.

3.7 Coefficient of Fluctuation of Speed, K_s

This is the ratio of difference between maximum and minimum angular velocities of the crankshaft to its mean angular velocity. This is the limiting factor in design of flywheel.

$$K_s = (\omega_{max} - \omega_{min}) / \omega_{mean} \quad (8)$$

$$\omega_{mean} = (\omega_{max} + \omega_{min}) / 2 \quad (9)$$

Where,

ω_{mean} = mean angular velocity.

ω_{max} = maximum angular velocity.

ω_{min} = minimum angular velocity.

TABLE 1
 Values of (K_s) for Different System for most stone crushers

Type of machine or class of service	Coefficient of fluctuation of speed (K_s)
Crushing machines	0.200
Electrical machines	0.003
Electrical machines (direct drive)	0.002
Engines with belt transmission	0.030
Gear wheel transmission	0.020
Hammering machines	0.200
Pumping machines	0.03 to 0.05
Machine tools	0.030
Paper making, textile and weaving machines	0.025
Punching, shearing and power presses	0.10 to 0.15
Spinning machinery	0.10 to 0.020
Rolling mills and mining machines	0.025

3.8 Fluctuation of Energy

Fluctuation of energy E_f is the excess energy developed by the engine between two crank positions. It is determined for one complete cycle of operation [9].

$$E_f = K_e E \quad (10)$$

$$E = (I \omega_m^2) / 2 \quad (11)$$

$$I = m k^2 \quad (12)$$

K_e = coefficient of lubrication of energy of the flywheel

E = mean kinetic energy of the flywheel

ω_m = mean angular speed of the flywheel

I = moment of inertia of the flywheel

m = mass of the fly wheel

k = radius of gyration of the flywheel

As speed of flywheel changes from ω_{max} to ω_{min} this can be expanded as:

$$\Delta E = E_{max} - E_{min} = I[\omega_{max}^2 - \omega_{min}^2] / 2 \quad (13)$$

Combining the equations we obtain;

$$\Delta E = (m k)^2 k_s \omega_{mean}^2 \quad (14)$$

or

$$R = \sqrt{\left(\frac{\Delta E}{mKS \omega_{mean}^2}\right)} \quad (15)$$

The loading on the shaft involves shock and fatigue. To account for these the equation has to be modified using factors that depend on the type of loading.

3.10 Design of Spring

For a spring, the value of C should lie between 4 and 16. We opted for the minimal ratio of 4 to minimize the spring size[10].

$$K = (4C - 1)/(4C - 4) * (0.615/C) = 0.1921875 \quad (16)$$

From the normalized torque ratios, the values for the torque on the jaw varied from

$$39 T_2 \leq T_3 \leq 60 T_2$$

Hence it varied from 10647 Nm to 16380 Nm, and these were the variations during the cycle that were absorbed by the spring, a variation in the torque of 5733 Nm. For a length of 0.7 m of the jaw, this implied a force of (8190 N).

Resolving this force in the z- direction $F_z = 8190 \cos 20 = 7696N$

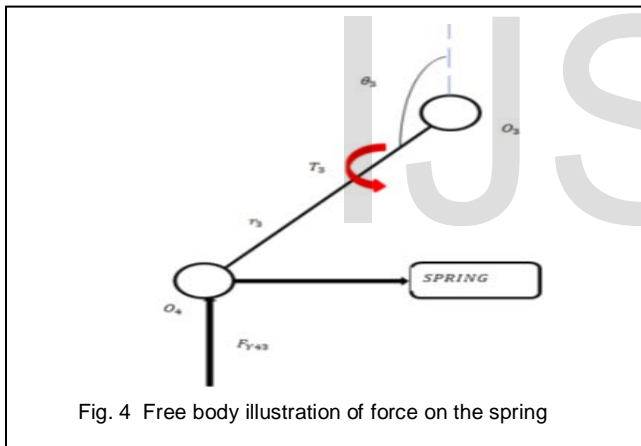


Fig. 4 Free body illustration of force on the spring

For a load W_s of 7696 N ≈ 7700 N ,

$$d_{sp} = 13 \text{ mm and } D_{sp} = 52 \text{ mm}$$

$$\tau = (K * 8 * WS * D1) / (\pi d_{sp}^3) \quad (17)$$

τ = maximum shear stress on the spring

K = spring factor

W_s = load on the spring

$$D_1 = d_{sp} + D_{sp}$$

d_{sp} = diameter of the steel wire,

used for making the spring

D_{sp} = mean diameter of spring

Using a carbon steel of 2nd grade with 8 active coils.

$$\delta = (8 * WS * C^3 * n) / (Gm * d_{sp}) \quad (18)$$

δ = deflection of the spring

G_m = shear modulus of elasticity of the material

n = no of active coils in the spring

$n' = n + 2 =$ total no of coils in the spring

$L_f =$ free length of the spring

$$\delta_{max} \approx 1.5 \delta$$

$$L_f = n' * d_{sp} + \delta_{max} + 0.15 \delta_{max} = 175.884 \text{ mm}$$

P_{sp} = pitch of the spring

$$P_{sp} = L_f / (n' - 1) = 19.542 \text{ mm}$$

3.11 Design of Bearings

The approximate rating (or service) life of ball or roller bearings is based on the fundamental equation;

$$L_b = \{C_b / W_b\}^k * (10)^6 \text{ rev} \quad (19)$$

Where k=3 for small bearings

L_b = Rating life

C_b = Basic dynamic load rating

W_b = Equivalent dynamic load

The reliability (R) is defined as the ratio of the number of bearings which have successfully completed L_b million revolutions to the total number of bearings under test. According to Weibull, the relation between the bearing life and the reliability is given as;

$$[\log_e \{1/R\}] = \{L_b/a\}^b \quad (20)$$

Where a = 6.84

b = 1.17

The total force on one bearing is approximately 3924N.

The bearings carry maximum load of 3924N during working hours of about 33% of the total time and a lesser load of 1.962KN for about 67% of the time.

We fix our bearings to have an expected life of $20 * 10^6$ revolutions at 95% reliability. Since most catalogues are tabulated at 90% reliability, the following formula converts to 90% reliability:

$$\{L_{95}/L_{90}\} = \{\ln(1/R_{95})/\ln(1/R_{90})\}^{(1/b)} \quad (21)$$

$$L_{95}/L_{90} = \{(\ln 1/0.95)/(\ln 1/0.9)\}^{(1/1.7)}$$

$$= 0.54$$

Considering life adjustment factors for the operating conditions and material to be 0.9 and 0.85 respectively,

$$L_{95}/L_{90} = 0.90 * 0.85 * 0.54 = 0.4131$$

$$\text{Therefore, } L_{90} = (20 * 10^6) / 0.4131 = 48.4 * 10^6 \text{ revolutions}$$

Equivalent radial load

$$W_b = \{(n1 W1^3 + n2 W2^3)/(n1 + n2)\}^{(1/3)} \quad (22)$$

Therefore, $W_b = 2.92398 \text{ KN}$

Dynamic load rating C_b is given the following expression,

$$C_b = (L_{90}/(10)^6)^{(1/K)} \quad (23)$$

= 10.656 KN

From the catalogue of bearings, we choose for a bearing type with

$$C_0 = 10.656 \text{ KN}, L_{90} = 48.4 \times 10^6 \text{ revolutions}$$

Based on the above values, the available bearings for the shaft is JIS 1523 SKF, self-aligning ball bearings double row with cylindrical bore SKF, mild steel. For the 2 sets of bearings, we choose those with the following specifications:

TABLE 2
 Bearing specifications

Dimensions	JIS 1523 SKA(A) SKF 2218
INSIDE DIAMETER	90mm
OUTSIDE DIAMETER	160mm
FILLET RADIUS	2mm
STATIC LOAD RATE	28500N
LIMITING SPEED	3600 RPM
FRICTION FACTOR	0.001

3.12 DESIGN OF TOGGLE

Assume from our jaw crusher:

$$r_3 = 0.7 \text{ m } \theta_3 = 159.559 \text{ T}_3/T_2 = -4421.31 \text{ T}_2 = 273 \text{ Nm}$$

$$F_3 = T_3(r_3 \sin[2(\theta_3)]) \quad (24)$$

$$P_{cr} = (\pi^2 * E * I_g) / (L_g^2) \quad (25)$$

$$I_g = b * t^3 / 12 \quad (26)$$

$$t = \sqrt[3]{(12 * I_g / b)} \quad (27)$$

$I_g = 2^{nd}$ moment of area of toggle

P_{cr} = critical load

Based on this, we designed a toggle with a thickness of 2 cm.

4. EXPERIMENTAL WORK

4.1 Determination of Crusher Dimensions

4.1.1 Rugged Eccentric Shaft

These rugged eccentric shafts are hammer forged from the finest quenched, Tempered and stress-relieved alloys. There is just enough eccentric throw to give clean impact-like crushing and yet avoid harsh rubbing motion which robs horsepower and

creates excessive jaw wear. The first step of making the eccentric shaft is designing and drawing the shaft with all dimensions. Obtained the shaft with a length of 120 cm and 80 cm diameter, the next step is reducing the length of the shaft to 55 cm and reducing the diameter to 6.5 cm using a lathe machine. Then, machining the shaft to move the center of the shaft 0.5 mm from the old center in order to obtain an eccentric shaft. After that, the ends of the shafts' diameters are reduced in order to place the bearings and machining the grooves for the keys. Finally, surface finishing is performed for the shafts to achieve the best surface in order to reduce any stress concentration on the surface.

4.1.2 Jaw

Back faces of all jaws are machine ground to provide firm support. Two piece reversible jaws are provided on our larger crushers to allow maximum jaw life. The jaw-faces are fully reversible. Replaceable jaw-face backing plates are provided to protect the machined jaw-face locations and the jaw holder guard, provides protection for the jaw holder bearing housing. The jaw plates are created using two plates with the dimensions of 40 cm high and 30 cm wide, then a long square beam of dimensions 20x20 cm is cut into pieces, those pieces are joined onto those plates in order to obtain the jaw teeth, these welded parts were 13 ones, 7 parts for the fixed jaw, and 6 parts for the movable jaw, the joining operation used is welding.

4.1.3 Main Fram

Fully fabricated heavy-duty designs on all models. Fully stress relieved after fabrication. Our designs have been thoroughly field tested under arduous conditions. Heavy-duty frames of low carbon steel plate, reinforced with ribs, are fabricated with all mounting surfaces fully machined to accurately align critical components. The main frame was created using three plates, two of them having the same dimensions which are 55 cm wide, 53 cm high, and 2 cm thick. Half a circle was created on top of each of the two plates with a radius of 7 cm. A hole was turned at the center of the half circle with a diameter of 5 cm for locating the shaft and the bearings. The extra material at the top of these plates is removed to create the final shape.

The third plate is a rectangular shape with the dimensions 30 cm wide, 45 cm high, and 2 cm thick.

4.1.4 The Assembly of All the Parts of the Jaw Crusher

The first step of joining the jaw plates to pitman is by welding and joining the shaft to the movable jaw by two anti-friction bearings to create the move movable jaw. Next is to mount the shaft into the frame using two anti-friction bearings as well. The balanced flywheels are joined to the ends of the shaft using keys into the machined slots of the shaft.

The springs, toggle plate, and movable jaw are assembled to the two plates of the frame. Finally joining all of the plates of the frame using six M24 bolts, and connecting the crusher to the motor using two belts. We should mention that the movable jaw is pivoted and can be adjusted to change the gap distance, having a range of (2-7.5) cm.

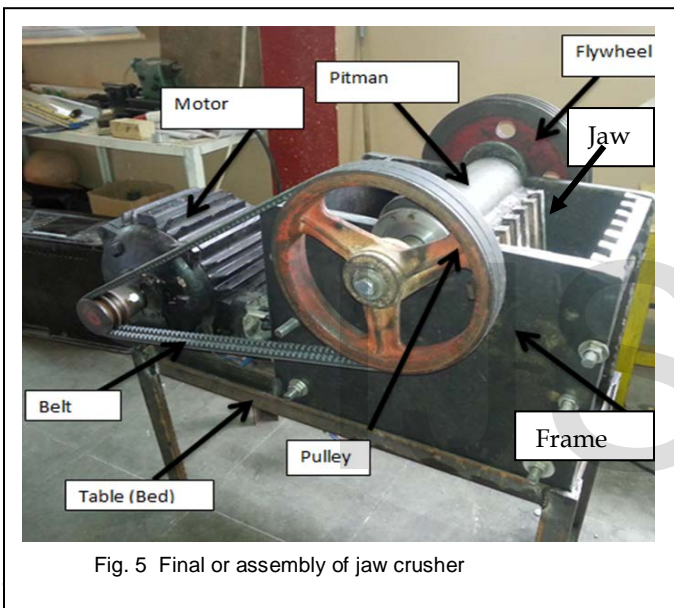


Fig. 5 Final or assembly of jaw crusher

Given the weight of the rim is 88.612Kg, we estimated the weight of the flywheel to be 120Kg each i.e. 1177.2N.

Mas of jaw and wear = density * volume = (8400 * 0.08 * 0.6 * 0.7) = 282.24 kg. Mas of rocks = (1/2 * 0.3 * 0.76 * 0.6) * 2650 = 181.6 kg

But the rocks normally occupy just about 60% of the capacity hence the mass of the rocks is just about 100 Kg. The mass of the jaw and plate approximated as 300 Kg. But since the shaft is a very critical component and works at very high speed, we designed it to carry twice that load. Hence the weight distributed on the point of contact with the shaft was 3924N on each of the points of contact at the bearings.

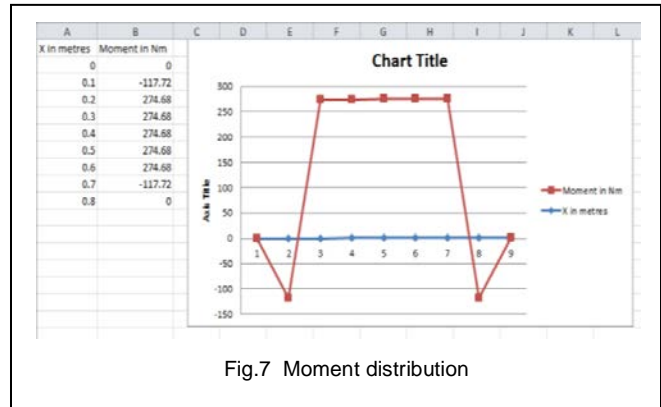
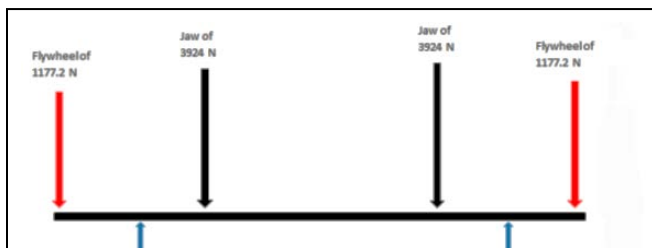


Fig.7 Moment distribution

TABLE 3
Shock and fatigue factor table

Type of loading	K_b	k_t
Load gradually applied	1.5	1
Load suddenly applied with minor shock	1.5 - 2	1.0 - 1.5
Load suddenly applied with heavy shock	2.0 - 3	1.5 - 2.0

In jaw crushers, the load is applied suddenly with a moderate shock. Therefore, from the table of shock and fatigue factors above, the appropriate values chosen are:

$$k_b = 2.0$$

$$k_t = 1.5$$

Where,

k_b = shock and fatigue factor for bending moment.

k_t = shock and fatigue factor for torsion.

Testing jaw crusher by using rocks at different distance of the lower gap, for determination of the product of crushed rocks, the results are:

a- In the minimum distance (2cm) the amount of crushed rocks are (1.2 kg) for one minute, (2.0 kg) for three minutes, and (3.4 kg) for five minutes. when the time increase the products of the rocks are increases. The size of rocks was very small like as pow-

der.

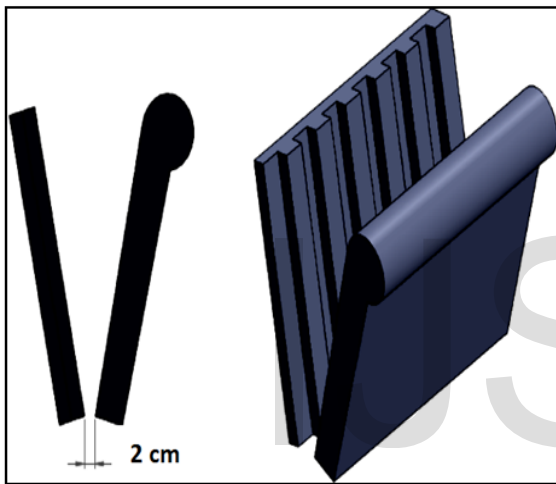
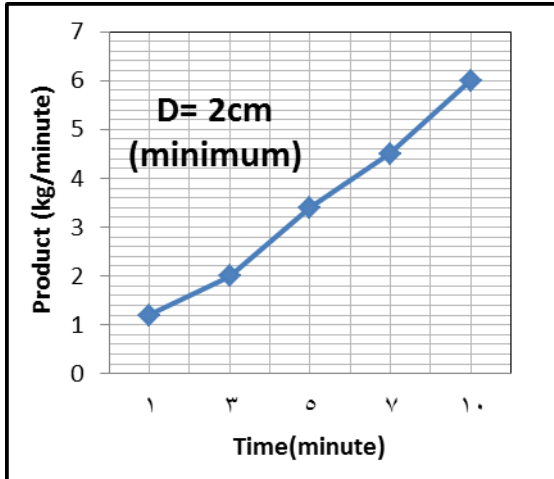


Fig. 8 Relation between time and product.

b- when increasing the distance to (4cm) the amount of crushed rocks are (2.5 kg) for one minute, (4.5 kg) for three minutes, and (5.8 kg) for five minutes. The size of the output rocks was bigger than in the previous test as shown in fig. 4.

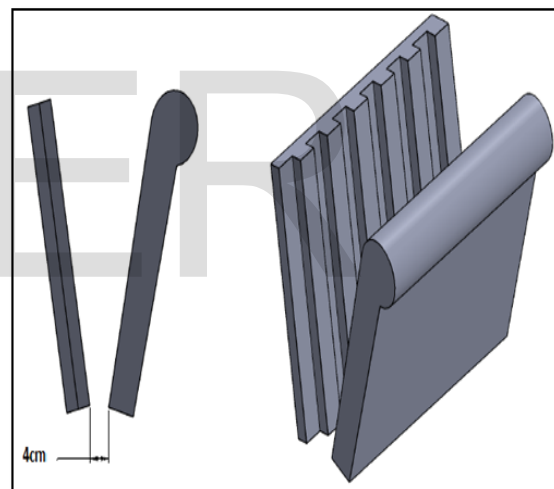
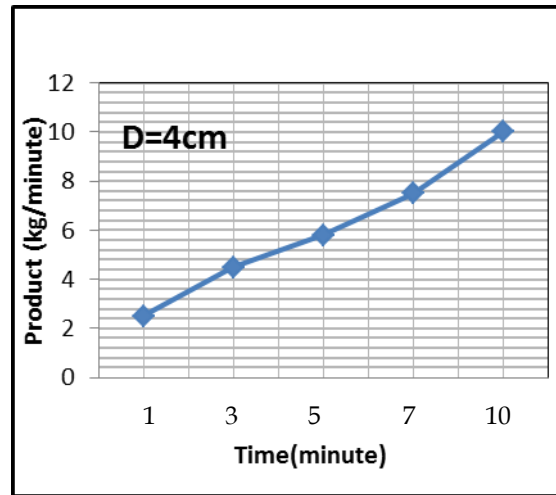


Fig. 9 Relation between time and product.

c-When increasing the distance to the maximum which was (7.5cm) the amount of crushed rocks are (4 kg) for one minute, (7.6 kg) for three minutes and (10.5 kg) for five minutes, the biggest rocks are crushed and the size of rocks are bigger than other tests.

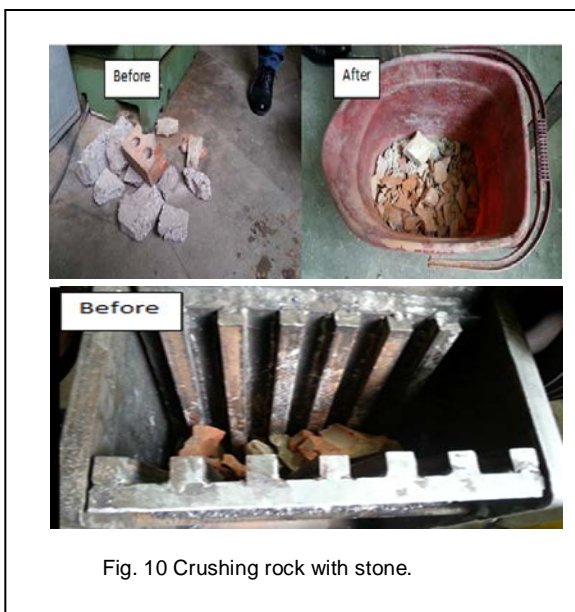
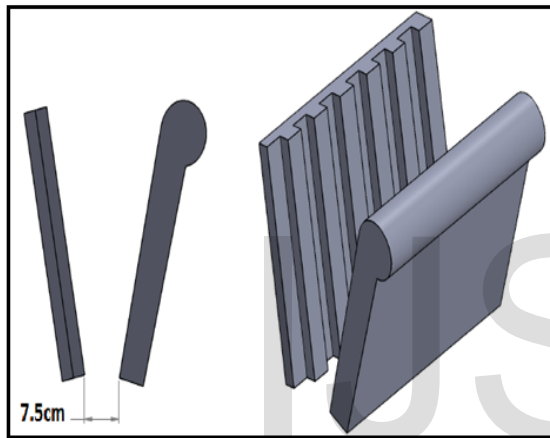
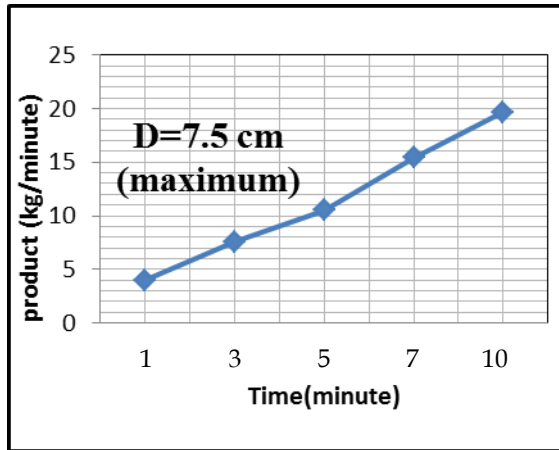


Fig. 10 Crushing rock with stone.

The result of the wear analysis can explain some of the phenomenon in practice. With the rock material breakage character taken into consideration, the blindness brought by

the traditional empirical designing can be greatly decreased. It is helpful to design the crusher for improved performance.

The breakage force is measured in the experiment and some new information on the material flow in jaw crusher chamber is illustrated with the particle breakage character taken into consideration. Based on the movement analyses of the moving jaw and the crushing force distribution analysis, the jaw plates wear is analyzed. The relationship between the slide and the wear is reasonable and some results of the wear analysis are validated in practice. Predicting the jaw plates wear on a macroscopic level will be helpful to the jaw crusher design for better performance. Since the slide between the particles and the jaw plates is replaced by the vertical movement distance of the moving jaw plate in this paper, the further study is needed to predict the accurate wear rate.

6 CONCLUSION

Kinematic analysis is helpful for understanding and improving the operating performance of the size reduction machine. Kinematics and dynamic analysis have very important significance for the life of the specific parts. Specific process will be no longer introduced. This concept of kinematics is followed by number of researches for their application. This review provides the background of Jaw crusher Kinematics to carried out further research work in same area.

1. with larger feed openings and longer crushing chamber, suitable to crush big lumps of stone.
2. main frame made of welded high strength steel plates, with heat treatment which makes it particularly strong.
3. chose heavy-duty roller bearings can carry heavy load during crushing with gives long life for bearings.
4. this machine is created at lower cost than the other jaw crushers which created by factories.
5. the biggest modification in this project is creating the part to control the distance of the lower gap from (2 to 7.5cm) so by this modification we can control of the size of output rocks .

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