Design and Fabriction of an Interlocking Tiles Crusher

Igbinoba J.O, Aimuamwonsa I.O, Omorodion, Amiebenomo.S.O
Department of Materials and Production! Department of Mechanical Engineering! ! ! Ambrose Alli University, Ekpoma Nigeria Tel: +2348033538536 Email: igbinscoker@yahoo.com

ABSTRACT
The design and fabrication of an interlocking tiles crusher using a reciprocating mechanisms presented in this paper possesses a crushing pressure of about 3 MN/m and draws it energy from an A.C. squirrel cage induction motor of 3.71KW running at about 980RPM. It is capable of handling the crushing of 300 tiles per hour as attested to by a destructive crushing test carried out on the machine.
KEY WORD: Interlocking tiles, ram, reciprocating mechanism

1. O INTRODUCTION

During the transformation period (Bronze age) limestone was discovered as an important construction material and because of its perpetual source, (sedimentary rocks) man began to reduce sedimentary rocks for domestic use the prime method employed for size reduction has being with man right from the bronze age it was in various forms, they include cutting milling, grinding and crushing crushes which are machine designed to reduce materials (soil) into usable sized are of immense importance to the social economic development of any nation due to it relevance in the production road constructional material.

1.10 OBJECTIVE OF STUDY

Design a crusher using a reciprocating mechanism to crush interlocking tiles

- Produce a design that will reduce environmental pollution resulting from dust particles during tiles making.
- Provide a relatively cheaper means of crushing constructional waste.
- Produce a design that will able to overcome the shortcomings of the industrial crusher that possesses high quantity of lubricant consumption and high procurement.
- Produce a design that will be affordable to all categories of consumer.

1.20 SIGNIFICANCE OF STUDY

This work was carried out in order to help put an end to wastage in terms of materials and energy that is always experienced in factories during interlocking tiles production using the traditional methods.

1.30 METHODOLOGY

In the design and fabrication of this work a lot of factors were put into consideration right from materials selection to the procurement of component needed, a careful market survey and examination of existing tiles was also undertaken by considering the following factor's

i. Availability of raw materials and equipment.
ii. Procurement cost of associated items.
iii. Size and flexibility of proposed design.
iv. Maintenance cost of propose design.
v. Operational and constructional cost.
vi. Strength and rigidity of design
vii. Power requirement.

The procedure and correct sequence for fabrication was also analyzed, based on the factors highlighted above.

1.40 LITERATURE REVIEW

Right from time immemorial man has always, carried out reduction of component in one form or the other to suit their domestic used crushing sedimentary rocks then was with traditional methods however it was in 70 BC that the Romans was recorded to have constructed the first road from reduce rocks. Using mechanical crushes powered by beast of burden. In 1690 a French man named Denis discovered stream power which led to the modification of crushes power sources Numerous king of crushes is now in existence but selecting an appropriate crusher is best made from a consideration of the purpose, cost, size of crushes and desired efficiency this design has the advantage of reducing wastage that is experienced in factories as well as excessive energy dissipate during the use of traditional crushing methods. Several other crushers with similar operational mode have been produce both at local and international level. However this work will discourages importation of crusher into our market as the capacity and utilization and efficiency is guaranteed.

Crushes are devices used to change sizes of material by applying compressive force in excess of the unit to be reduced. Reduction in size of the materials by crushers does not change the chemical properties of the material, but produce product with uniformity in size.

Crushers are of two main types

- Size reduction by shearing
- Size reduction by cutting.

Size reduction by shearing is achieved by combination of both cutting and crushing mechanism gives the pattern line on the material to be sheared as the cutting mechanism shear through.

Size reduction by cutting.

Reduction in the size of material by cutting can be achieved by using a sharp metal edge to slice through the material.

1.61 CLASSIFICATION OF CRUSHERS.

Jaw crusher, Gyratory crusher, Impact crusher and Roller crusher

1.62 PROPOSED DESIGN

A careful analysis of the crushers enumerated above shows that the jaw crusher has the combination of qualities of all other crushers. This crusher consist of a conventional frame, a flywheel a connecting red which transmit rotational motion to a linear/reciprocating motion of the ram (crushing jaw). It will be powered by an electric motor with the aid of a belt drive.

2.0 DRIVE DYNAMICS

The mechanism employed in this design comprises of a shaft carrying a pulley on the crank supported on bearings. The rotation of the shaft is provided by an electric motor linked to the shaft by a belt drive. The rotating crank motion is converted to reciprocating motion by using a connecting rod whose other end is attached to the crushing jaw.

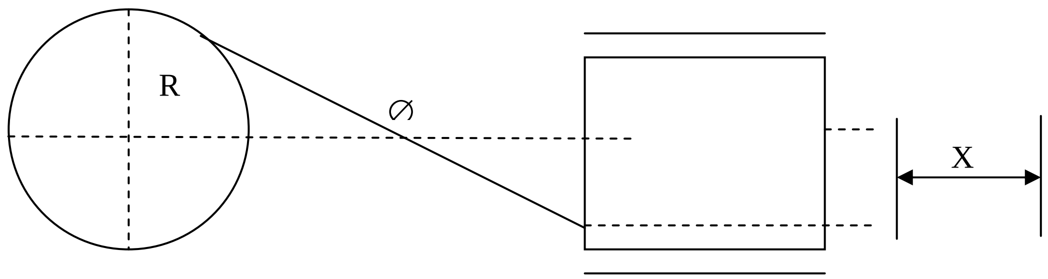


Fig 1.0 Geometric Analysis

$X = R\,(I\text{-}\mathrm{Cos}\ \theta) + L\,(1\text{-}\ \mathrm{Cos}\ \Phi)$

But $R \sin\theta = L \sin\theta \rightarrow \sin\theta = R/L \sin\theta$

If $L/R = n \rightarrow \sin\theta = R/L\ \frac{\sin\theta}{n}$

$\sin^2\theta + \cos^2 = 1 \rightarrow \cos^2\theta = 1 - \sin^2\theta$

$\cos\theta = \sqrt{1\text{-}\sin\theta} \rightarrow$

$\cos\theta = \sqrt{1\text{-}\sin\theta} \rightarrow$

$1 - \frac{\sin^2\theta}{2n^2}$ (Taylor series)

Hence

$x = R\,(1\text{-}\mathrm{Cos}) + L\,(\frac{\sin^2\theta}{2n^2})$

$x = R\,(1\text{-}\cos\theta) + L\,(\frac{\sin^2\theta}{2n^2})$ ……………………………eq (I)

$v = \frac{dx}{d\theta} = R\,\frac{(d\theta)}{dx}\ w \sin\theta + \sin^2\theta\ R/2L$

I.e. WR (Sin θ + $\frac{\sin\theta}{n}$ ….,,, eq 2

$A = \frac{d^2x}{dt^2} = W^2R\left(\cos\theta + \frac{\sin^2\theta}{n}\right)$ ………………………….. eq 3

Force required to accelerate the crushing law (Ram) is derive.
$F = MA \to MW^2R\left(\sin\theta + \frac{\sin 2\theta}{n}\right)$ ………………….. eq 4

Belt selection
An open flat belt was used with a
Velocity ratio $\frac{N_1}{N_2} = \frac{d_1}{d_2}$ ----- …………………………….eq 5
$V = \prod dN/60$ … ……..eq 6
The reaction due to ram impact FR = б x a [where б = crushing strength]
∴Initial force of the reciprocating part
F1 = mass x acceleration
$= We\ W^2R\left(\cos\theta + \frac{\sin^2\theta}{n}\right)$ ……………………… eq 7

∴ The length of the open belt drive is given by $L = \prod/2\ (d_1 = d_2) + 2x + d1\text{-}d2\backslash 4x$….. ……………………eq8
(X= Distance between centers of two pulley.

2.10 POWER TRANSMISSION

Power transmitted by belt is given by
$P = (T_1\text{-}T_2)\ V$ ……………………………………… eq 9
Where v = rw
Similarly the ratio of the given tension is given by
$\log T_1/T_2\ N\theta$ ……………………………………….. eq 10.
Centrifugal tension is also induced in belt due to continuous run over pulleys whose effect is to increase tension on side and cannot be neglected at speed more than 10m/s
I.e. $Tc = MV^2$ ….,, eq 11
Transmission of power to shaft. The Hub diameter (Di) in terms of them staff diameter d is D. = 1.5d + 25mm … while the length of the hub = ∏ xd\2 ……………… eq 12
Due to the crushing effect of the Ram a shear force will be transmitted to the power shaft according to the maximum normal stress theory the MAX normal stress are Ymax=1/2 $(b^2]+4r^2$ (where r = share stress induced to twist)

putting $\sqrt{b} = \sqrt{32M/ưd^3}$ and $Y = 16T/ưd^3$

$Ymax = 16T/ưd^3[\sqrt{M^2+T^2}$

And $D^3 = 16T/UTmax[\sqrt{M^2+T^2}$

$M=(T_1+T_2+2Tc)L$…………………………………. e.q 15

Where $T = P\ x60/2\prod$

$\sqrt{b}max = ½\ \sqrt{b} + ½\ \ \sqrt{b^2 + 4Y^2}$ .. ,,,,,,,,,,,,,,,,,,,,,eq 16

Since a machine like a crusher is faced with fluctuating loads, shock and fatigue factor must be taken into account hence the theory can be rewritten as

$- d^3 = 16Ymax/Y\ [\sqrt{(km\ M)^2 + KIT]^2}$ . . ………. eq 17

$- d^3 = 32[½\ (kmM) + \sqrt{(kmM)^2 + (KIT)]^2}$ . . . ……..eq 18

Km and k4 value of Rotating shaft can be gotten from standard tables

Following AsMe code for solid shaft without axial loading base on maximum shear theory of failure

$D^3 = 16/u\sqrt{a}\sqrt{(kb)M^2 + (KIT)^2}$ . . . eq 18

The reactive force due to ram impact = $\sqrt{b}$ x A

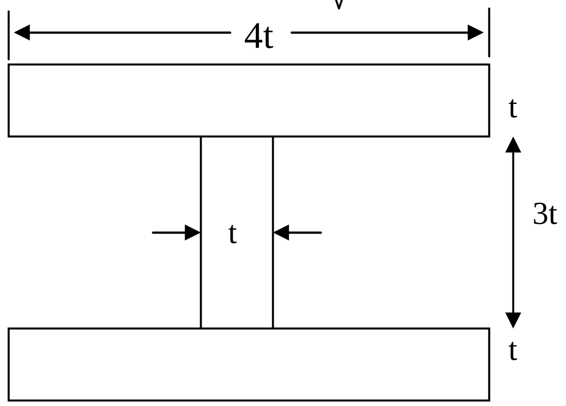
Initial force of reciprocating part

$F_1 = WrW^2r$

2.20 CONNECTING ROD

For the connecting Rod design it is similar to an I section moment of initial about X-axis

$Ixx = ½ (4t + (5t)^2 + \sqrt{3t \times (3t)^2}$ . . . ,,,,,,,,,,,,,,eq 20



$A = IIt^2$ $B = 5t$ $H = 4t$

Where A B and H represent. The Area breath and height respectively

L = L for both ends longed

L = L/2 for both ends fixed

For the connecting Rod to be equally strong in buckling about both axes buckling load must be equal i.e.

$\sqrt{c}A/ 1 + \sqrt{a (1/Kxx}^2 = \sqrt{c}A/1 + A (L/Kxx)^2$ . . ..eqn 21

Ixx = 4Iyy . . . .eqn 22

Load on crank pin = protected Area x Allowable bearing stress = dc *Ic+ rbc ....eqn 23

Ic = 1.25 dc to 1.5dc of similarly Fr = dc x Ic x bc.........eq24

2.30 POWER REQUIREMENT

The jaws attached is to have projections (about 10) with diameter of 0.56mm the area of the projection from IID 2/4 = 3.14×10^{-4} m^2

Force on the Ram from eqn 4 = 9426N power = force x velocity

. : A Motor of 3.73×10^3 watts 980Rpm is required.

For pulley

From eqn 12 ($T_1 = PV^2$

Tc = 4.5mpn

Given V = 25m/s and D = 0.81 (811mm)

A pulley of 900mm will be selected for the motor from eqn 5 while a pulley of 500mm was selected for shaft pulley

From eqn 9 and 10 the tension on both side of the belt is derived i.e

$T_1 = 1899.3N$,$T_2 = 739.3N$

The tension on both side of the belt the belt length from equation 8 is 8853mm

Bending moment on the power shaft due to the pulley tension on the belt from eqn 15 is 9506NM

Similarly

From equation 15 Buckling load (wer) is equal to 9426 x 6 = 56556N

6c = 320mpn (wer = 6cA)

Kxx = 1.78t where A = Ht^2

t = 6mm

I.e. thickness of web = 6mm

Width of he session B = 5t B = 30mm

Height of section H[from H=4t = H] = 24mm

Load on the crank pin from eqn 22 and 23

bc = 34.7mm/N

Tc = 1.3dc

Loc = 10N/mm

Similarly Dimension of ram pin

F = 9426N , (9246 = $30dp^2$),dn = 18.5mm (Ip = 2dp)

Ip = 35mm ,Pp = $15N/mm^2$

Table 2.0 Bill Quantities & costing (BQC)

S/N	Component	Material	Dimension	Quantity	Unit cost	Amount₦
1	Solid shaft	Medium carbon steel	Ø93.1mm L = 1000m	1	N 2500	2500
2	Ram	Cast-iron	220 x 160 x 450mm	1	3800	3800
3	Crusher frame	Cast iron	950 x 500 x 1000	1	8000	8000
4	Crusher pulley	Cast iron	Ø900mm	1	2000	2000
5	Motor pulley	Cast iron	Ø500mm	1	1500	1500
6	Flat belt	Rubber	L=3854mm	1	1200	1200
7	Pins	M^1/d steel	L=35.5mm Ø17.7mm	1	300	300
8	Connecting rod	M^1/d steel	L=900mm	1	N/A	N/A
9	Roller rod	M^1/d	L=300mm Ø30	14	400	5600
10	A.C motor		P=29kw N=980Rpm	1	2900	2900
11	Sheets	Vanished steel	A=9000 000 mm^2	1	3500	3500
Total					₦ 57,400	

Total cost of equipment materials and N 57,400,Labor cost = N600

Total cost = material cost + labor cost = N57,400 + 600 = N63,400

A test conducted on the machine gave the following information

Input = 3kg,Output = 2.5kg

Efficiency = output/input x 100/1 = 83%

3.0 CONCLUSION

In appreciation of the short coming of the industrial jaw crusher which includes bulkiness high cost of purchase and maintenance and importation cost of spare parts the beauty of the new design is born.

The designs incorporate a curve Hooper to reduce air pollution. It possesses a pressure of about $3MN/m^2$ from test carried out on it is found to be reliable and highly efficient it is relatively cheap when compared to important products.

References

Benjamin A L, Endicott, L J & Blake R J (1978). The design and constructing of jaw crusher proceeding of the institution of mechanical engineer mare-millian Publisher New York Pp. 40 – 41

Febrenwald A. S Holewenko A. R (1982) Machine Design problems Mac-Graw-Hill Book Company Texas 4th Edition Pp. 382 & 383

Hall .A. S J Hollowenko R A & langhlin G.H (1961) “schum’s outline of theory and problems of machine design schum’s outline series McGraw-Hill book Company New York Pp. 41 –48.

Henderson W.T & Pery J P (1982) Mechanics technology and Design Journal of the institute of structural engineers. New Delhi No.19.

Hinch L.W & McDowall D.M (1984) Design of Engineering Materials Proceedings of the institution of mechanical Engineers. Bangladesh P.46.

Hixon C.M (1998), Schuttle Bufferlo crusher pillverise company publications New York Pp. 40 – 41.

Hyatt K.E and Morley G.W (1952) mechanical technology and design journal of the institution of structural engineers. No. 19 Pp.80 – 83

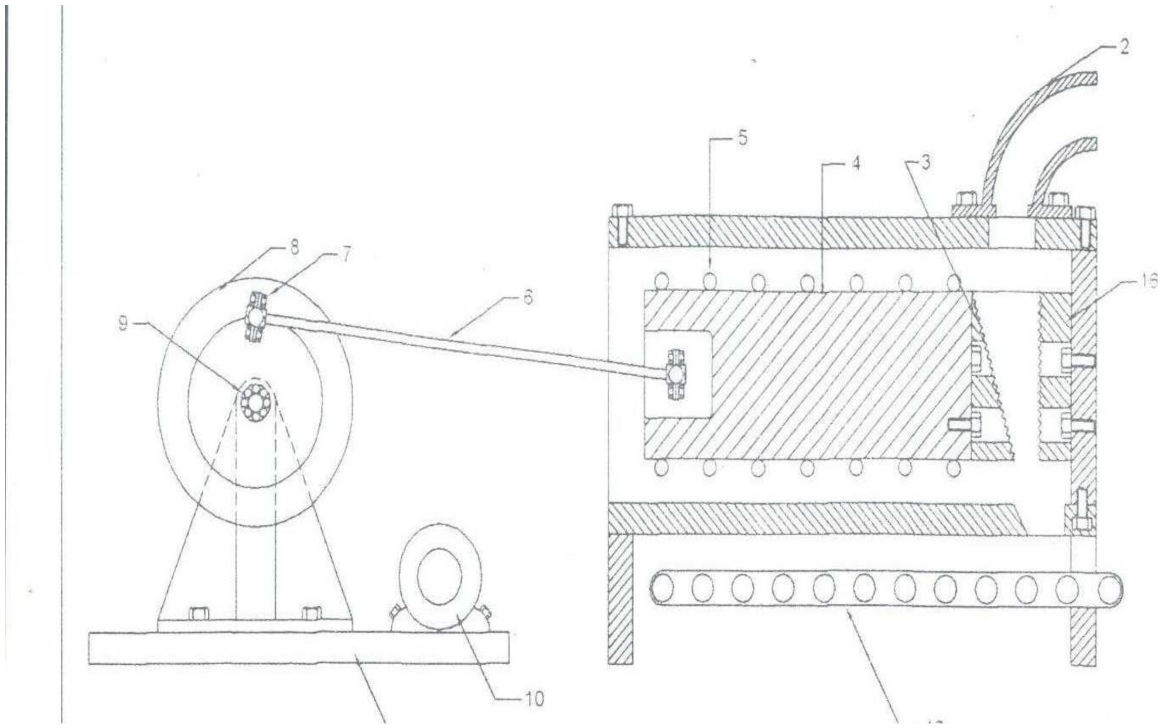
Khurmi, R S and Gupta J K (1979). A textbook of machine Design Eurasia Publishing House Ltd Ram Nagar New Delhi Pp. 48 – 53.

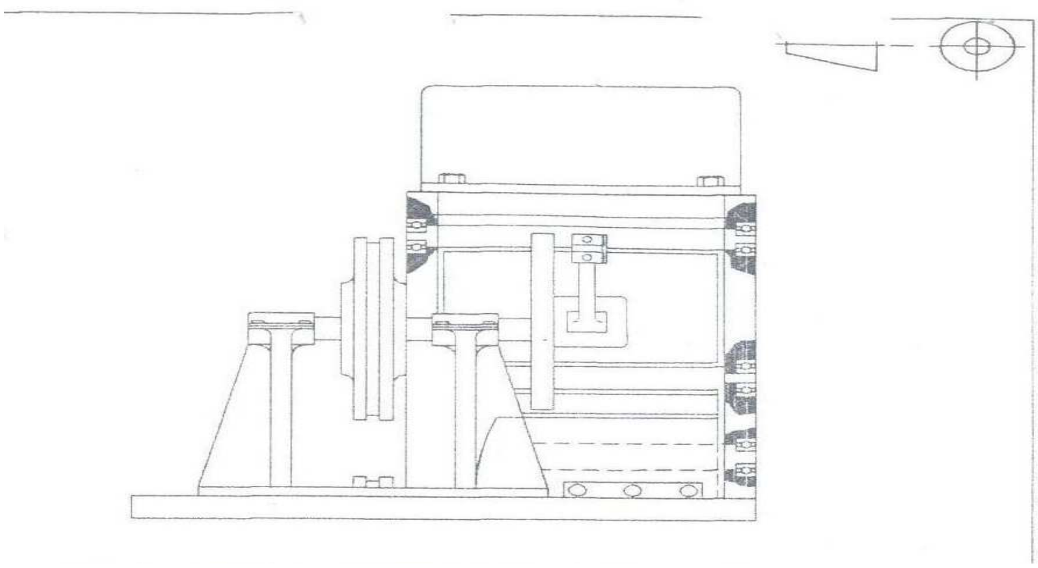
Rupert Le Grand (1985) The new America Machinist’s Hand Book Mac Graw-Hill Book 14th Edition New York Pp. 30 –32.

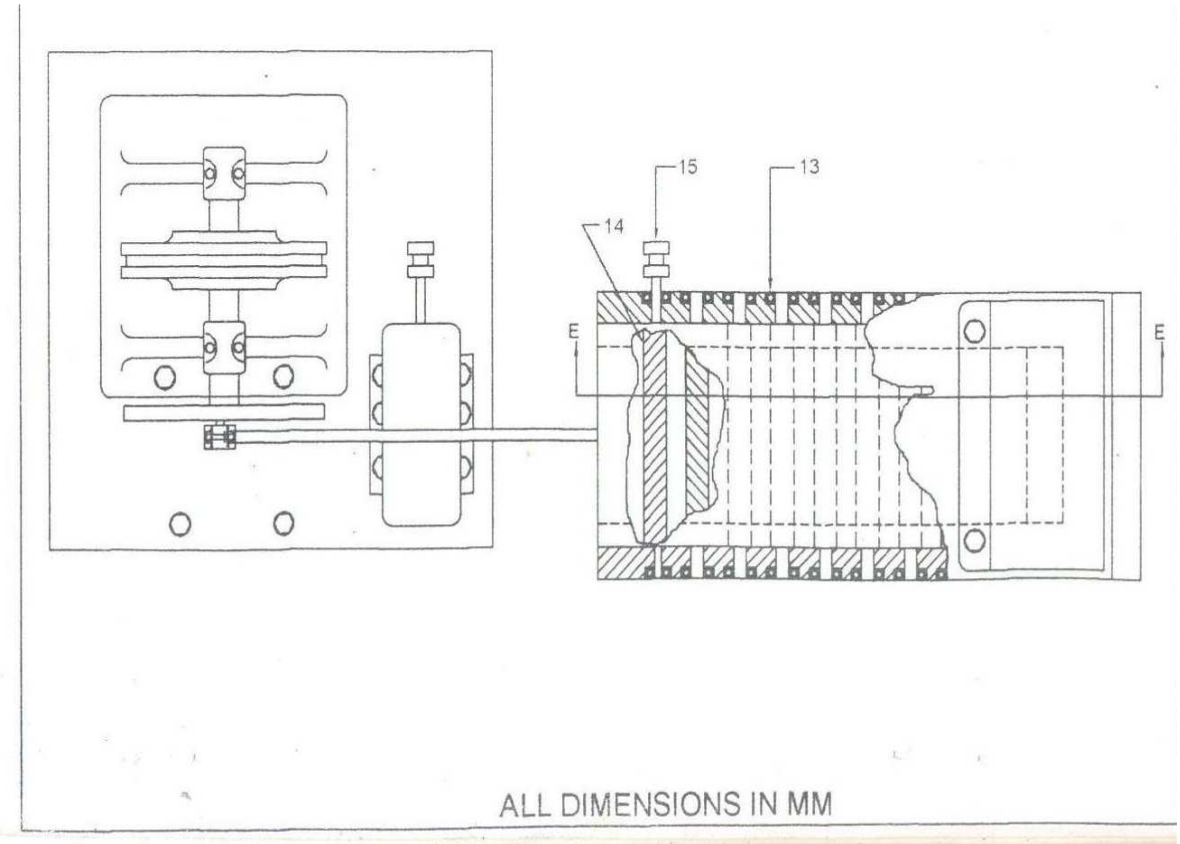
Rupert A. P and Green Don (1984) Perry’s Chemical Engineer’s Handbook. McGraw-hill international Edition section 8. New York Pp. 10 –12

Ramayya T.A (1978). Gyratory Crushes Journal of Institutions of Engineer India P.45

Ryder G.H (1977) strength of materials, 3rd Edition. The Macmillan Press Ltd Great Britain Pp. 72 – 74.


2
5
4
3
8
7
6
9
16
10





S/No	ITEM	MATERIAL
16	IMMOVABLE JAW	TUNGSTEN CARBIDE
15	PULLEY	CAST IRON
14	ROLLER RODS	MILD STEEL
13	ROLLER BEARING	STEEL
12	CONVEYOR BELT	RUBBER SHAFT
11	BASE	CONCRETE
10	ELECTRIC MOTOR	
9	ROLLER BEARING	STEEL
8	PULLEY	CAST IRON
7	CRANK PIN	MILD STEEL
6	CONNECTING ROD	MILD STEEL
5	ROLLERS	CARBON STEEL
4	RAM	CAST IRON
3	MOVABLE JAW	TUNGSTEN CARBIDE
2	HOPPER	GALVANISED IRON (SHEET)