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PERFORMANCE EVALUATION OF A LOCALLY FABRICATED CRUSHER (HAMMER MILL)

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ABSTRACT

A bone-crusher (Hammer Mill) was designed, constructed and tested. The machine was designed to crush 1000kg of bones in one hour. The motor operating speed employed is 2920rpm, the sieve hole diameters are 7mm and 5mm while the numbers of hammers are 12 and 18 pieces. The performance tests show that the mill is capable of crushing between 860 to 1170kg within an hour.

KEYWORDS: Crusher, sieve, smouldering, bones, effluents.

1. INTRODUCTION

Calcium phosphate is an important livestock supplement. Ordinarily, it is found in bones and over time the need for a constant supply of this supplement have made livestock producers to device techniques of getting bones converted to a feed supplement for feeding live stocks. Bones are collected and heated for reasonable length of time in oven designed specifically to reduce moisture content to a minimum 2-4% . Usually the bones are collected from abattoirs and slaughter fields for cattle, sheep and goats. However, the need to produce tonnes of crushed bones by pounding with heavy stones on concrete slabs has proved laborious and have overridden the essence of rearing healthy livestocks to meet food production for a number of people. Furthermore, the product grains are not even and fine and would over stretch the metabolic capacity of the livestock especially the poultry

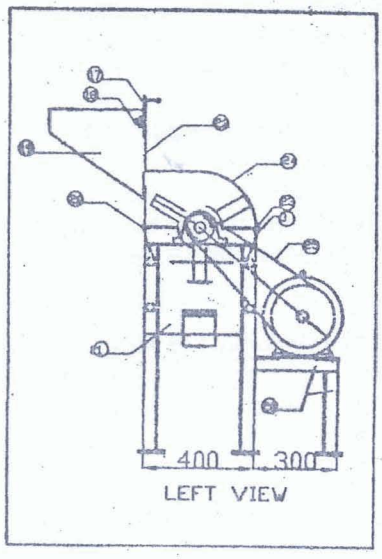
In view of the above discussed problems, it is pertinent to develop a good hammer mill that would enhance the quality of grains from crushed smouldered bones. Hammer mills can also be used for pulverizing limestone and ingredients for commercial production of feed and food products as well as household uses

2. DESIGN CONSIDERATIONS AND CALCULATIONS

The hammer mill was designed to crush bones by the swirling motion of hammers in a crushing chamber. The crushed grains are continuously passed through the sieve. Uncrushed grains are thrown back to be crushed by high-speed hammers. The hammer mill comprises of the hopper, crushing chamber which houses the hammers carried on pin rods (Fig. 1). The pin rods are inserted through a parallel arrangement of circular disks welded to the rotating main shaft. The prime mover is connected to the rotating shaft using a 2-groove pulley connection.

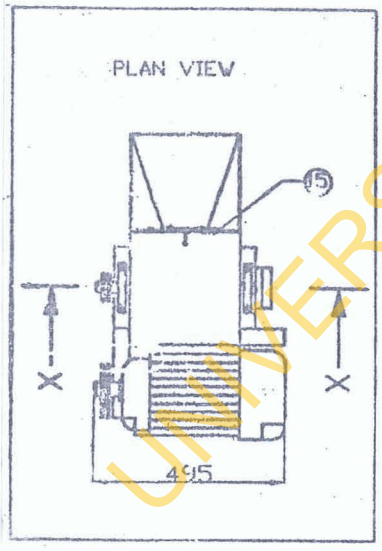
2.1 Power Requirement

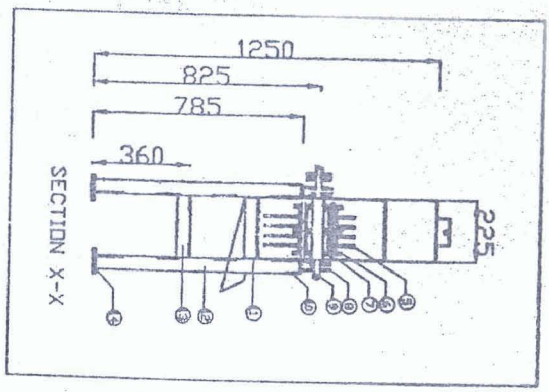
From the hydraulic press, the average amount of pressure required to break the simple sizes of bones required is about 100 ton/in^2. The test procedure included putting sample sizes of the bones on a flat metallic plate and jacking down the die / ram to crush the bones. Force required to crush bone of the required sizes is 645N. An electric motor with 2920rpm was used for the mill.



LEGEND

Part No.	Description
1	Hammer spacers
2	Shaft pulley
3	Sieve hanger
4	Hopper front plate
5	Hammers
6	Flange
7	Pin
8	Pillow block
9	Shaft
10	Pillow block mounting
11	Sieve
12	Leg
13	Leg brace
14	Foot plate
15	Feed control guide
16	Electric motor
17	Feed control plate
18	Nuts & Bolts
19	Hopper side plate
20	Hinge
21	Grinding chamber with outlet chute
22	Hopper back plate
23	Chamber lock
24	Top chamber cover
25	V-belts
26	Motor mounting frame assembly





1: Layout of the Hammer Mill

2.2 Hammers

A number of feed mills were visited. The visits revealed that the average size mill has 18 hammers with a capacity of 1.5 ton/hr, sieve diameter of 5mm and between 2800 and 3000 rpm shaft revolution. This fact was taken into consideration in the overall design.

2.3 Shaft Design

Table 1 shows the shaft diameters based on strength, critical speed and torsional rigidity. These are based on the ASME design code.

Table 1: Calculated shaft diameters

Based on strength (mm)	Based on Critical speed (mm)	Based on torsional rigidity (mm)
D=21.75	D=21.45	D=25.92

A diameter of 33mm was chosen to provide sufficient safety.

2.4 Bearing Selection

The section of the shaft where the bearing is to be located has a diameter of 30mm. An NP30 bearing with a tolerance of 0.013m was selected.

2.5 Vibration Control

In order to reduce vibrations, 2.5cm rubber dampers were used.

2.3 Design of Other Transmission Elements

Double V-belts are used on driver and driven pulleys which are both125mm diameter.

3. RESULTS AND DISCUSSION

The mill after construction was tested and observed to have output capacities ranging between 800 and 1170 kg/hour. The hammer mill compares favourably in performance and cost to those available in the market. Similar models in the market were being sold at N90,000.

By varying the number of hammers and the sieve sizes, the output varied as shown on Table 2.

Table 2: Effect of Number of Hammers & Sieve Sizes on Output.

Hammers	Sieve ϕ (mm)	Output (kg/hr
12	5	857
12	7	1023
18	5	1058
18	7	1169

An output efficiency of 87% for the original desig consideration i.e. 5mm sieve diameter, 2920rpr speed and 12 hammer pieces when the gate to th crushing chamber was half opened (250mm 100mm) was obtained. It was observed that th bones after crushing to fine grains reduced i volume by about 50%. The gate to the crushin chamber was preferably kept at half its full openin The larger the opening, the higher the mass flo rate into the crushing chamber hence an increase output capacity. However dust and backflow crushed bones through the gate need to be reduc considerably to a manageable and tolerable lev Cost details of the mill are as shown in Table 3.

Table 3: Cost of the Hammer Mill

NO	MATERIALS/OPERATION	(PARTS USED FOR) (USE)	UNIT	RATE (N)	COST(N)
1	3mm × 4ft × 8ft mild steel sheet	Casing, Disks	1	4000	4000
2	∅ 38mm × 360mm mild steel	360mm main shaft	1	500	500
3	2in × 2in × 26ft Angle Bar	Frame	1	1800	1800
4	Cutting Disk	Cutting	2	280	560
5	Grinding Disk	Grinding	1	250	250
6	Saw blades	Cutting	2	80	160
7	Pin Rod ∅ 11mm ×180mm	Pin Rods	1	180	180
8	4mm × 225mm × 600mm mild steel	Sieve	2	360	720
9	Drill Bits ∅ 5mm	Drilling	5	50	250
10	Drill Bits ∅ 7mm	Drilling	4	70	280
11	Pillow Block Bearing Np30	Bearing	2	1250	2500
12	∅ 80mm Pulley	Pulley	2	800	1600
13	Paints, Body filler, potty	Painting		N	1000
14	Bolts and Nuts		10		500
15	Square Rod 1/2in × ft	Screen lining	1	500	500
16	Hinges and Nuts		1		100
17	A Belt		2	200	400
18	Electrode G12 1 1/2 packets	Welding	1 ½	500	750
19	Flat Bar 2in × 6ft		1	250	250
20	3-phase induction motor	7.5hp	1		25000
21	Gear switches and wiring accessories		2		10000
23	Workshop Rent				6000
24	Transportation				1750
25	Labour+OTHERS				10000
				Total	69090

ONCLUSION

The developed hammer mill was quite successful in the grinding of bones and also performed well in grinding oyster-shells, palm kernels, yam cakes and cowpeas.

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