DESIGN AND CONSTRUCTION OF A HAMMER MILL

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<u>DEDICATION</u>

I dedicated this work to the memory of my late father, Alh Abdullahi Kaka

Yauri for motivating me to acquire Western education.

APPROVALPAGE

This research work project has been read through and approved as meeting

The requirement for the award of postgraduate diploma in Agricultural

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ABSTRACT

The need for grinding of agricultural product especially grains is very imperative in Nigeria, since majority of the food we eat must be grinded for consumption or to allow further processing operation. The local method practiced is too laborious and time consuming. The available imported ones are not affordable to majority of Nigerians due to exorbitant prices and difficulty in operating the machine. This calls for the design and construction of a simple, relatively cheap, durable and efficient grinding machine affordable to majority of Nigerians using available local materials. The machine grinds maize, cassava, sorghum, rice and millet efficiently. The machine grinds to any determine fineness depending on the size of the screen and the moisture content of the material to be grinded.

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content. Henderson and Perry (1976) opined that the efficiency of milling machines is a function of the moisture content of the material to be grinded.

Well-dried materials are shattered by impact and gradually reduced to the required fineness. Consideration should be given to the dryness of the materials to be grinded. The mill is to be powered by an electric motor of 2.5 HP mounted on the near stand of the frame or by an electric generator of 3HP. Power is transmitted by V-belt riding in sheaves. Materials for the construction are purely from available local source. The hammer mill like any other machines can be adjusted or improved to suit local farmers and easy adaptation to the local environment for efficient performance.

CHAPTER TWO

LITERATURE REVIEW

2.1 REDUCTION METHOD

Different types and models of size reduction machines are available. They however vary in sizes; mode of operation, source of power, number of hammers and functions, the power consumption of size reduction machines during operation is very high. It accounts for up to 90 to 95% of power required for all operations. The remaining l0 to 5% is lost due to friction. Because of the role friction played during operation the power utilization of any machine cannot be 100% efficient. Therefore adequate care must be exercised in choosing the system and machinery for size reduction. Henderson and Perry (1976) listed some factors to be considered in choosing the system and machinery for size reduction, which include the following: -

(i)   Type of materials to be grinded (e.g. grain, e.t.c.)

(ii)   Variety of grain

(iii)   Moisture content

(iv)   Extent of treatment given to the material (e.g. hydrothermal treatment such as parboiling of rice e.t.c.)

(v)   Objective of the size reduction e.t.c.

The studies of mills have been an old one and many books have been written on the subject. Size reduction is effected by the application of forces in compression, shear, friction, impact or a combination of such forces depending on the nature of the material being handled. The important factors in size reduction are the sizes of the end product and the energy required by the machine. It is desirable to know how fine a material is grinded and how uniform is the grinding. This can be done through size analysis, a factor termed fineness modulus is established to indicate the uniformity of the grinding, Hunt (1960) said uniformity

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connecting the centers of rolls. The slow roll holds the grain during the action of the fast roll. In the grinding zone, the grain is simultaneously subjected to compression and shear, resulting in the deformation of the grain. Roller mills include the following.

2.2.1 **THE BREAK ROLL**: - It has smaller diameter rolls and is used for initial Breaking of grains to release the endosperm.

2.2.2 **THE REDUCTION ROLL**: - This has a larger diameter rolls and therefore Longer grinding zone. It is used for crushing of grains to fine flour.

2.2.3 **FLUTED ROLLS**: - This is used for crushing of sugarcane, kenaf for fibre e.t.c.

2.3 BURR MILL

The burr mill grinds by crushing and shearing between two cast iron plates, one rotating and the other stationary. The feed is introduced through a hole in the rotating plate and is moved outwards and grinded by the spiral ribs on the plates. The rib design varies according to the type of grain and fineness of grind required. Plates are usually held together by spring pressure adjustable for fineness. Plates should not run empty unless it is released or the plates are held positively apart. The shaft carries a spiral screw for feeding and grinding. The shaft can slide in and out to vary the gap between the grinding plates.

2.4 ATTRITION MILL

The attrition mill grind by crushing and shearing between two cast iron plates. The material is carried towards the two grinding cast iron plates by the auger of the rotating shaft. They are used in feed manufacturing plant and food processing industries.

2.5 AMUDA MICRO GRINDING MILL

Amuda micro grinding mill consists of 12 pieces of oil tempered hammers and breaker plates. It is designed to reduce wide range of materials to any pre-determined fineness from coarse to fine powder.

The grinding operation is through beating, shearing, crushing of material with breaker plates. Large pieces of material suitable to the inlet size of micro grinder are fed directly in the center of the rotor and conveyed to the periphery of the rotor through a series of 12 pieces of oil tempered special type of hammers. The walls of the machine are fitted with hardened cast iron breaker plates, which gradually reduced the material to the desired fineness during operation.

Sieves of required mesh are placed at the bottoms of the rotor and allow the material to be ejected into the collection chamber. There is a provision at the outlet to hold the collection chamber. Drive is by V-belt and the revolution of the micro-grinding mill per minute is between 3400 to 3800r.p.m. The effective capacity of micro grinding mill depends on the moisture content of the material being handled e.g. maize 13% to 15%. The machine is suitable for grinding maize, cassava, sugar, charcoal, bones, cola nut fiber, linseed, and ginger e.t.c. Tuners and Shippen (1973)

2.6   BEN TALL SIMPLEX 'SUPER B' MILL

This is more compact and it is extremely robust but yet can be conveniently dismantle for packing. All the main parts are manufactured from cast iron and steel and all working parts mounted on ball bearing thus ensuring years of trouble free wear. A grinding plate with 267mm diameter are fitted as standard this being most suitable for dealing with all cereals such as wheat, barley, oats, maize but when required for grinding wet maize for which it is particularly suitable, it is recommended that fine grooved plates be fitted. Easy access to the grinding chamber is assured by means of a hinged cover and further more there is virtually no residue in the chamber after milling. The Ben tall mill specifications are as follows: -

Mill No.	Diameter of Plates	HP reqd.	Speed Advised	Size of Pulley	Approx Output/hr
200	267mm	5	600rpm	254 x 114mm	227 – 272kg

2.7 WORKING PRINCIPLE OF A HAMMER MILL

The working principles of a hammer mill is based on the sequence of operation of the major parts. The feed is introduced into the funnel shaped hopper, which serves as a reservoir.

The hammer mill consists of hammers rotating at high speed in a strong housing. Grains from the hopper are introduced into the grinding chamber sideways round the rotating horizontal shaft carrying the hammers. The hammers impact on the grains reduce the grain to powder and push them through a screen lining the grinding chamber periphery. Size of the screens determines the fineness of the grinding. The screen retains large particles until they have been grinded small enough to drop through. Hammers are made of tough steel with wear resistance tips; square corners at the tip of hammers are required for efficient shearing. Hammer speed ranges from 1500r.p.m to 4000rp.m.

Because of the high speed, rotor assembly should be accurately balanced to prevent vibration. The grinded material in passing through the screen are collected at the chute under the frame. Fineness of grinding is primarily controlled by screen size, number of hammers, hammer speed and the moisture content of the material. The source of the drive is from an electric motor. The drive is by two pulleys connected with a V-belt. The frame bears the whole body of the hammer mill and the engine. In operating the machine, the following precautions should be observed.

(i) Understand the machine properly before operating it.

(ii) Electric motor should be well tightened

(iii) The V-belt should be of correct size and in tension.

(iv) The use of proper device to control the rate of feeding.

CHAPTER THREE

3.0 DESIGN OBJECTIVES: -

To produce a hammer mill from available local materials, affordable to our peasant farmers and comparable in terms of efficiency to the imported ones.

3.1 DESIGN APPROACH

From the study of the existing models a lot of factors were considered in the design for the construction of the simple Hammer mill.

(a) Durability built into the machine by the use of materials with adequate strength.

(b) The machine was designed to have a higher efficiency.

(c) The cost of production is intended to be kept low through its simplicity in construction, easy replacement of worn out part, and use of readily available materials for the construction.

3.2 PARTS NEEDED FOR THE CONSTRUCTION.

In the design, prime consideration was given to locally available and in expensive materials for constructing the various parts of the machine. The parts and materials needed for the construction are as shown in table 3.1.

TABLE 3.1 PARTS AND MATERIALS NEEDED FOR THE CONSTRUCTION.

S/N	PARTS	QTY.	MATERIALS
1.	Hopper	1	Sheet metal 2mm thickness
2.	Hammer cover	1	Sheet metal 2mm thickness
3.	Milling housing	1	Sheet metal 2mm thickness
4.	Delivery chute	1	Sheet metal 2mm thickness, length 960mm x 960 each
5.	Square plates	5	20mm thickness sheet metal

Hammers	16	5mm thick flat mild steel 88mm long
Rotor shaft	1	50mm diameter 474 long
Hammer Holders	4	10mm diameter128mmlong iron rod
Feed Regulator	1	2mm thick sheet metal
Spacers	16	Pieces of pipes of l5mm diameter and 11mm long each
Screen	1	140mm x 625 sheet of metal perforated with 2mm drill (hole)
Bearing	2	25mm inside diameter and 60mm outside diameter
Bearing housing		3mm thick flat bar and 16mm wide bent round the bearing.
Frame work	1	Angle iron, length 800mm and 500mm wide
Belt	1	V – belt
Motor	1	Flat bar Angular iron.

3.3 DESCRIPTION AND FUNCTION OF PARTS.

(i) HOPPER: - The mill hopper is made up of sheet metal of 2mm thick. It accommodates the material to be grinded. It acts as a holding bin.

(ii) HAMMER COVER: - The hammer cover is also made up of sheet metal of 2mm thick. It covers the hammers for efficient milling. Milling operation takes place inside the hammer cover.

(iii) MILLING HOUSING: - It is made from 2mm thick sheet metal shaped into circular form. It is constructed to be strong and able to withstand the grinding forces. The crushing is done against the milling housing.

(iv) DELIVERY CHUTE: - It is made form sheet metal of 2mm thick. The length 960mm x 960mm each. It serves to collect the end product after milling. An empty sack has to be attached at the bottom for the collection of end product.

(v)   SQUARE PLATE: - These are made from 2mm thick sheet metal plate. A hole of 50mm is drilled in the center. Where the rotor shaft is force through. Each of the four edges suspends a swinging hammer. These are the components on which hammers and spacers are fixed.

(vi)   HAMMERS: - They are made from 5mm thick flat mild steel 88mm long each. There are sixteen (16) hammers hanging from the corners of five square plates through 10.5mm diameter hole. The hammer act to break to pieces the materials being grinded. The hammers wear out with use and are eventually replaced. The wearing of the hammers does not decrease the efficiency.

(vii)   ROTOR SHAFT: - It is made from mild steel. It is constructed from 50mm diameter and 474mm long bar. The rotating shaft carries the hammers, which develops high centrifugal force for pulverizing the material to be grinded.

(viii)   HAMMER HOLDERS: - These are rods that pass through the drilled holes on the disc and hammer. They hold both the hammers and spacers in position. They are four in number and each of 10mm diameter and 125mm long. Both ends are threaded.

(ix)   SPACERS: - Spacers prevent the hammers from moving axially on its axis but only permits rational movement. They are sixteen in number and each of 15mm diameter and 11mm long.

(x)   FEED REGULATOR: - The feed regulator is made from 2mm thick sheet metal, it is a device that is used to prevent the rebounding back of the grind mill or ungrounded mill.

(xi)   SCREENS: - It is made from sheet metal of 3mm thickness of the length 140mm by 625mm perforated by using a drill of drill bit of 2mm to drill the holes. The screen is curved to take the shape of the grinding chamber

and permits the grinded material to drop freely through it into a sack or feed bin. Screens are subject to wear as the grains are grinded against them. They are however replaceable. The screen retains large particles until they have been grounded small enough to drop through.

(xii) PULLEYS: - Two pulleys are used, one as the driving and the other as the driven. The driving pulley is mounted on the shaft of the electric motor while the driven is on the shaft of the grinding portion.

(xiii) BEARINGS: - There are two (2) bearings each of 25mm inside diameter and 60mm outside diameter. These permits free motion of the main shaft carrying the hammers with minimum of friction. Ball bearings are to be used because of their moderate prices and availability in the market.

(xiv) BEARING HOUSING: - It is made from 3mm thick flat bar and 16mm wide, bent round the bearing and tacking it round the bearing with a small piece of metal to prevent the bearing from coming out. The bearing can be firmly fixed into bearing housing.

(xv) FRAME WORK: - These are made of angle iron of length 800mm and 500mm wide. They form part of the hammer mill. It serves as a rigid support.

(xvi) V- BELT: - It connects both the driven and the driving pulley. It requires periodic adjustment to compensate for wear and stretching. It is relatively quiet in operation and usually designed to slip under excessive load. A V-belt is used where the distance is relatively short, to transmit power between two short distances.

3.4 POWER REQUIREMENT AND EFFICIENCY OF THE DRIVE

The power is transmitted by a V- belt between the two pulleys. The pulleys are the driving and the driven. In the design we used the following.

Diameter of the driven pulley in meter $(D1) = 0.14m$

Diameter of the driving pulley in meter (D2) = 0.06m
The distance between the pulleys can be varied between 0.135m to 0.5m.
Speed of the driving pulley = 3600rpm. 3

3.4.1. SPEED OF DRIVE

The speed of the driving and the driven pulleys are in revolution per minute.
Therefore speed of the driven pulley = speed of the driving x diameter of driving pulley \ diameter of driven pulley.

Speed of the driven pulley = $\frac{3600 \times 0.06}{0.14}$

$$= 3600 \times 0.4285714285$$
$$= 1542.86 \text{rpm} = 1543 \text{rpm}.$$

Diameter of driving pulley = 0.6m
Diameter of driven pulley = 0.14m   Driving speed = 3600rpm
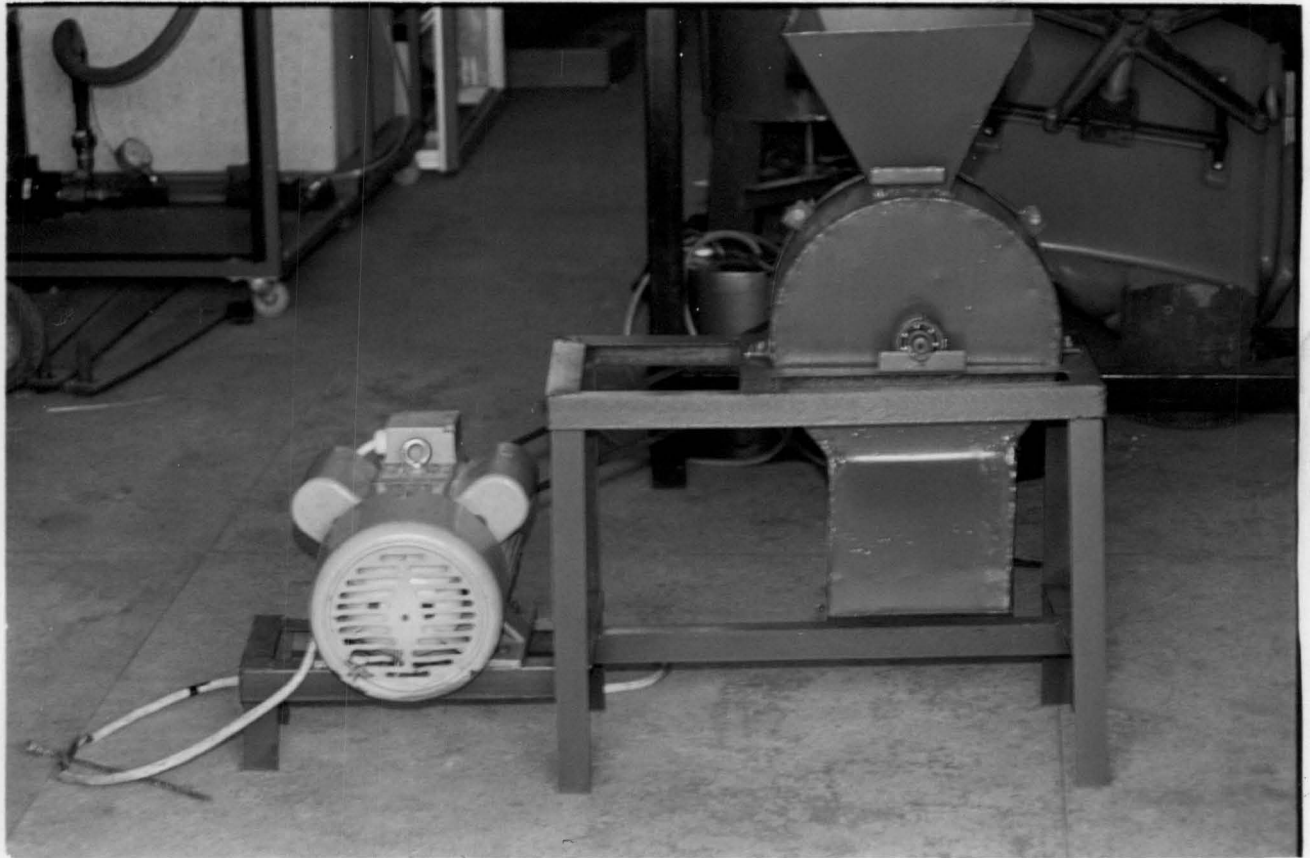Driven speed = 1543rpm   Mass of belt = 0.9kg\ m

PLATE 1 THE ASSEMBLED MACHINE

Our maximum allowable distance between the two pulley = 0.5m

To find the angle of lap on each pulley.

Angle of lap of the driven pulley = $\theta/2$

$\cos\theta/2$ = radius of driven pulley – radius of driving pulley

Distance between the two pulleys

$\cos\theta/2$ = $\dfrac{0.07 - 0.03}{0.5}$ = $\dfrac{0.04}{0.5}$

$\cos\theta/2$ = 0.08

$\cos\theta$ = 0.08 x 2 = 0.16

θ = 01.41 rad

= 80.79°

Angle of lap on smaller pulley (0)

θ = 2 x 1.41

= 2.820 radian

= 161.57°

= 161°. 34'

3.4.2 BELT SPEED

The belt speed is the speed that corresponds to the peripheral speed of the driving pulley.

Let the diameter of the driving pulley = D1

Let the diameter of the driven pulley = D2

Let velocity in meter per minute = V

Speed of the belt = velocity ratio meter per second (V)

$$V = \text{Driver speed} \times \frac{2\,\Pi}{60} \times \frac{D1}{D2}$$

$$V = 3600 \times 0.104719755 \times \frac{0.06}{2}$$

$= 3600 \times 0.104719755 \times 0.03$

$= 11.30973355 \text{ m/s}$

$= 11.31 \text{ m/s}$

3.4.3 CENTRIFUGAL FORCE

The centrifugal force is calculated by using the formula $Tc = MV^2$ Stephen & Hannah (1972)

Where Tc = centrifugal force

M = mass of belt

V = velocity ratio in (mls) meter per second.

$Tc = MV^2$

$= 0.9 \times (11.31)^2$

$= 115.12 \text{ KN}$

$= 0.115 \text{ KN}$

3.4.4.1   TENSION BETWEEN THE TWO SIDES OF THE BELT.

Stephen and Hannah (1972) said the tension from the belt on both the slack and tight sides can be calculated from the formula.

$$\frac{T_1 - T_C}{T_2 - Tc} = C^{\mu\theta}$$

Where

      μ = 0.45 which is the coefficient between the belt.

      θ = 2.820 radian

      T1 = Tension on tight side of the belt

      T2 = Tension on slack side of the belt

      e = Exponential term of the natural log

      Tc = centrifugal force

Tc = 1\3 T1, for maximum power transmitted

$$T1 = 3Tc$$
$$= 3 \times 115.12$$
$$= 345.36N$$
$$T1 = .345KN$$

To find the tension on the slack side, we substitute in the formula, since we got the following

$$Tc = 115.12N$$
$$T1 = 345.36N$$
$$T2 = ?$$

$$\frac{T1 - Tc}{T2 - Tc} = e^{\mu\theta}$$

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$$\frac{345.36 - 115.12}{T2 - 115.12} = e^{0.45 \times 2.82}$$

$$\frac{230.24}{T2 - 115.12} = e^{1.269}$$

$$\frac{230.24}{T2 - 115.12} = 3.5579349$$

$$\frac{T2 - 115.12}{230.24} = 4$$

T2 – 115.12

4 (T2 – 155.12) = 230.24

4 T2 – 460.48 = 230.24

4 T2 = 230.24 + 460.48

$$T2 = \frac{690.72}{4}$$

T2 = 172.68 N

T2 = 0.173 KN

To find the torque on the two sides of the driving and the driven, Stephen and Hannah (1972) said the following equation is used.

Torque on the Driving pulling = T1 – T2 x $\dfrac{D1}{2}$

$$T1 - T2 \times \frac{D1}{2}$$

$$345.36 - 172.68 \times \frac{0.06}{2}$$

172.68×0.03

Torque on the Driving pulling = 5.1804 NM

Torque on the Driving = $T1 - T2 \times \frac{D2}{2}$

$$T1 - T2 \times \frac{D2}{2} \quad = 345.36 - 172.68 \times \frac{0.14}{2}$$

$$= 172.68 \times 0.07$$

Torque on the Driving pulling = 12.0.876 NM

3.4.5 POWER TRANSMITTED

Stephen and Hannah (1972) provided a formula for calculating the power transmitted using

(T1 –T2) x V (unit in watts or kilowatt)

Power transmitted = (T1 –T2) x VC

$\qquad$ = (345.36-172.68) x 11.31

$\qquad$ = 172.68 x 11.31

$\qquad$ = 1953.0108 watts

1 horse power (HP) = 746 watts

Power transmitted in horse power = $\frac{1953.0108}{746}$

$\qquad$ = 2.617976944 HP

$\qquad$ = 2.6 HP

CHAPTER FOUR

CONSTRUCTION TESTING AND RESULT

4.1   CONSTRUCTION: -

The construction process carried out in this work includes cutting, filing, drilling, turning, boring, facing, folding, grinding, chiseling, welding, and spot welding.

Some essential parts constructed in this work are as follows in table 4.1 below.

TABLE 4.1 CONSTRUCTION PROCESSES

S/NO	PARTS	TECHNIQUES	TOOLS USED
1.	HAMMERS	Care was taken that the required square edges were obtained and the tips heat-treated and the holes properly drilled and filled to the required size.	Hacksaw Universal Cutting Machine, Drilling machine and furnace File
2.	SCREENS	3mm thickness sheet metal (140mm x 625mm) perforated with hand drill machine of a drill bit of 2mm	Hand operated drilling Machine, 2mm drill bit, Files.
3.	HOPPER	The parts were first tagged before the proper welding/brazing to make sure that the parts do not run off or go out of line	Universal Cutting Machine and Brazing (Brass), gas welding.
4.	BEARING HOUSING	Adequate care was taken to make sure that the housing tightly fits the bearing	Power hacksaw, lathe and welding machines
5.	SHAFT	It was carefully cut, and turned to avoid bending.	Power Hacksaw, And lathe machines.

6.	MAIN FRAME	Particular attention was given to the angling of the stand and parts equally cut out and spaced.	Power hacksaw, drilling and welding machines.
7.	MILLING HOUSING	In creating or making the grinding chamber, slots were used to get the required cylindrical shape. Parts were adequately drilled, folded, tagged and welded.	Universal cutting Machine, drilling, Folding and welding Machines.
8.	SQUARE PLATES	The plates were carefully cut out according to specification and a proper attention was paid to the drilling and boring of the Centre holes. The plates were tagged together before drilling the holes at the four corners for concentricity.	Universal Cutting machine, Drilling and lathe Machines.
9.	SPACERS	Adequate care was taken in cutting, facing and drilling of the pieces of iron rods to get the required material.	Hacksaw, drill And lathe Machine.
10.	HAMMER HOLDERS	Adequate attention was given to the length of the holders and the threads at the edges.	Hacksaw and die
11.	ASSEMBLING	The general assembling was purely manual either by welding or using bolts and nuts where necessary.	Hand drilling Machine, welding Machine.

4.2   COST OF CONSTRUCTION

The cost of production was based on the following categories.

(i)   Material cost

(ii)   Labour cost

(iii)   Miscellaneous cost

4.2.1 MATERIAL COST

Material cost is the cost of the materials used for the construction of the machine parts. These are reflected on the table below and are based on the current market prices.

TABLE 4.2 MATERIALS AND COSTING

S/NO	MATERIALS	QUANTITY	UNIT PRICE	TOTAL COST
1.	Concave	1 160 x 630mm	500.00	500.00
2.	Pulley	1	400.00	400.00
3.	Nuts and Bolts	12	20	144.00
4.	Angled Iron	1 length 6, 300mm	1, 755.00	1, 755.00
5.	Sheet Metal 2mm thick	1, 000 x 3000mm	2, 900.00	2, 900.00
6.	Bearing	2	450.00	450.00
7.	Vee belt	1	250.00	250.00
8.	Iron Rod diam. 10mm	1 length 650mm	1, 150.00	1, 150.00
9.	Pipe	1 length 180mm	900.00	900.00
10.	Washers	8	20	160.00
11.	Paint	2 tins	400.00	800.00
12.	½ length of angled Iron	180mm	750.00	750.00

TOTAL COST OF MATERIALS USED   **₦10, 159.00**

From the market survey, the cost of existing ones are: -

2000,   one cost ₦46, 000.00 at Kaduna.

4.2.2   LABOUR COST

The Labour cost was based on 25 per man-hour and eight (8) effective working hours were used per day.

Thus:

Cost per day $= 25 \times 8$ $= ₦200$

And a total number of working days is 30.

Total cost for these days

$\therefore$ Labour cost $= 200 \times 30$ $= ₦6, 000$

4.2.3   MISCELLANEOUS COST

The miscellaneous cost or expenses includes the following: -

(i)   Transportation $= ₦1, 000.00$

(ii)   External Services $= ₦750.00$

(iii)   Parts damaged replaced $= ₦300.00$

Total $= ₦2, 050.00$

4.2.4   TOTAL COST OF MACHINE

The total cost of machine   = Material cost + Labour

Cost + Miscellaneous cost

$= 9790 + 6000 + 2050$

$= ₦17, 840.00$

4.3   TESTING AND RESULT

The screen used for my hammer mill is with round holes each of diameter 2.0 millimeters.

The test of the hammer mill was carried out using dry maize with 13% mixture content and dry cassava with 13% moisture content.

The machine was driven by a small petrol engine (generator). The machine was driven for 8 minutes without any material fed to it. The noise level and vibration was more than that of the existing ones in the market, but the noise can be accommodated by the ears. The noise was reduced when material was fed in.

4.4   TEST USING DRY MAIZE

The sample of maize used weighed 3.8 kg.

The maize was fed from the hopper to the grinding chamber under regulated quantity. The time taken to grind 3.8 kg was 6 minutes. The output was collected and weighed 3.72 kg.

The quantity cost	$= 3.8 - 3.72$		$= 0.08$ kg
Percentage loss	$= \dfrac{0.08}{3.8}$	x 100	$= 2.105263158\%$
Output percentage	$= \dfrac{output}{Input}$	x 100	
Efficiency	$= \dfrac{3.72}{3.8}$	x 100	$= 94.8947318\%$

Form the result above; we can find the time to grind a certain quantity say 50kg.

3.8 kg took 6 mins.

50 kg will take x mins

$$\therefore \quad X = \frac{50 \times 6 \text{ mins.}}{3.8} = \frac{300}{3.8} = 78.94736842 \text{ mins.}$$

$$X = \qquad\qquad = 1.315789474 \text{ hrs.}$$

$$X = 1 \text{ hr. } 18.94736842 \text{ mins}$$

$$= 1 \text{ hr. } 19 \text{ mins.}$$

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A sample of the ground maize was taken for sieving test.

Weight of empty container	= 42. 5 gm
Weight of container + ground maize	= 197.3 gm
Weight of ground maize	= 197.3 – 42.5
	= 154.8 gm

The ground maize was sieved using a sieve with 2.0mm diameter holes equal to the diameters of machine screen holes. The retained material in the sieve was weighed, weight of container + retained material = 101.5 – 42.5 gm

$$= 59.0 \text{gm}$$

Efficiency of grinding $= \dfrac{\text{Actual weight} - \text{weight of Material retained}}{\text{Actual weight}}$

$$= \frac{\text{Actual weight} - \text{weight of material retained}}{\text{Actual weight}} \times 100\%$$

$$= \frac{154.8 - 59}{154.8} \times 100\%$$

$$= \frac{95.8}{154.8} \times 100\%$$

$$= 61.8863049\%$$
$$= 62\%$$

To grind 50 kg of maize with the existing ones it takes about 30 mins using 2mm screen and about 55 mins using 500-micrometer screen.

RESULTS AND DISCUSSION

The machine was noisy and vibration was high compared to the existing ones.

It shows that the machine is more effective for grindimg maize. Some materials were being knocked backs to the hopper by the hammers, which makes it very difficult to empty the hopper completely while the machine is in operation.

Material ground is not completely discharged from the screen. Why the material ground are not complete discharged form the screen is because the clearances between the concave screen and hammer are to wide. Adjustment are to be made between the concave screen and hammer, so that ground material will be completely discharged from the screen.

There was a lost percentage during the grinding, due to the spaces between the hammer cover and the grinding chamber. To prevent the lost percentage, packing are to be made of the open spaces between the hammer cover and grinding chamber.

It takes longer time to grind a certain quantity compared to the existing ones.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

A hammer mill was designed and constructed from readily available local materials.

The mill compactness, size and simple working principle makes it easy to understand and ease the problems associated in grinding. It's ease of maintenance serves as an inducement to would-be buyers. Perhaps this locally designed and constructed mill could be found acceptable thus helping to save some of the country's foreign exchange used in importing mills.

5.2 RECOMMEND DATION

The milling machines have been tested.

The following recommendation are made

1. Thicker sheet metal than the one used in this work should be used for the milling housing to withstand wears.

2. The hammer tips should further or properly be heat treated to resist wears.

3. More thicker material should be used for the screen to withstand the initial impact and be more durable.

4. If possible there should be a different size of screen mesh for different types of operation. Since screen mesh are changeable.

   Material ground is not completely discharged from the screen.

   Adjustments are to be made between the concave screen and hammer so as to reduce the clearance. I .e. Too wider clearance.

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