DESIGN AND CONSTRUCTION OF A HAMMER MILL

BY

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DEDICATION

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 Engineering (farm Power and machinery).

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ACKNOWLEDGEMENT

Praise be to Allah the Almighty who spared my life to the completion of this work. My sincere appreciation and gratitude to my Supervisor Engr. Dr. M.G Yisa the Head of Department for his guidance and sharing his knowledge with me. My appreciation to my wife for her understanding throughout the programme. Also my gratitude to all my friends who contributed in one-way or the other to the success of this work. To my employer College of Agriculture, Zuru for giving me the opportunity to enroll for the programme.

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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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CHAPTER ONE

INTRODUCTION

Grain milling is the breaking down of grain, from bigger to smaller or minute sizes in order to facilitate further processing operation. Grain milling is carried out to process it to other forms of food for human or livestock consumption.

Presently, various machines are available for different milling operation and therefore different machines are available for grain milling in various size, type, and brands. Taking into consideration that majority of farmers in Nigeria are peasant farmers with low income as such they cannot afford the ones available in the market and they experienced some difficulty in operating th~~an~~em because of the complexity involved in their operation.

This brings about the need for the design and construction of a simple, relatively cheap, durable and efficient grinding machine affordable to our peasant farmers. This becomes necessary because of the local method presently practiced by the peasant farmers is laborious, using pestle and mortar, whereby the grain is poured into the mortar and pound with pestle until it is broken to smaller sizes. Another local method is the use of stone to grind, which is laborious and time consuming.

In order to improve on these local methods a simple milling machine called a Hammer mill was developed. The hammer mill as the name suggests, consist of sixteen (16) free swinging square hammers. It is a specially designed size reduction machine to deal efficiently and economically with wide range of materials such as cassava, maize, rice, sorghum, and millet e.t.c. The machine grind to any predetermined fineness depending on the size of screen used. The machine is primarily designed to grind dry materials and not materials with high moisture 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 ~~smelt~~ 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 (l976) 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 (l960) said uniformity in particle size of the end product is highly desirable but often not attainable. Hunt (1960) in discussing the Bentall group size reduction machine, listed that output depends on the condition of the material being crushed, its moisture content and degree of crushing. The flatter the sample the lower the output.

The various available type of mills discovered include the following: -

2.1 CRUSHERS

Crushers are used to reduce the size of bulky materials by impacting and pressing or squeezing on them with heavy hammers until it is crushed in a few cases. There are two common types of crusher's namely the jaw crusher and the cone (gyratory) crusher. Crushing is an important industrial operation and a variety of types of machines are in use. Agricultural application of Crushers is important but not extensive.

2.1.1 **JAW CRUSHER:** - The jaw crusher consists of a stationary plate and a heavy steel jaw. The swinging heavy steel jaw bangs against the stationary plate and any material that fall in between them will be crushed by impact and squeezing. This is commonly used. An example of jaw crusher is a palm kernel nut Cracker.

2.1.2 **CO~~V~~NE (GYRATORY) CRUSHER**: - This has a higher capacity and operates smoother. The gyratory crusher consist of hammers hanging from a rotating shaft with a cam arrangement on it that makes the lower end of the hammer to gyrate against the conical walls of the crusher to do the crushing.

2.2 ROLLER MILLS

These are commonly used in grain processing industry for primary reduction before material is fed into a hammer mill. The roller mill consists of two cylindrical steel rolls revolving in opposite direction at different speed. The grain or material being handled is rapture in the space between the rolls, which is narrowed, towards ~~forwards~~ the bottom. Certain degree of rupturing starts above the line 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.

(v) When milling, machine should not be stop, unless there is a fault.

(vi) Always run the machine with rotor and screen well fitted in their proper position.

(vii) Machine should not be operated without a cover.

(viii) Hands should be kept away from rotating part.

2.8 OPERATION OF HAMMER MILL

The hammer mill is used for a variety of size reduction "grinding" jobs. Besides feed preparation, it is used for pulverizing limestone and the ingredient for commercial fertilizers. It has also many industrial applications. A hammer mill consists essentially of a rotating beater and a heavy perforated screen. The material is introduce into the housing, and the beater, which consists of a series of hammers turning at 1500 to 4000rpm, beats and pounds the material until it is small enough to pass through the screen at the bottom. The hammer mill break up material by means of a revolving beaters with swinging hammers which strike the material and reduce it in size until it will pass through perforations in a steel concave or screen around the underside of the beater.

Fineness of division is controlled mainly by the size of holes in the screen, although the rotor revolutions per minute and the rate of feed are additional control factors.

The hammers are rigidly fixed to the shaft or swing. There is less danger of the swinging hammer causing damage if a large metallic objects gets into the mill by accident. The hammer mill is assumed to reduce size by impact. The terrific speed of the hammer produces kinetic energy that is dissipated on the material, causing it to disintegrate. The material is beaten and hammered until it is small enough to pass through the screen.

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 reboun~~ding~~Ging 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 l6mm 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.

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

$$= 3600 \times 0.4285714285$$

$$= 1542.86\text{rpm} = 1543\text{rpm.}$$

Diameter of driving pulley = 0.6m

Diameter of driven pulley = 0.14m

Driving speed = 3600rpm

Driven speed = 1543rpm

Mass of belt = 0.9kg\ m

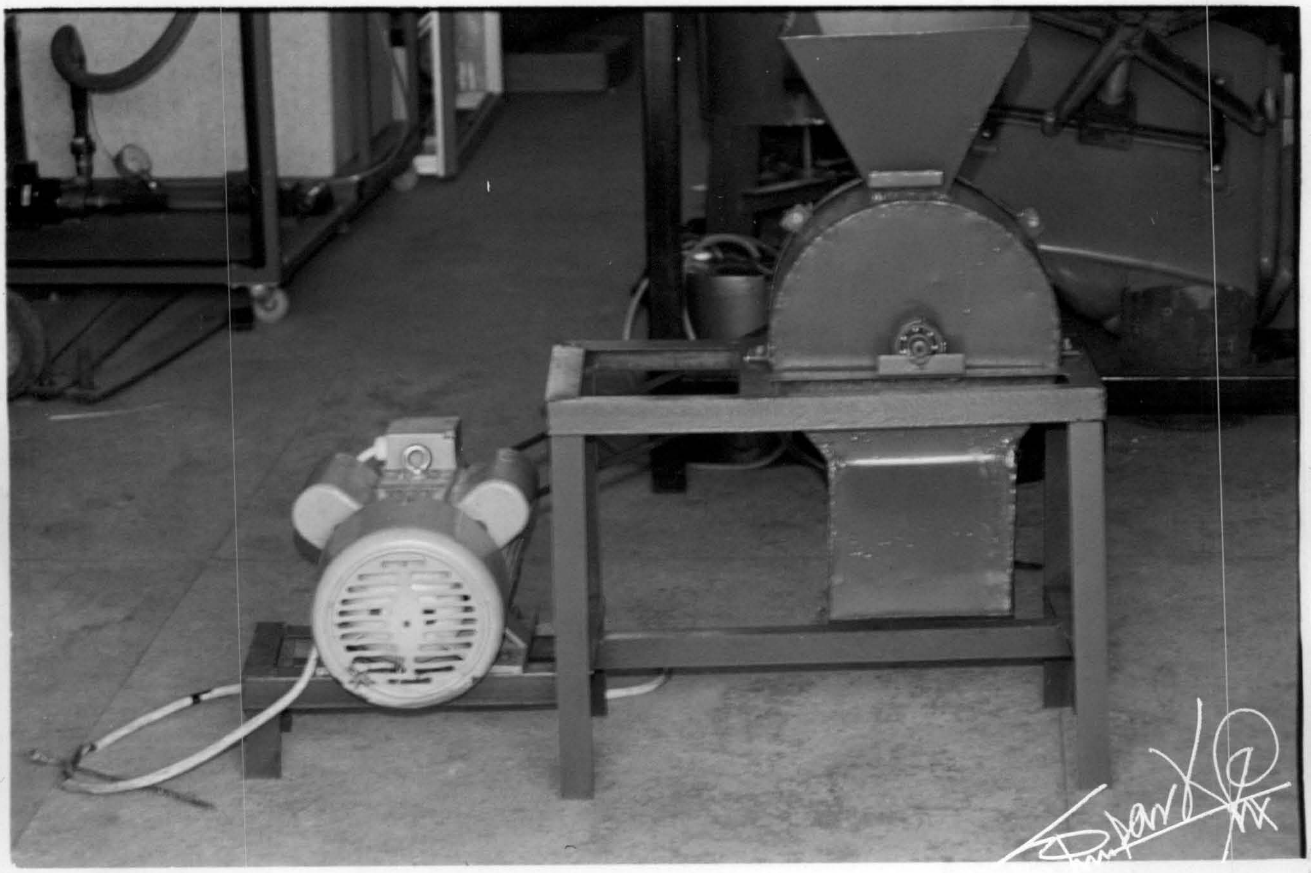

PLATE 1 THE ASSEMBLED MACHINE

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 $= \theta/2$

$$\cos\theta/2 = \frac{\text{radius of driven pulley} - \text{radius of driving pulley}}{\text{Distance between the two pulleys}}$$

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

$\cos\theta/2 = 0.08$

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

$\theta = 01.41$ rad

$= 80.79^{o}$

Angle of lap on smaller pulley (0)

$\theta = 2 \times 1.41$

$= 2.820$ radian

$= 161.57^{o}$

$= 161^{o}.\ 34'$

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)

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

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

2

$= 3600 \times 0.104719755 \times 0.03$

$= 11.30973355$ m/s

$= 11.31$ 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.

$Tc = MV^2$

$= 0.9 \times (11.31)^2$

$= 115.12$ KN

$= 0.115$ 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

$$
\begin{aligned}
T1 &= 3Tc \\
&= 3 \times 115.12 \\
&= 345.36N \\
T1 &= .345KN
\end{aligned}
$$

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 =?

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

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

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

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

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

$4 (T2 - 155.12) = 230.24$

$4\,T2 - 460.48 = 230.24$

$4\,T2 = 230.24 + 460.48$

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

$T2 = 172.68$ 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 = $T1 - T2 \times \frac{D1}{2}$

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

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

$$172.68 \times 0.03$$

Torque on the Driving pulling = 5.1804 NM

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

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

$$= 172.68 \times 0.07$$

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

= (345.36-172.68) x 11.31

= 172.68 x 11.31

= 1953.0108 watts

1 horse power (HP) = 746 watts

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

= 2.617976944 HP

= 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 x 8 = ₦200

And a total number of working days is 30.

Total cost for these days

∴ Labour cost = 200 x 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 $= \frac{0.08}{3.8} \times 100 = 2.105263158\%$

Output percentage $= \frac{\text{output}}{\text{Input}} \times 100$

Efficiency $= \frac{3.72}{3.8} \times 100 = 94.8947318\%$

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

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

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

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

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

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

= 59.0gm

Efficiency of grinding

$$= \frac{\text{Actual weight} - \text{weight of Material retained}}{\text{Actual weight}}$$

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

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

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

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

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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