DESIGN AND CONSTRUCTION OF A MAIZE THRESHER

BY

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(PGD/AGRIC ENG/1999/2000/090)

A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING, IN PARTIAL FULFILMENT OF THE REQUIMENTS FOR THE AWARD OF POSTGRADUATE DIPLOMA IN AGRICULTURAL ENGINEERING (FARM POWER AND MACHINERY OPTION).

AUGUST, 2001

APPROVAL PAGE

This research project by Mu'azu Haruna Aliyu has been read through and been approved as meeting the requirement for the award of Postgraduate Diploma in Agricultural Engineering (Farm Power and Machinery) of the Federal University of Technology Minna.

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DEDICATION

To my parent Alhaji Mu'azu Haruna and Hajiya Aishatu Mu'azu Haruna for their encouragement

ACKNOWLEDGEMENT.

Most beautiful thanks to Allah the all known for granting me the opportunity to undertake the program.

I wish to acknowledge the UN-quantifiable, timely and valuable contribution of my supervisor Dr. M.G Yisa, Whose inspiration, criticisms, constant words of encouragement, spool of knowledge in the area covered, led to the successful and timely completion of this project. Fine acknowledgment also to all my lecturers in the Department of Agricultural Engineering for their immeasurable assistance. Especially, to Malam Bashir Mohammed for going through the manuscript and offering valuable corrections.

Finally my special appreciation to all my brothers, sisters, friends, well wishers who are too numerous to mention here for their concern and to my employer College of Agriculture, Zuru for the sponsorship.

ABSTRACT

Maize threshing as is normally done by peasant and medium scale maize Producers is laborious and time consuming. An electrically powered maize thresher designed for small and medium scale use has been constructed and tested. The design and construction of the thresher utilized locally available raw materials. Hence could be affordable. After testing, the thresher was found to have a capacity to thresh 78.33kg of maize per hour with absolute cleaning at a speed of 800rpm.

LIST OF FIGURES.

LIST OF SYMBOLS USED

NAMES	SYMBOL.
Linear Velocity	V
Angular Velocity	ω
Radius	R
Phi	π
Volumetric flow rate	V_f
Height	H
Length	L
Density	ρ
Mass	M
Bending Moment	BM
Section Modulus	Z
Stress	δ
Diametre	D

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CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTORY NOTES

Corn is an important crop in many countries of the world including Nigeria. It is first and foremost an American crop. According to Wayne (1975) corn is grown in every state of the union, especially in the corn-belt from Ohio westward to the Missouri and beyond. Similarly, in Nigeria corn is grown nearly in all the 36 states of the federation and Abuja, particularly in the middle belt states where it is grown in abundance owing largely to the climate, which supports optimum production.

In recent years, corn production is gaining in popularity among most farmers in Nigeria because of its numerous uses. As a result it becomes imperative to make production costs, especially as they relate to post-harvest expenses as minimum as possible so as to make our small and medium scale farmers realise optimum benefits from corn production. One way of reducing post harvest cost is by using appropriate machines in threshing.

Corn threshing is the removal of maize grains from the cobs. It is one of the post harvest operation aimed at obtaining clean grains either for immediate use or for storage. According to Juo and Lowe (1986) maize can be threshed in two ways viz: (i) traditional or manual methods and
(ii) Mechanical methods. .

The traditional methods are derived from long standing tradition. Based on traditional methods, maize threshing is done by either of the following methods; beating the cobs in heap with sticks; pounding with pestle in morta or by trampling with animals.

The mechanical method of threshing on the other hand is achieved through the application of tools of science and technology in agriculture. Through such applications, mechanical threshers were devised and developed. With mechanical threshers, threshing is accomplished by impact exerted on the cob by a rotating drum inside a concave.

Although modern mechanical threshers help to minimize the drudgery of threshing associated with traditional methods, unfortunately in a typical setting like ours, their use is found to be exploited only by the large scale farmers (who constitute the minority in Nigeria's farming populace) who can readily afford the cost of buying and employment of skilled operators to over see their operations. The small and medium scale farmers (the obvious majority) continue to rely on the traditional methods, which are Labour intensive.

The design and construction of this thresher is made simple and cheap, as such can be affordable by both the medium and small-scale farmers. Apart from being simple and cheap, the design specifications and construction utilized local materials and also minimize the technical skills and equipment required for its maintenance.

1.2 STATEMENT OF THE PROBLEM

The manual method of maize threshing which our low scale maize producers employ is extremely Labour intensive and the output per time is low. This is seen to serve; as an impediment to would be likely producers. It is also true that the conventional imported mechanical threshers are beyond the reach of our peasant farmers who are the obvious majority of our farming populace. It is therefore essential to design and fabricate locally a thresher that would readily alleviate these difficulties and at affordable rate.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Maize threshing is the removal of grains from the cobs. It can be achieved by either impact of a fast moving member upon the material (e.g. action of a rotating drum on cobs inside the concave) or by rubbing action. In this chapter a review is made of the various methods of threshing maize.

2.1 THRESHING METHODS

With appropriate threshing equipment, maize may be threshed according to any of the following methods.

i Manual

ii Mechanical

2.1.1 THE MANUAL METHODS

Maize threshing is done manually using one of the following methods:

(i) By pounding: In this method, the maize cobs are placed inside a morta and a pestle is used to pound on the cobs several times until all the grains are removed from the cobs. Later on cleaned grains are obtained by winnowing (see fig 2.1).

1.3 DESIGN OBJECTIVES

The objectives of this project are:

1. To design and fabricate a maize thresher using locally available raw material.
2. To be simple in construction and cheap so that both the medium and small-scale farmers can readily own and or use one.
3. To be easily convertible into pedal operated in situation where electrical power is not available.

(ii) By beating (sticks method). In the stick method of threshing maize, the maize cobs to be threshed are gathered in a pile or heap and people (usually men), each holding stick surround the heap of cobs and beat the cobs with their sticks collectively and severally until all the grains or nearly all the grains are removed from the cobs. In stick method, just like pounding method of threshing, cleaned grains are also obtained through winnowing (see fig 2.2)

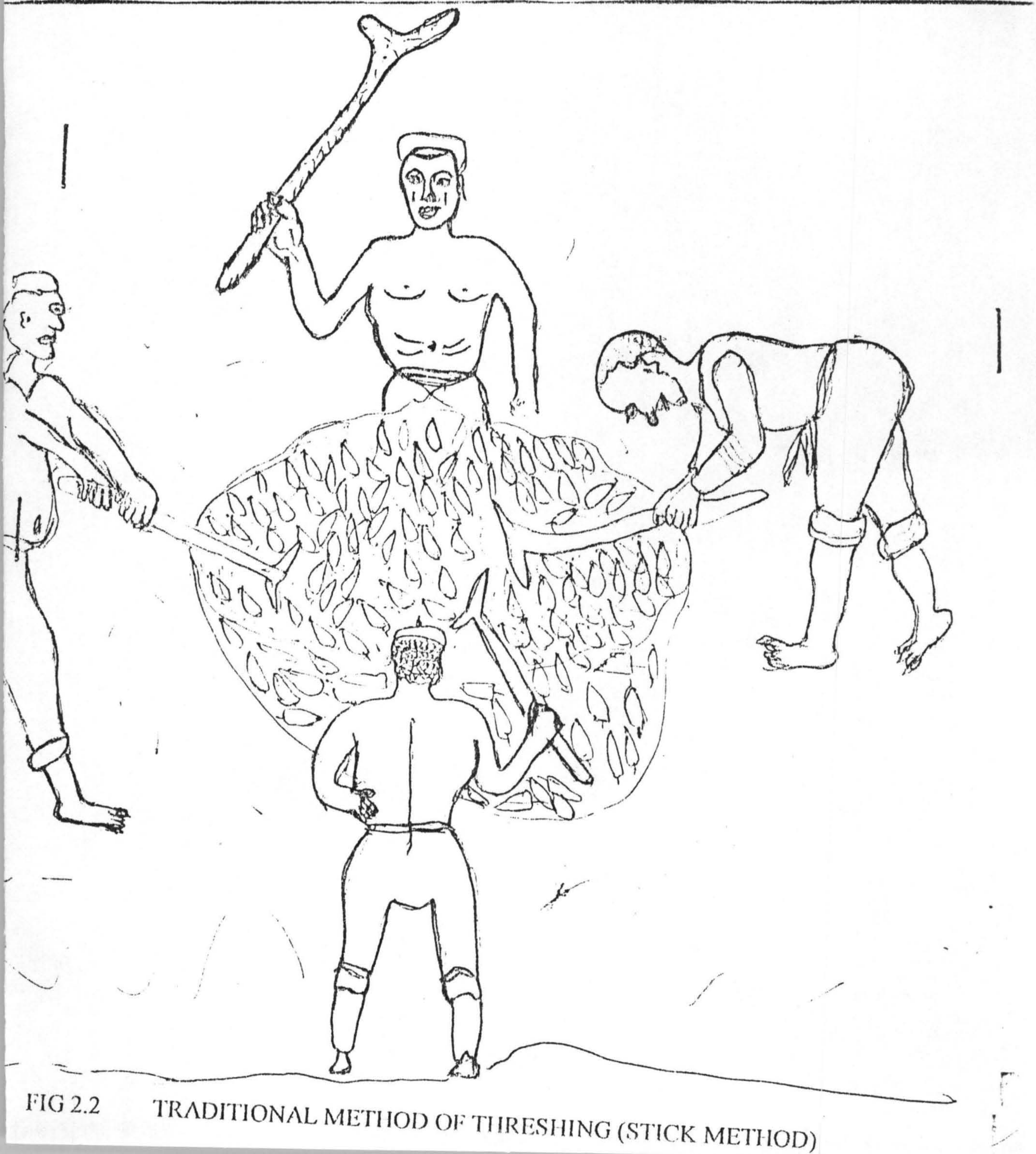


FIG 2.2 TRADITIONAL METHOD OF THRESHING (STICK METHOD)

(iii) By rubbing action: This method of maize threshing requires the person doing the threshing to hold a cob of maize with one hand while at the same time using the other hand to scrap off grains from the cob usually with a light solid object. This method seems to be the best of the three because cleaned threshed grains are obtained. However, the one major limitation of this method is low output/time (see fig 2.3).

FIG 2.3 TRADITIONAL METHOD OF THRESHING (KNIFE METHOD)

Generally, the manual methods of threshing maize are characterized by low output/time and Labour intensive. It is in attempt to address these pressing problems that modern mechanical threshers were devised and developed.

2.1.2 THE MECHANICAL METHOD

The mechanical method of threshing came into play resulting from the application of tools of science and technology in agriculture for the purpose of mechanizing. Resulting from increases in agricultural productivity from the use of high quality seeds, better technical know-how, more and more areas put under cultivation, threshing machines (threshers) are needed to enhance the separation of grains from the ears at a faster rate, cleaning and freeing them from unwanted material (Asoegwu, 1998). Mu'azu (1991), observed that various mechanical thresher have been invented to replace the manual methods which are Labour intensive and time consuming. Basically a typical mechanical thresher consist of the following parts the feed hopper drum and concave assembly, grain sieve and a blower.

2.2.0 DEVELOPMENT OF MECHANICAL THRESHERS

The development of mechanical threshers started more than a century ago. The development of threshers started as early as December, 1837, when Hiram.A and John A. Pits were granted patents for their work on threshers (Wilkes & Smith, 1977). Although horse operated, it was said to be the beginning of threshers. By 1900, these threshers were equipped with self-feeders and other working accessories.

Hosokawa (1995) also posit that an animal-powered upright axial flow thresher was first developed in 1880 and further argued that the methods of threshing by having an animal tread on panicles or pull a roller are still in use in some parts of the world. Kepner etal (1982) classified mechanical threshers into two groups as follows:

i. Stationary threshers

ii. Combine harvesters.

2.2.1 THE STATIONARY THRESHERS

These threshers as the name suggests are threshers with neither access wheels nor prime mover to move them about. With this category of threshers, the material to be threshed has to be fed into the feeding unit either manually or using an automatic belt conveyor. The stationary mechanical threshers are classified by Culpin (1976) according to the feeding system of the straw into the drum. Thus we have the axial flow and tangential flow stationary threshers.

2.2.1.1 AXIAL FLOW STATIONARY THRESHERS

With this type of threshers, the material to be threshed is fed through inclined cylinder mounted longitudinally. The grains stay longer in the threshing unit with more threshing action. However, grain breakage and clogging of the cylinder-concave clearance occur.

The Swaraj multi-crop thresher is a multi-crop axial flow thresher (Mu'azu, 1991). It is highly versatile, suitable to thresh most cereals under different field conditions. This type of thresher has a spiral relenting louvers fitted in the drum to provide greater crop retention in the machine. The grains are detached from the cobs due to impact. The threshing drum rotates at an approximate speed of 600 – 750rpm. This thresher has an output of between 150 –180kg/hr. and an efficiency of 95%.

2.2.1.2 THE TANGENTIAL FLOW STATIONARY THRESHERS

These types of threshers are suitable for handling a wide range of crop. The problem of clogging in cylinder – concave clearance associated with axial flow type is eliminated. A tangential flow thresher allows a direct flow of crop through it and about 85 – 90% of what is fed into the drum is threshed (Bamba, 1982). Bamba thresher falls into this category. This is a very simple strong machine, which is very easy to maintain. Threshing action is done by impact. The threshing speed is 800rpm for corn. Cleaning sieve with holes0.8mm is used and a V-belt commands the motion of the cleaning sieve and fan from the thresher shaft (see fig 2.4).

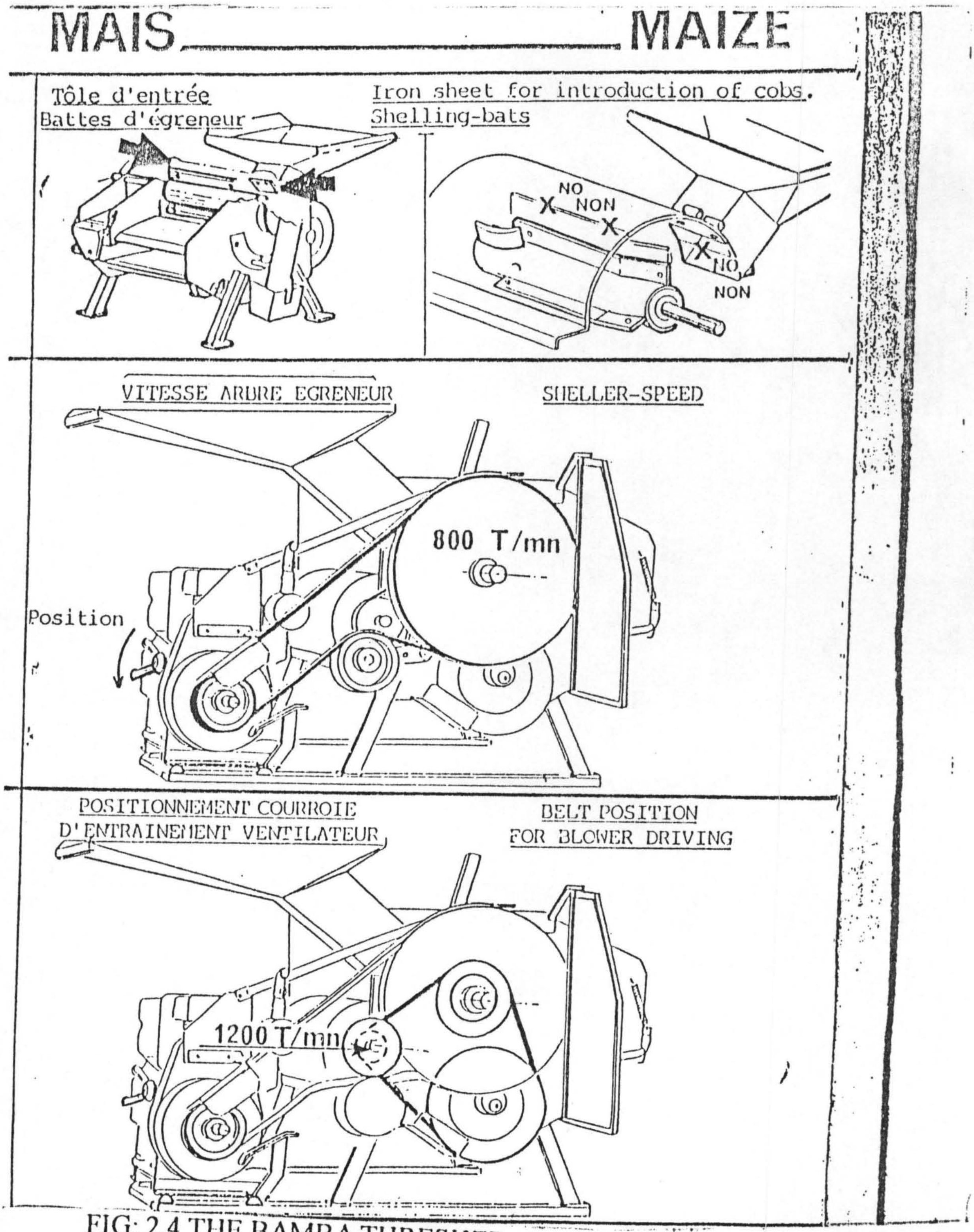


FIG: 2.4 THE BAMBA THRESHER

2.2.1.3 OTHER TYPES OF STATIONARY THRESHERS

(A) CEREAL THRESHING MACHINE B.C 40.

This is another type of stationary thresher that threshes, ventilates and sacks most cereals. It has a total weight of 250kg and dimension of 2.10 x 1.46 x 1.34m. This type of thresher has the capacity to threshed 60kg/hr.

(B) ANDREW MEIKLE THRESHER OF SCOTLAND

This thresher derived its name from its inventor – Andrew Meikle of Scotland. It consists of a drum with four longitudinal iron beater bars and steel concave. The maize cob after being fed is held by two fluted rollers while they are subjected to an upward blow from the beaters thereby separating the grains from the cobs.

2.2.2 THE COMBINE HARVESTER

Combine harvesters are mostly used to cut and thresh in one operation. They may also often be used to advantage to pick up and thresh crops, which have been cut previously and left in the swath, or as stationary or portable threshers for dealing with crops which have been cut by a binder and stoked or staked (Culpin, 1976). The first combines were made in America in the 1830s and by 1900 combine harvesters, some steam driven and others pulled by a team of horses or mules, were quite common (Brain, 1993).

The idea of building a combine around a tractor, tried by Claas August in 1930 was reintroduced 30years later by J.F farm machines in Denmark. According to Brain (1993) a sales leaflet for the MS90 combine, informed prospective buyers that one man could fit it into a tractor in less than 5 minutes. All combines consist essentially of a cutting mechanism attached to traveling thresher. Kepner etal (1982) classified combine harvesters according to the system of motion thus:

i. Pull type combine
ii. The self-propelled combine.

2.2.2.1 PULL TYPE COMBINE

The pull type combine is a p.t.o driven machine mounted on two wheels. It has a cutter bar, elevator, threshing drum and shakers arranged so that the straw travels straight back through the machine (Culpin, 1976).

2.2.2.2 THE SELF-PROPELLED COMBINE

This type of combine is powered with industrial type of engine of 60 – 150 HP (Culpin 1981). With this type of combine, the corn is cut from the stalk, fed and picked up by chain and slat conveyor and raised to the drum where threshing takes place. Grain, chaff and straw pass on to the shakers, and grain return chutes bring back chaff and grain to join that which passes on to the sieves, where blast blows the chaff out of the back of the machine. The grain that passes through the cleaning sieve is collected in the tank via the auger and grain elevator.

The great advantage of the self-propelled combine harvester is its ability to go straight into the crop and cut it in the most convenient direction. The wide variation of its forward speed also allows it to deal effectively with a wide range of crops (see fig 2.5).

2.2.3 GRAIN STRIPPERS

The stripper harvester is an Australian invention dating back to the 1840s, the original idea is credited to John Bull who had previously migrated from Kent to south Australia (Brain, 1993) forty years later engineers in America and Australia were said to have strived hard to design a commercially acceptable grain stripper.

However as the combine harvesters became popular less interest was shown in the development of grain strippers but they reappeared in the late 1940s with the introduction of the wild harvest thresher from Australia. Further development work on grain stripper started in Great Britain during the mid 1980s and after a successful field-testing by the Institute of Engineering Research, Shelburne Reynolds. Engineering produced several grain strippers in 1988. With a grain stripper, long triangular – shaped tines guide corn ears from a 4ft width of the crop into the engine driven stripper rotor where the grain is removed from the straw. The threshed grain is bagged off and the chaff is returned to the ground by two large diameter spouts.

Kidds Farm Machinery exhibited a prototype trailed grain stripper at the 1990 Smithfield show. The stripper said to have the output of a medium size combine for half the price, consisted of a Shelburne Reynolds stripper header, drum and concave, conventional sieves and fan but instead of straw walkers it had four rotary separators.

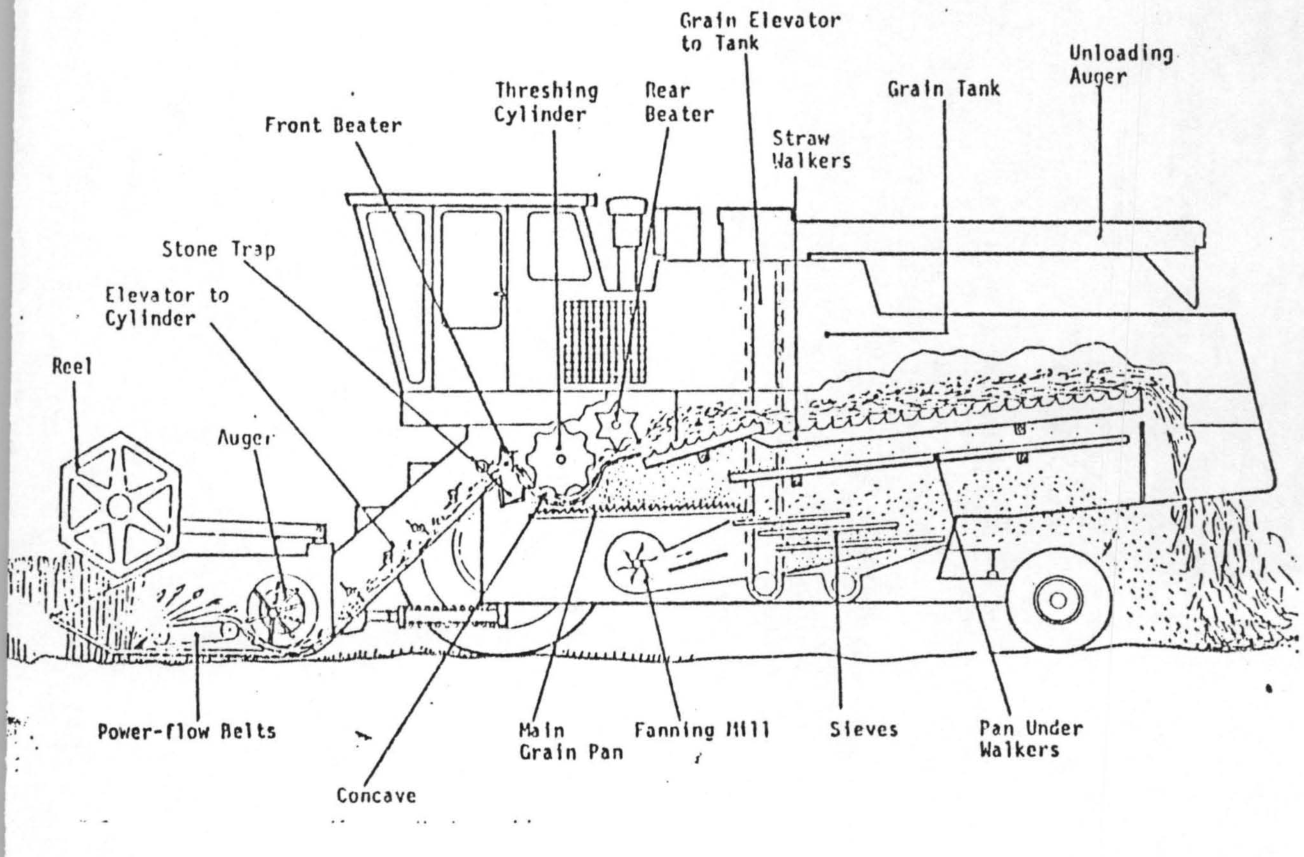


FIG: 2.5 THE SELF PROPELLED COMBINE

CHAPTER THREE

3.0 DESIGN APPROACH

3.1.0 PRINCIPAL FEATURES

V-shaped fingers cut from angle iron and spaced 20mm apart are used to effect threshing and ejection of cobs from the threshing unit. The thresher has minimum number of component parts, which are structurally durable, and therefore requires minimum maintenance. The machine is also simple in design and construction hence simple to operate. Above all the thresher is flexible and portable.

3.2.0 DESCRIPTION OF THE MACHINE

3.2.1 FEEDING UNIT.

The hopper is constructed from a mild steel sheet of 1.5mm. It is trapezoidal in shape with dimension of 160 x 70-x 150mm. The side of the hopper conforms to the shape of the drum housing. The hopper is designed to be bolted to the drum housing (see fig 3.1).

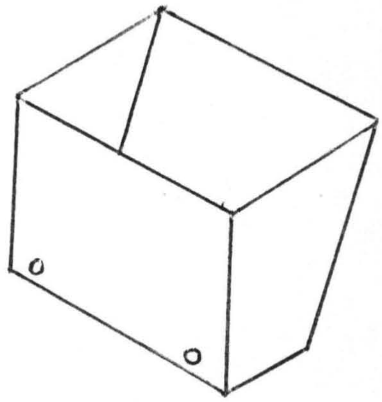


FIG 3.1 THE HOPPER

3.2.2 THRESHING UNIT

The threshing unit consists of the following

i. Drum housing (Upper concave)

ii. Rotating drum (Cylinder)

iii. Concave (Lower concave)

3.2.2.1 DRUM HOUSING

The drum housing otherwise called the upper concave is made from a mild steel sheet of 1.5mm with dimensions of 500mm length and 300mm diameter (see fig 3.2).

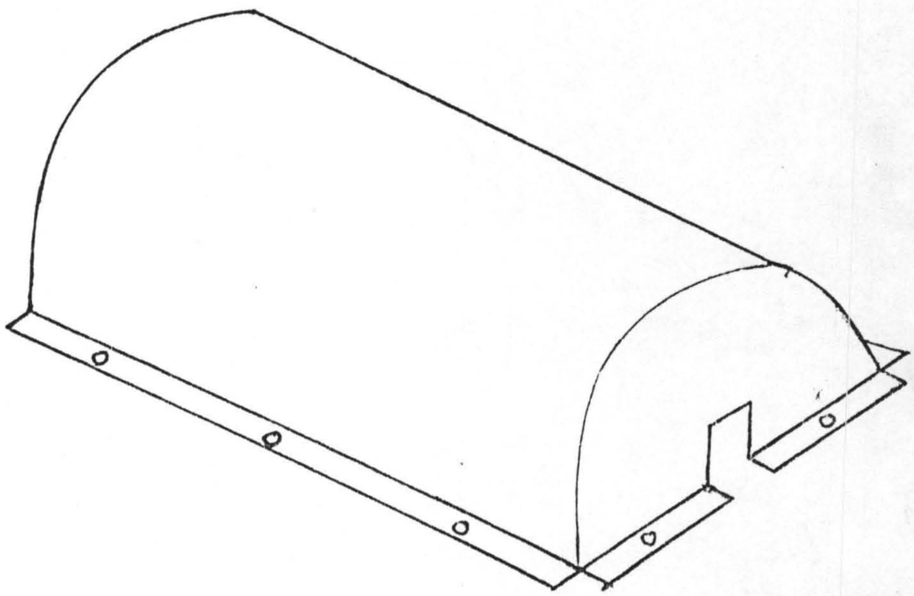


FIG 3.2 THE UPPER CONCAVE

3.2.2.2 CYLINDER

The drum is cylindrical in shape and made with dimensions of 470mm length and 170mm diameter. It is constructed from the following materials; 3mm sheet metal, 25mm x 25mm square pipe and a 25 x 25 3mm cross-section angle iron. The 3mm sheet metal forms the two sides of the cylinder plate with shaft passing centrally through them. Six straps of angle iron of 480mm length each were spaced equally and incline at 60^0 to the square pipes. Each end of the angle iron is welded to the cylinder plates. The cylinder serves the function of threshing and ejecting of cobs. Cobs ejection is achieved by the spiral-like arrangement of the fingers (see fig 3.3)

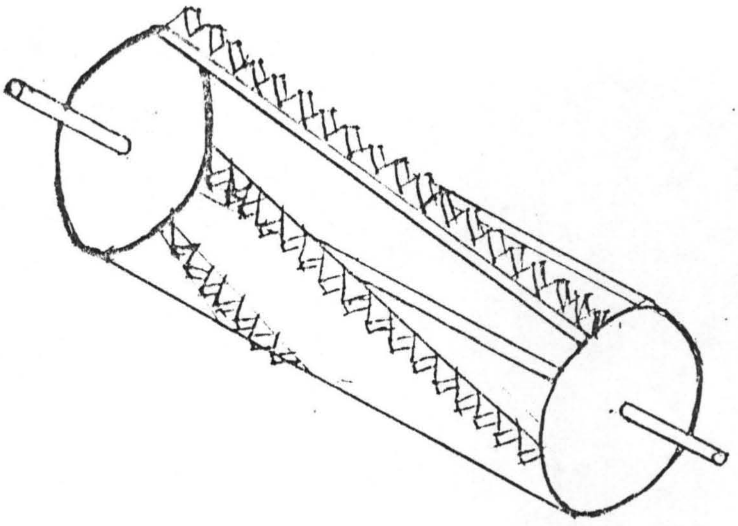


FIG 3.3 THE CYLINDER (DRUM)

3.2.2.3 THE CONCAVE

The lower concave is constructed from a 3mm sheet metal of length 5oomm and effective diameter of 300mm. The concave has perforations for threshed maize grain to pass through. The drilled holes are of 12mm diameter, large enough to take the grains. The concave is fastened by bolts and nuts to the frame in four positions to ensure stability (see fig 3.4)

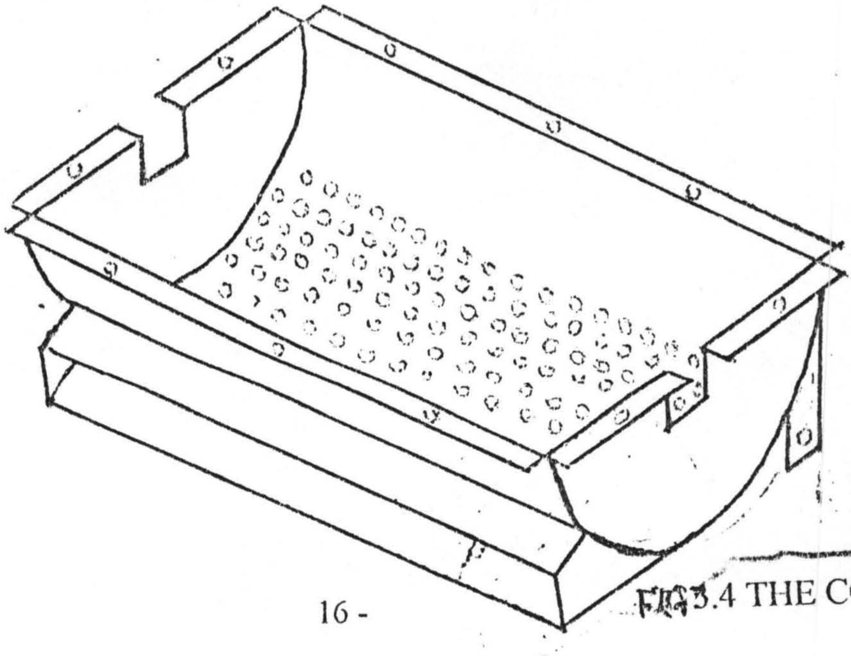


FIG 3.4 THE CONCAVE

FIG 3.4 THE CONCAVE

3.2.3.0 CLEANING UNIT

The cleaning unit consists of three parts thus:

i. Fan blades.

ii. Casing.

iii. Grain sieve.

3.2.3.1 FAN BLADES

A forward curved centrifugal flow fan is used in this design. There are three blades arranged 120° apart from each other on the shaft. The blades are constructed from 1.5mm mild steel sheet with the following dimensions: 400mm length and 100mm height (see fig 3.5)

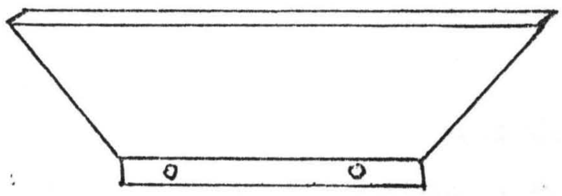


FIG 3.5 THE FAN BLADE

3.2.3.2 FAN CASING

The fan casing is positioned directly beneath the threshing unit. It is constructed from a mild steel sheet of 1.5mm thick with an effective diameter of 250mm and length of 430mm. Its side covers are provided with an airflow opening of 150mm diameter. The casing is fastened by bolts and nuts in two strategic positions to the frame (see fig 3.6)

3.2.4 POWER TRANSMISSION UNIT

There are three mild steel pulleys used. The main power-transmitting pulley (prime mover pulley) transmits motion to the threshing unit from where it is transmitted to the fan shaft by means of belts and pulleys. An eccentric crank commands the motion of the grain sieve by converting the rotary motion of fan shaft into the reciprocating motion of the sieve.

The two shafts used were reduced to 20mm and 15mm diameter to match the bearings for cylinder and fan shaft respectively (see fig 3.8).

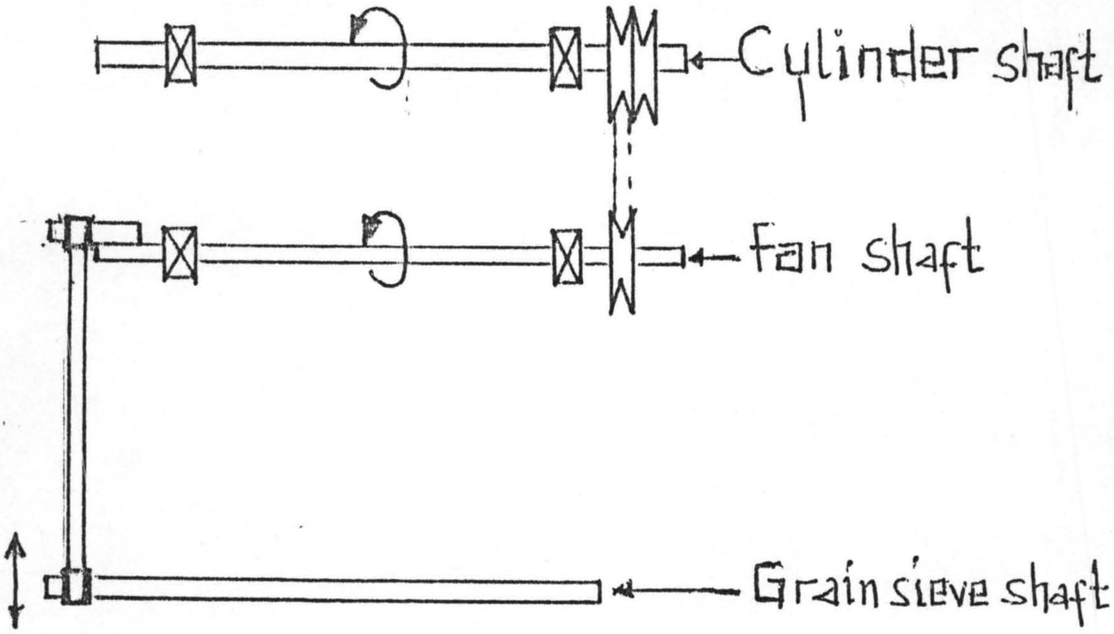


FIG 3.8 THE DRIVE

3.2.5 THE FRAME.

The frame is constructed from an angle iron of 45 x 45 x 3mm with the following dimensions: length 1000mm, width 500mm and height 500mm. Angle iron is used because of its stability workability and low cost. The frame is made detachable and it serves as backbone of the thresher.

3.3.0 **CHOICE OF MATERIALS**

Material for any construction be it a structure, machine e.t.c. must be suitable for the job in order to perform the work expected of it as efficient as desired without failing every now and then. Since part's failure e.g. due to wear, breakage, e.t.c. is not completely avoidable, it is thus, desirable to design units as self – contained assemblies, which are individually assembled, adjusted and finally installed as completely ready-to-operate units on a machine using appropriate material for each component. Orlov (1997) argued that although sometimes unitization may complicate the design, in the long run however, it always give large savings in the total machine manufacturing costs, reliability and convenience in use.

Thus, the choice of material is very vital for a satisfactory performance of machine as such, must be done with great care and patience. The materials used for the project are based on design specification and availability in the market. A 3mm mild steel sheet was used for parts like concave and drum because these parts generate impact on the maize cob. A 25 x 25 x 3mm cross section angle iron was used for the fingers with a 25 x 25 x 1mm square pipe serving as base for them 1.5mm mild steel sheet was used for the drum housing, hopper, grain discharger, fan blades, fan casing and grain sieve. Three mild steel pulleys were used and a 45 x 45 x 3mm cross-section angle iron was used for the frame because of its stability and good workability.

3.3.0 WORKING PRINCIPLES

The maize cob is fed into the hopper, passes down by gravity into the threshing unit. The prime mover (small engine or an electric motor) drives the drum at an approximate speed of 800rpm (recommended) Resulting from the rotary motion of the threshing cylinder, the V-shape tines (fingers) on the drum inconjunction with the concave threshes the maize as the cob is carried about the concave.

As the cylinder continues to rotate, the empty cob is expelled out due to the action of spirally arranged tines on the drum. The mixture of grain, chaff and other small pieces of broken cob passes through the concave openings and are directed to the reciprocating grain sieve. The mixture of chaffs and grain passes through the grain sieve openings where the chaffs are blown away by an air blast supplied by a fan located under the threshing unit. For the larger materials, the reciprocating actions of the grain sieve make them to roll over the sieve and are discharged at the extreme end of the thresher.

3.5.0 **DESIGN OF VARIOUS THRESHER PARTS.**

The thresher consists of three main units as follows:

I. Feeding unit.

II. Threshing unit.

III. Cleaning unit.

3.5.1 **FEEDING METHOD**

Test conducted by G.E Pick (1982) have indicated that damage is considerably less when cobs are fed into the cylinder with their axis parallel to the cylinder axis rather than longitudinally or in a random orientation. With this in mind, the feeding unit is designed to direct the cobs into the threshing unit parallel to the cylinder axis.

3.5.2 THRESHING UNIT

3.5.2.1 **CYLINDER SPEED.**

Cylinder speed = 800rpm (courtesy Bamba thresher)

Cylinder radius = 0.085m (Design specification)

Height of tines = 0.025m (Design specification)

The finger – cylinder peripheral speed was computed from the relationship:

$V = \omega r$

Where V = Linear velocity in m/s

ω= Angular velocity in rad/s.

r = Cylinder radius + height of fingers in m

$$= V = \frac{[800 \times 2 \times \pi \times (0.085 + 0.025]}{60} \text{ m/s}$$

$$= \frac{[552.92]}{60} \text{ m/s}$$

$= V = 9.22$ m/s

This speed (9.22m/s) falls within the acceptable range of cylinder peripheral speeds. Laboratory studies have indicated that damage from a rasp bar or spike tooth cylinder increase with peripheral speed especially at speed above 15.2m/s (Pick).

3.5.2.2 CYLINDER DIAMETER

Cylinder diameter = 170mm (0.17m).

A cylinder diameter of 170mm was used for design purposes to facilitate have a low (acceptable) peripheral speed so as to lessen grain damage, if any.

3.5.2.3 CYLINDER LENGTH

Cylinder length = 470mm (0.47m).

A cylinder length of 470mm was adopted because the thresher is designed for medium scale use.

3.5.2.4 CYLINDER-CONCAVE CLEARANCE

The cylinder – concave clearance is made adjustable. The clearance can be adjusted from 10mm to a maximum of 80mm depending on the size of cobs being handled.

3.5.3 CLEANING UNIT

A centrifugal fan with forward curved blades operating at an approximate speed of 800rpm was selected.

In cleaning the required volume flow rate of air to throw a material to a distance of at least 3ft (0.914m) from the duct to avoid contamination of grains is found to be 15 times the volume flow rate in ordinary conveying (Pick, 1982).

The airflow rate necessary to remove mass of chaffs from grains in threshers is the expression of volumetric flow rate is given as:

$$Vf = V.A$$

Where: Vf = volumetric flow rate of air in m^3/s

V = velocity of air in the housing in m/s

A = surface area of fan housing.

Thus from the expression Vf = V.A

$= V = Vf/A.$

But Vf = $(0.224 \times 15)\ m^3/s$.

$Vf = 3.36 m^3/s$.

And $A = 2\pi rh$

$= (2 \times \quad \times 0.125 \times 0.430)\ m^2$

$A = 0.338 m^2$

Then $V = [3.36/0.338]$ m/s

$V = 9.94$ m/s

But actual air velocity (va) is given as the product of the coefficient of friction due to air (u) and velocity of air (v). Assuring the coefficient of friction due to air resistance (U) is 0.85, then, actual air velocity (Va) is computed thus:

$Va = V \times U$

$= (9.94 \times 0.85)$ m/s

- $Va = 8.449$ m/s

The radius of the fan blade was determined form the equation Va = ωr. So that r = Va/ω. where Va = actual air velocity (i.e. 8.449 m/s) and ω= angular velocity of the fan [i.e. 800 x 2 /60 = 83.787 rad/s].

Since, r = Va/ω

r = (8.449/83.787) m/s

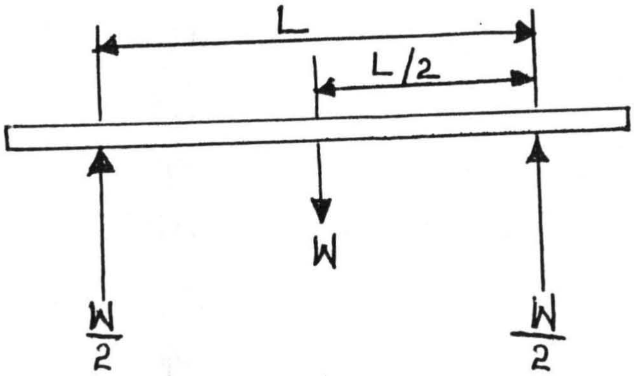
r = 0.100m

Thus, the design incorporate a blade size of 400 x 100 x 1.5mm with a total number of three blades.

3.6.0 POWER TRANSMISSION CALCULATION

3.6.1 CYLINDER SHAFT

A shaft loaded centrally and supported at its ends has a maximum bending moment (BM) at the center (Champion and Arnold, 1986). Figure below illustrate the cylinder shaft under bending moment analysis.



Where: w/2 = the reaction at the support.

L = Distance between two ends = 600mm.

W = Load about the center

L/2 = the distance from either end to the middle of the Shaft

Neglecting the mass of the shaft, the moment of the force about the middle of the shaft is w/2 x L/2 = WL/4 = BM. Since W = mg, the mass of cylinder (Mc) need to be known. It was computed by summing up the masses of the following component parts:

i Cylinder plate

ii Fingers.

iii Square pipe bars.

a. Mass of cylinder plates (Mp)

$$Mp = \rho \times Vp$$

$$= l \times \frac{\pi D^2 h}{4}$$

$$= [7800 \times 3.142 \times (0.17)^2 \times 0.003]kg$$

$$= [2.125/4]kg$$

$$Mp = 0.531kg.$$

Since the number of plates are 2, it means

That $Mp = (0.531 \times 2)kg.$

$$Mp = 1.062kg$$

b. Mass of fingers (Mf).

$$Mf = \rho \times Vf.$$

$$= l\ [Lbh + \tfrac{1}{2}(Lbh)]$$

$$= 7800\ [0.48 \times 0.025 \times 0.002 + \tfrac{1}{2}(0.48 \times 0.025 \times 0.002)]$$

$$Mf = 7800 \times 3.638 \times 10^{-5}kg.$$

Since the number of fingers used is six, it implies

That $Mf = [7800 \times 3.638 \times 10^{-5} \times 6]\ kg$

$$Mf = \underline{1.703}kg$$

c. Mass of square pipes (Ms)

$$Ms = n\rho \times Vs.$$

$= 6 \times 7800\ [(0.463 \times 0.025 \times 0.025)-(0.463 \times 0.023 \times 0.023)]$

$= [6 \times 7800 \times 4.489 \times 10^{-5}]$ kg

Ms = 2.101 kg.

d. Total mass of cylinder on shaft (Mc)

Mc = Mp + Mf + Ms

= [1.062 + 1.703 + 2.101]kg

Mc = 4.866 kg.

Thus, since W = Mg, it implies that from

B.M = WL/4,

$$B.M = \frac{[4.866 \times 9.81 \times 0.6]}{4} \text{ Nm}$$

B.M = 7.160Nm

Stress in material (δ) is given by

$$\delta = \frac{B.M}{Z}$$

Where B.M = bending moment in Nm.

Z = modulus of section in m^3 which for solid shaft is given as $Z = \frac{\pi D^3}{32}$ (Champion & Arnold, 1986)

$$Z = \frac{3.142 \times (0.02)^3}{32}$$

$Z = 7.85 \times 10^{-7}\ m^3$

From $\delta = \frac{B.M}{Z}$

$\delta = [7.160 \times 10^{-7}]\ N/m^2$

$\delta = 9116395.14\ Nm^2$

Torque on shaft is given by

$$T = \frac{\pi D^3 \tau}{16}$$

$$= \frac{[3.142 \times 0.02^3 \times 9116395.114]}{16} \text{ Nm}$$

$$= \frac{[229.12]}{16} \text{ Nm}$$

$$T = 14.32 \text{ Nm}$$

Power transmitted to the cylinder shaft was found using the expression: $Pc = \frac{2\pi NT}{60}$

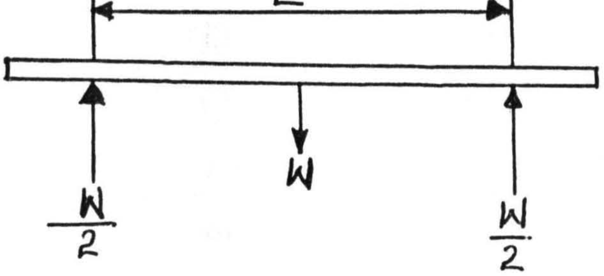
Where: N speed of shaft in rpm.

From $P = \frac{2\pi NT}{60}$

$$P = \frac{[2 \times 3.142 \times 800 \times 14.32]}{60} \text{ W.}$$

$P = 1199.67w$ or $P = \frac{[1199.67]}{746}$ Hp $= 1.61$Hp

3.6.2 FAN SHAFT



The moment (B.M) about the shaft is given by

$$BM = \frac{WL}{4}$$

But W = Mg

Where: M = Mass of fan.

The mass of fan on fan shaft was computed by summing up the masses of fan blades and their respective holding flat bar.

d. Mass of blades

Dimension = 400 x 100 x 100mm

The blades are trapezoidal in shape. Thus area of blade

$= \frac{1}{2}(A + B) H$

$= [1/2 (400 + 100) 100]\ mm^2$

$= (\underline{500} \times 100)\ mm^2$

2

A $= 25,000mm^2\ (2.5 \times 10^{-2}m^2)$

For 3 blades their total area is equal to

$(25,000 \times 3)\ mm^2 = 75,000mm^2\ (7.5 \times 10^{-2}m^2)$

Volume of blades = Area x thickness

$= (7.5 \times 10^{-2} \times 0.0015)\ m^3$

Volume of blades $= 1.125 \times 10^{-4}\ m^3$

Mass of blades = ρ X Volume

$= (7800 \times 1.125 \times 10^{-4})$ kg.

Mass of blades = 0.878kg

b. Mass of flat bars.

Dimension = 100 x 20 x 5mm

Volume of flat bars = n.Lbh.

$= (3 \times 100 \times 20 \times 5)\ mm^3$

Volume of flat bars $= 30000mm^3(3.0 \times 10^{-5}m^3)$

Mass of flat bars = ρX Volume

$= (7800 \times 3.0 \times 10^{-5})$kg.

Mass of flat bars = 0.234kg

Total mass of fan = 0.878 + 0.234 = 1.112kkg

Since $B.M = \frac{WL}{4} = \frac{MgL}{4}$

$B.M = \frac{[1.112 \times 9.81 \times 0.6]}{4}$ Nm

$= \frac{[6.545]}{4}$ Nm

B.M = 1.636 Nm

Stress $(\delta) = \frac{B.M}{Z}$

Where $Z = \frac{\pi D^3}{32}$

$= \frac{3.140 \times (0.015)^3}{32}$

$Z = 3.31 \times 10^{-7}\ m^3$

From $\delta = \frac{B.M}{Z}$

$= \frac{1.636}{3.31 \times 10^{-7}}$

$\delta = 4936888.512 Nm^{-2}$

Torque on fan shaft was given computed form

$T = \frac{\pi D^3 \delta}{16}$

$$= \frac{[3.142 \times (0.015)^3 \times 4936888.512]}{16} \text{ Nm}$$

$$= \frac{[52.352]}{16} \text{ Nm}$$

$$T = 3.272\text{Nm}$$

Power required by the fan shaft was computed from the expression:

$$Pf = \frac{2\pi \ NT}{60}$$

$$= \frac{2 \times 3.142 \times 800 \times 3.272}{60}$$

$$= \frac{16448.998}{60}$$

$$Pf = 274.150 \text{ W (or } \frac{274.15 \text{ HP}}{746} = 0.367\text{HP).}$$

Total power required to drive the two shafts was computed using the relationship:

$$P = Pc + Pf$$

$$= (1199.67 + 274.15) \text{ W}$$

$$P = 1473.82\text{W or } \frac{1473.82\text{HP}}{746.} = 1.98\text{HP}$$

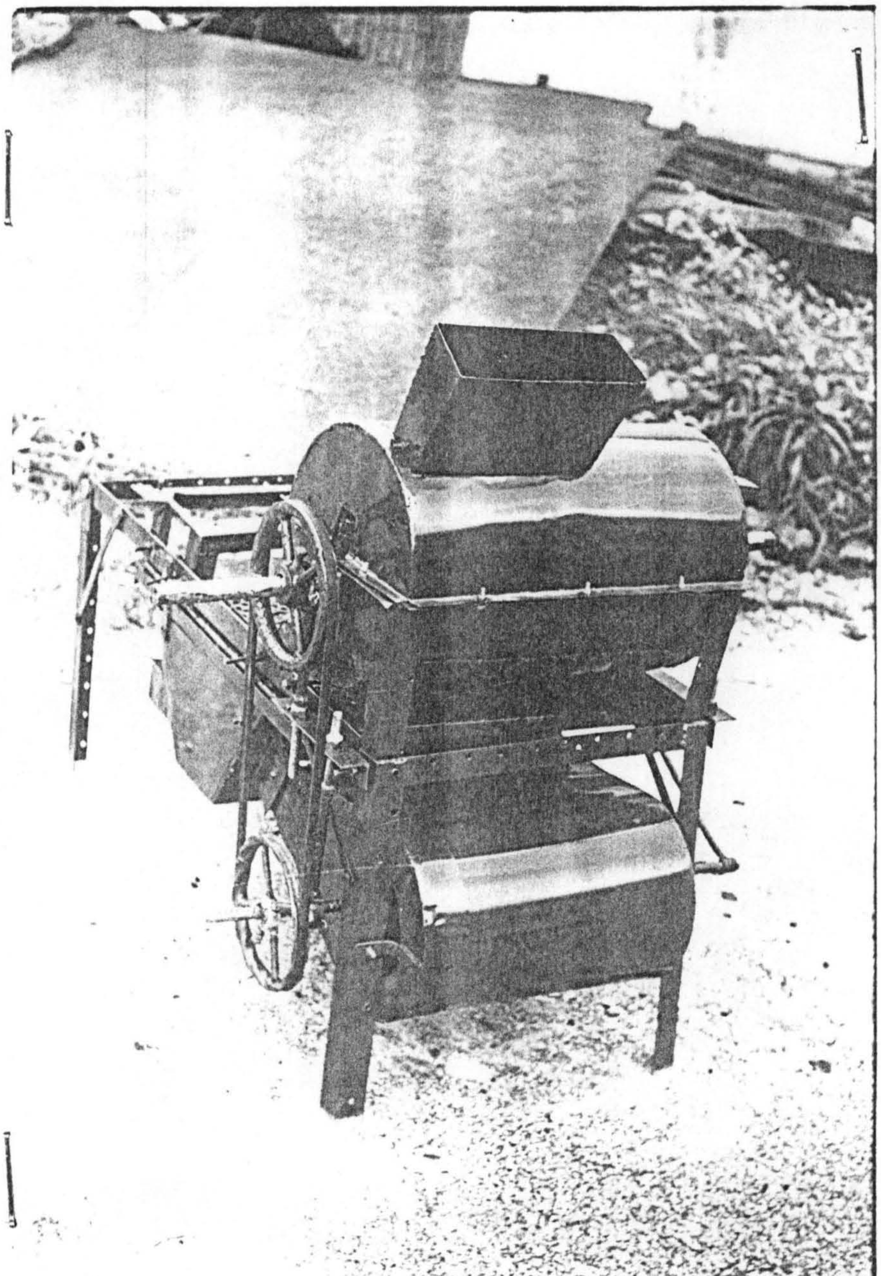


FIG: 3.9 THE ASSEMBLED THRESHER

CHATER FOUR

TESTING AND RESULTS

After the construction, prior to testing all the parts that need adjustment were carefully adjusted before testing the machine.

These parts include: -

(i) Cylinder- concave clearance was well adjusted to suit the size of cobs handled.

(ii) Fan blade- fan casing clearance was adequately adjusted to avoid rubbing contact.

(iii) Belt drive was adjusted for pulley alignment and optimum tensioning.

With the machine completely set, a total number of three tests were conducted. The test time was recorded using a stop – watch. The quantity of maize threshed was collected and weighed. The capacity of the thresher was computed by dividing the average weight of threshed maize by the average threshing time as presented in table 1 below.

TABLE 1: Thresher performance.

Test	Mass of threshed Maize (kg)	Time Taken (min)
1.	75	60
2.	83	60
3.	77	60
Total	235	180

Average mass of threshed maize (M_{av}) $= \frac{[235]}{2}$ kg

$M_{av} = 78.33$kg

Average time (T_{av}) $= \frac{180}{3}$

$T_{av} = 60$min.(1hr)

4.1 THRESHER CAPACITY.

The thresher capacity (c) was computed thus:

$$C_{th} = \frac{M_{av}}{T_{av}}$$

$$= \frac{(78.33)}{60} \text{ kg} \backslash \text{min.}$$

$C_{th} = 1.31$ kg \ min (or = 78.33kg \ hr).

4.2 THRESHING EFFICIENCY.

The threshing efficiency (η_{th}) was computed using the relationship:

$$(\eta_{th}) = \frac{\text{No. of threshed cobs}}{\text{Total no of cobs fed into the thresher.}} \times 100$$

$$= \frac{87}{93} \times 100$$

$$\eta_{th} = 94\ \%$$

4.3 CLEANING EFFICIENCY.

Cleaning efficiency (η_{cl}) is given by.

$$\eta_{cl} = \frac{\text{Mass of cleaned grains}}{\text{Mass of grains + chaffs.}}$$

The cleaning efficiency of the thresher could not be ascertained due to the difficulty in trapping blown chaffs. However it was observed to be adequate.

4.4 OBSERVATIONS

During testing, the following observations were made:

(i) Grain splashing at the cobs spout was observed.

(ii) Grain splashes at the hopper too.

(iii) About 98% of the expelled cobs came out of the threshing unit unbroken.

(iv) The reciprocating grain sieve works fairly all right with advance and retard travel of 37.5mm.

CHPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Since our system of maize cultivation is gradually changing from the old, crude, drudgerous and cumbersome traditional method which is characterised by poor yield into a modern and efficient mechanized form, it therefore becomes apparent the need to device locally a powered maize thresher for use at both small and medium scale levels.

This needed thresher has been designed and constructed from readily available raw materials. The thresher is made compact, portable, few component parts and simple working principles. This in addition to easy maintenance, high efficiency, reasonable capacity, ability to thresh maize with out breaking cobs, and unitization in construction which allow every item of the thresher dismantable, may serve as an inducement to farmers.

Indeed this locally designed and constructed maize thresher if found acceptable by small and medium scale maize producers would in no small measure help to save some of the Nigeria's foreign reserve used in importing threshers of its kind.

5.2 RECOMMENDATION.

The following recommendations are deem fit for better performance of the thresher during operation and future modifications.

i. Before operating the thresher, attention should best be place on the cylinder- concave clearance. Since it is important in relation to good quality threshing. Whereas too much clearance leads to poor threshing, too small a clearance leads to excessive power requirement and crushing of cobs.

ii. Similarly it is recommended to ensure free movement of the reciprocating sieve before operation. Else, proper adjustment should be made to achieve it.

iii. The position of the hopper on the upper concave should be further lowered so as to attain adequate tangential flow of the maize cob. This will take care of grain splashing at the hopper during operation.

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APPENDIX

PROJECT COST ESTIMATE

The total cost of constructing this thresher is computed from the following costs.

i. Material Cost

ii. Labour Cost

iii. Other Cost.

A. **MATERIAL COST**

This refers to the cost of purchasing raw materials used in the construction of the various parts that make up the machine. The table below indicates a breakdown of the materials used in the construction and their associated costs.

Table 2 : Material Cost Analysis

S/No	Materials	Quantity Required	Specification	Unit Price (₦)	Total Price (₦)
1.	Sheet metal	1 plate	2000x1200x15mm	1200	1,200
2.	Angle iron	1 length	25x25x3mm	400	400
3.	Angle iron	1 length	45x45x5mm	1, 200	1, 200
4.	Square pipe	1length	25x25x1mm	380	380
5.	Flat bar	1 length	1 inch 0.5 inch	100	100
6.	Pulley	3	200mm diametre	500	1, 500
7.	V. belt	2	12.5x1450 A55	250	500
8.	Roller Bearing	2	6305	150	300
9.	Roller bearing	2	6302	100	200
10.	Roller bearing	4	5300	60	240
11	Electrode	1 packet	Standard gauge	1, 000	1, 000
12.	Bolt & nuts	50	Assorted	300	300
13.	Paint	1 tin	Enamel	800	800
14.	Shaft	½ length	20 mm steel rod.	1, 800	1, 800
				Total	₦9, 920

B. **LABOUR COST**

This refers to the money paid to people who have worked in the construction. It was calculated as 5% of the material cost. Thus;

$$\text{Labour Cost} = \frac{5 \times 9920}{100}$$

$$= 0.05 \times 9920$$

Labour cost = ₦496

C. OTHER COST (CONTINGENCY COST)

This refers to the expenses incurred in the cost of construction, which are of contingency in nature other than materials and labour costs. Hypothetically, it was calculated as 5% of the materials cost.

Hence,

$$\text{Other cost} = \frac{5 \times 9920}{100}$$

$$= 0.05 \times 9920$$

other cost = ₦496

D. TOTAL COST OF CONSTRUCTION.

This is the summation of materials, labour and contingency cost. It was computed as below

Total cost = Material cost + Labour cost + Contingency cost.

= 9920 + 496 + 496

Total Cost = ₦ 10,912:00