DESIGN, FABRICACATION AND PERFORMANCE EVALUATION OF A TRACTOR – POWERED MAIZE SHELLER

BY

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M.ENG/SEET/2003/1005

A PROJECT THESIS SUBMITTED TO THE POST GRADUATE SCHOOL, FEDERAL UNIVERSIY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE (M.ENG) IN AGRICULTURAL AND BIORESOURCE ENGINEERING (FARM POWR AND MACHINERY)

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DECLARATION

I hereby declare that this project work was carried out by me under the guidance and supervision of Engr. Dr. D. Adgidzi, of the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna.

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CERTIFICATION

This thesis titled design fabrication and performance evaluation of a tractor–powered maize sheller by ZUBAIRU MUSTAFA M.ENG/SEET/2003/1005 meets the regulations governing the award of the degree of masters of engineering (M.ENG) of the Federal University of Technology Minna, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to my parents.

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ABSTRACT

Techniques for shelling grain crops are still the traditional method of the hand beating method. This method is time wasting, un-economical, and laborious. Most shellers in use in Nigeria are imported and costly, therefore, are not affordable by the small scale farmer. A maize sheller with output capacity of 250.2 kg/hr was designed and constructed. Physical properties of the maize grains such as length of ears, length of breadth of grains, grain/huske – cob ratio and moisture content of grains were measured. The sheller was evaluated for its performance in terms of its shelling efficiency, cleaning efficiency, and percentage grain losses. At an average moisture content of 12.69 % and design cylinder speed of 540 rpm, test results reveal that the sheller has a shelling efficiency of 98.20 %, cleaning efficiency of 97 % and percentage losses of 4.90 %.

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CHAPTER ONE

1.0 INTRODUCTION

The most important post - harvest operation of grain crops is shelling. These consist of the detachment of the grain kernels from the stalk/cob or shell heads (Nkama, 1992). Traditional method of grain shelling in Nigeria is by hand beating with stick or pods on the floor. This method is laborious and the output is low; resulting in delay in handling large volumes of the harvested crops and subsequently leading to losses.

The use of powered shellers has been introduced to overcome these difficulties, but local acceptability has been low; due to the failure of the shellers to reach their rated capacities. The use of engine powered machine and equipment in Nigerian agriculture dates back to the early 1960's following establishment of farm settlements in Eastern and western regions of Nigeria (Chukwu, 1994).

Because of the above factors, there is the need to develop and evaluate performance of a tractor powered shelling machine. The sheller will be able to reduce grain damage, grain losses and improve the quality of the grain crop.

Physical properties of the maize grain such as length of crops; grain length, breadth, grain/husk ration, diameter of gain crops; are some important properties that can affect the design of the tractor powered maize shelling machine. The parameter to be considered for the evaluation will include shelling capacity, cleaning efficiency, visible seed damage and sieve losses.

1.1 Statement of Problem

Lack of locally fabricated shellers in Nigeria made the country to depend mostly on importation of Agricultural machines from different countries. With inherent problems within the machine combination and with local farming systems to non availability of spare – parts, in – adequate provision of power drive units, more-over these shellers are not suitable or met the demand of a Nigerian farmer.

Over seventy percent of Nigerian population are peasant farmers who live mainly in rural areas without access to modern technical facilities and lack adequate know – how and do not have any form of the power supply. Therefore, shellers that can handle the shelling of maize grain crop grown in rural areas with its power supply through a universal source like a tractor become necessary. Shelling is also one of the important operations after post – harvest.

1.2 Justification

There is a general awareness in Nigeria and other developing countries that rapid development of agriculture will depend; on successful introduction of modern indigenous agricultural machinery. Usually during dry season the tractor is left idle i.e. the time when shelling of grain crops is at pick level. During this time, the tractor can be utilized using its (P.T.O) for shelling of maize grains.

1.3 Specific Objective

1. To design and construct a tractor powered maize sheller.
2. To carry out performance evaluation of the machine using maize ears.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 History of Sheller

The need of mechanical shelling of maize has increased. Different maize shellers have been design and fabricated in different parts of the world. A power – operated threshing machine for threshing sorghum grains was developed and tested. The performance test have a maximum threshing efficiency of 95.3% and threshing capacity of 600kg/hr at cylinder speed of about 500rpm and grain moisture content of 14.5% wet basis, (Kebede and Mishra (1990).

A thresher with multi- crop potential, which can handle a wide range of crops, was designed and fabricated by Institute of Agricultural Research (I.A.R) Zaria using locally available materials. The machine can thresh sorghum, wheat, and millet by selection of appropriate speed, concave and sieve size. It uses an 8hp prime mover. It has a threshing capacity of 80kg/hr, 70kg/hrf for wheat, sorghum respectively.

It has threshing efficiency of 98%, cleaning efficiency of 89% grain damage rate of 4% (I.A.R. 1987). A sorghum thresher was also developed at I.A.R, ABU. The machine uses a power source of about 2.5kw for satisfactory operation. The machine has the following performance, threshing capacity of 100kh/hr, threshing efficiency of 97%, cleaning efficiency of 92% and grains damage of less than 1.0% (I.A.R; 1987).

A sorghum thresher was designed fabricated and tested, it was observed that the threshing efficiency increase with an increase in cylinder speed for all feed rates and cylinder concave clearances. Maximum threshing efficiency of 99.9% was obtained at the lowest feed rate of 6kg/h, cylinder concave clearance of 7mm and cylinder speed of 500rpm. Minimum threshing efficiency of 98.3% was observed at lowest cylinder speed of 30rpm and cylinder concave clearance of 1mm at a feed rate of 10kg/min. The thresher was therefore recommended to work effectively with a combination of 6kg/min feed rate, 7mm cylinder concave clearance and 400rpm cylinder speed (Mishra and Desta. 1990).

A maize thresher was designed, fabricated and tested on the field for its general performance. Tests were carried out to determine the effects of cylinder speed on the shelling output, cracking and grains losses of three moisture content levels. It was observed that the rate of shelling increase as the cylinder speed was increased. Grain losses decrease as the cylinder speed increase. While more breakages were recorded at high cylinder speed. It was also observed that the rate of shelling, grain losses and breakages decreases as the moisture content increases. Threshing efficiency decreases with an increase in moisture content. About 96.6% threshing efficiency was obtained at 13% moisture content and highest percentage grain losses was obtained at 15% moisture content, (Mishra and Desta, 1990).

Modification of threshing unit of sorghum thresher was designed, constructed and evaluated for its general performance. The thresher gave maximum threshing efficiency of 90.20% and cleaning efficiency of 90.35% (Komolafe, 2002)

An improved I.A.R multi-crop thresher was developed and tested for its general performance. The thresher gave maximum threshing capacity 237kg/hr and 79kg/hr for sorghum and millet respectively (Yavini, 2002).

A maize Dehusker-Sheller (motorized one) was designed and fabricated using locally available materials and used 3kw power engine for its operations. The machine has the following performance output 400kg/hr, shelling efficiency of 99.5% cleaning efficiency of 90%, grain damages below 1% (Thiestain, 1987).

A tractor operated thresher was designed, fabricated and tested for its performance. It was observed that the thresher has a maximum threshing efficiency of 92.8% and minimum of 91.4% at a cylinder speed of 1100rpm and 600rpm respectively and grain loss of 0.5% (Ghaly, 1983).

A modified I.A.R multi-crop thresher was fabricated and tested for its general performance. The thresher gave a maximum threshing capacity of 270kg/hr and 120kg/hr for sorghum and millet respectively (Musa, 2000).

2.2 Harvesting of Maize

Maize can be harvested at either dry or green, but majority of the maize in West Africa is harvested green for consumption. In many part of the world maize is harvested in green for silage. If maize is harvested green, it has to be harvested as soon as possible after the stick has turn brown. And if it wanted harvested dry, it should be harvested when the stick has completely dried up and the leaves are also dry. In Nigeria, early maize is harvested between May and August and late maize between November and December.

2.3 Different Machine-Crop Variables that affect Shelling

When developing a shelling machine, such parameters like cylinder peripheral speed, type of beaters, concave clearance, range of moisture content of grains to be handled, and grain straw ratio have to be studied. Tandon et al. (1988) studied the interaction of different machine and crop varieties. In order to identify the contribution of each variable they developed prediction equation using step- wise regression analysis.

Tandon et al. (1988) used the step wise multiple regression technique to study the relationship among different independent variables, namely cylinder types, concave clearance, cylinder peripheral speed and moisture content in relation to the two dependent variables, namely shelling efficiency and invisible gain damage on grains. The moisture content was found to have a significant effect on shelling efficiency, and invisible grain damage at 1% level. The effect of concave clearance and cylinder peripheral speed though numerically small was significant at 5% (Tandon, 1988) and the effects are listed as follows:

i. As concave clearance increased, grain damage decrease.

ii. Shelling efficiency increased with cylinder peripheral speed.

iii. The grain damage increased with an increased in the cylinder speed and the moisture content.

iv. The extent of variation in the shelling efficiency by moisture content alone was 63% while the extent of variation in grain damage explained by moisture content alone was 41%.

v. The inclusion of cylinder concave clearance in addition to grain moisture content accounts for 66% and 48% of variation in shelling efficiency and grain damage respectively at 63% and 41% explain by moisture content alone.

vi. The inclusion of concave clearance and cylinder accounted for 68% and 5% variation in shelling efficiency and grain damage respectively, as against 66% and 45% that is explained by moisture content and clearance.

vii. Inclusion of cylinder beater did not account for an increase greater than 1%

Because of finding of Tandon et al. (1988) it can therefore be concluded that moisture content has a high significant effect on shelling efficiency and grain damage. The effect of concave clearance and cylinder speed is also important.

Yunus (1987) identified grain moisture content, grain number, length of grain, weight of 1000 grains, speed of sheller-drum, and sieve aperture are some of the crop machine properties that affect grain losses at harvesting and shelling of paddy in Turkey.

Based on the above mention points, several machine crop parameters influence the performance of a sheller. Some of these parameters are grain moisture content, grain number, grain length, cylinder type, cylinder peripheral speed, concave clearance and size of sieve aperture.

2.4 Sheller Parameters

A lot of work was reported on shellers and combines to determine effect of different parameters on the shelling of different crops. Test reports of some existing shellers give a broad idea about the design parameters of threshers (Hem, 1981).

Herrighton (1970) designed a multi – crop thresher having spike-tooth cylinder and fixed concave on the basis of acceptance of Japanese paddy thresher and American wheat threshers, which used spike tooth cylinders. The clearance was kept at 2.5cm. the losses of paddy and wheat were 3%, the sheller was not suitable for straw making as it is normally reduced wheat straw 25-50% of original length depending upon cylinder speed and moisture condition. The cylinder speed ranged between 1,200 and 1,400m/min resulting in less than 0.1% unthreshed grain and between 8000m/min and 1000m/min resulting in less than 0.1% visible damage. The unthreshed grains were less than 1.0%.

The types of threshers developed and tested by Ramos (1975) are as follows:

I. Single drum no-blowers no separator.

ii. Double drum single blower no separator type

iii. Double drum-single blower with oscillating screen type

iv. Axial flow thresher

v. Single drum blower with oscillating screen type

He found that the capacity of these threshers were 704kg/hr, 250 kg/hr, 148 kg/hr, 936 kg/hr and 249 kg/hr respectively.

Chabbra (1975) developed and tested an axial flow thresher on the basis of drawing procured from IRRI. He found that it can thresh wheat, rice, and sorghum efficiently.

Descriptions of these machines are highly complex and costly. More over the operator must have sound technical experience and the knowledge to operate and maintain them. Again these machines are not in the hand of an average Nigerian farmer.

There is the need for multi-crop thresher, which is simpler in design, easy to operate with little technical knowledge to operate and to be affordable to any Nigerian farmer.

2.5 Tractor Power

Tractors deliver power in several in ways. Pulled or towed implements are powered through the traction of drive wheels and the pull or draft (draught) from the draw bar. Rotary power is obtained from the PTO shaft or from a belt pulley. Both linear and rotary power can be produced by a tractor hydraulic system. Some implement require electric power from tractors. (I.A.R., 1987)

CHAPTER THREE

3.0 METHODOLOGY

The maize sheller consists of the following parts: hopper, shelling drum, concave, sieves, shakers, fan and fan housing, shafts, bearings, belts, pulleys and frame. The sheller is to be powered by a 29.1kw tractor through the P.T.O.

3.1 Analysis of Physical Properties of Maize

The properties of maize with respect to the design of the tractor powered maize sheller were determined as length of grain, gain breadth: grain husk and ratio: grain diameter. The length and breadth of maize grain was used to select sieve hole diameters: the length of ears of maize crop was used to select hopper size and the grain/husk and cob ratio was to determine the theoretical capacity of the sheller. Grain moisture content was also determined by oven dry method at a temperature of 104^{oc} for 24 hours.

All the measurement has been taken in a laboratory in Kaduna Polytechnic at room temperature of 28°C. Following design parameters were established after measurement of the physical properties of the maize grains and a review of some available literatures (Hem, 1981, Ahuja and Sharma, 1989; Food Agency 1985).

A 540rpm was selected for .. cylinder speed, 4.46m/s for blower air velocity, 40mm concave clearance: sieve perforation diameter of maize, Ø18mm, and a power requirement of 29.1kw. Moisture content of the maize grain crop was obtained using the oven dry method at a temperature of 104°C, using the expression.

$$MC = \frac{(W_1 - W_2)}{W_1} \times 100\% \qquad (1)$$

Where: MC= Moisture content of the maize grain

W_1 = Weight of wet grain

W_2 = Weight of oven dry

Table 1: Average moisture content of maize, (%)

S/No	Maize Moisture Content
1.	12.61
2.	12.60
3.	12.57
Average	12.69

Table 2: Some physical properties of maize

S/NO	Length of ears of maize, (mm)	Diameter of maize grain, (mm)
1.	500	2.5
2.	400	3.0
3.	550	3.5
4.	250	4.0
5.	300	2.0
6.	350	3.6
7.	450	4.0
8.	400	2.5
9.	380	3.0
10.	360	3.8
Average	290.4	5.4

The above parameters were necessary and hence used in the design of the tractor powered shelling machine. The machine was designed to ensure that the section of materials, components, and dimension provide adequate strength, stiffness; stability; acceptable corrosion and wear with stipulated service life and load. Also factors influencing operations such as vibration, noise, handling e.t.c. was considered, cost effectiveness to be affordable by the farmers was also observed.

3.2 Design of the components of the maize sheller

3.2.1 Hopper

The hopper was constructed using a 2mm thick metal sheet which is rectangular and trapezoidal in shape having the following dimensions.

Density of mild steel = 7800kg/m^3, size/thickness of metal sheet = 2mm

:. Area of side A, = L x b (2)

= 0.540 × 0.350 = 0.19m^2

Volume of materials of side, VA = Area × Thickness (3)

VA = Area × thickness

= 0.19 × 0.002 = 3.8×10^{-4} m^3

Mass of materials of side A, MA = Volume × density

= 0.00038× 7850 = 2.99kg

Area of rectangular section ABCD = Length x Breath. AB = L x B

= 0.700 x 0.200mm = 0.14 m^2

Volume of the rectangular resection, VBi = Area x thickness

= 0.14 x 0.002 = 0.00028 m^3 = $2.8\text{x}10^{-4}$ m^3

Mass of materials of rectangular section ABCD, MB1 = volume x density

0.00028 × 7850 = 2.2 kg

Therefore, area of trapezium ADEF of the side B.

AB/F = ½ (a + b) x h

= ½ (0.700 + 0.200) x0.350 = 0.16 m^2

Volume of ADEF = VB = Area x thickness

= 0.16 x 0.002 = 3.2 x 10^{-4} m^3

Mass of material of trapezoidal shape ADEF (MB = Density x volume

= 7850 x 0.00032 = 2.51 kg.

Therefore, total mass of side B = Area of rectangular ABCD + Area of trapezoid ADEF. = 2.2 kg + 2.51 kg = 4.7 kg.

Total mass of hoppers = mass of side A x 2 + 2 mass of side B x 2

MA x 2 + MB x 2

= 2.99 x 2 + 2.51 x 2 = 5.98 + 5.02 = 11 kg

Therefore total mass of Hopper is = 11 kg

Mass of crop materials (Grain – crop) can be determined as:

Mass = volume x density

Volume of rectangular portion of Hopper = L x B x h (4)

$= 0.700 \times 0.200 \times 0.350 = 0.05\ m^3$

Volume of trapezoidal portion of Hopper (V_t)

$V_t = ½ (a + b) \times h$ (5)

$V_t = ½ (0.70 + 0.20) \times 0.35 = 1.6 m^3$

Total volume of hopper, $V_T = V_r + V_t = 0.076 + 1.575 = 1.6\ m^3$ (6)

Therefore, Mass of maize = (Mm) = Density of maize x volume of hopper

= 543 x 1.6 = 868.9 kg

Weight of crop material = $W_1 = 868.9 \times 9.81 = 8.52$ kN

Weight of hopper and materials = $M_{TM} (m_t + m_c)$

$= (11 + 868.9) \times 9.81 = 8.63$ KN

3.2.2 Design of the stand (Bars)

The maize sheller is supported by a four 350 x 45 x5 mm mild steel Bars. These bars can collapse due to the weight of the sheller and the crop materials contain inside the sheller, in order that the machine can be safe, to determine critical load, using Euler formula. Then we can compare with the actual load acting on it.

Euler formula for determining buckling is:

$$P_{cr} = \frac{\pi^2 E I}{L^2} \qquad (7)$$

Where, E = Elastic modulus of materials $GN/m^2 = 207 \times 10^2 N/m^2$

I = moment of inertia of materials where $I = \frac{b^3 h}{12}$

P_{cr} = Critical load, (N)

L = Axial length of members (m).

Using the formula: $I = \frac{b^3 h}{12}$

$$I = \frac{0.018^3 \times 0.045}{12} = 2.187 \times 10^{-8} m^4$$

Also, since, $Pcr = 4\pi^2 EI$

Then, $Pcr = \frac{4 \times 3.142^2 \times 207 \times 109 \times 10^{-8}}{0.1369} = 0.065kN$

3.2.3 Source of Power

The tractor powered maize sheller is design to be powered by a tractor. Most common tractors in Nigeria are with power ranging between 60 kw and 90 kw, P.T.O. speed of 540rpm. A tractor of 29.1KW will be used for the design of the maize sheller. Tractor available speed (ω_r) = 540rpm) while the speed at rotor ω_3 = 915rpm. Speed of PTO is to be multiplied to the required speed ratio based on the availability of gears in market.

Two gear wheels with 37 teeth and the pinion with 15 teeth has been selected.

Gear ratio (GR) = $\frac{no \quad of \quad teeth \quad on \quad gear}{no \quad of \quad teeth \quad on \quad pinion} = \frac{37}{15} = 2.47$

Speed at the gear output shaft, $\omega_2 = \omega_1 \times 2.47 = 540 \times 2.47 = 1334$ rpm

Speed at pulley (ω_3) = 915rpm

Speed at output shaft = (ω_2) = 1334 rpm

:. Speed ratio, (V_r) between the pulleys is:

$$\left\{ V_r = \frac{\omega_2}{\omega_3} = \frac{1334}{915} = 1.46 \right\} \quad (8)$$

Drive pulley pitch diameter PDR = 110 mm

Drive pulley diameter PDN can be calculated from the expression.

PDN = PDR (1 – S) V_r

Where S, = Slip factor usually 0.01, Vr = speed ratio of pulley = 110mm

PDN = PDR (1 - S) V_r = 110 (1 – 0.01) 1.46 = 158.9 mm

From above calculation, a 160mm pitch diameter pulley has been selected.

Drive speed (ω_3) = 915rpm, Pitch diameter of driver pulley = 160mm

Speed of agitation pulley (ω_4) = 540rpm

$$PDA = \frac{915x160}{540} = 271\ mm \quad (10)$$

Where, PDA is pitch diameter of a driven pulley

PDA = from equation (3) is obtain as PDA = 271 mm

Hence, the pulley diameter is selected as 260mm.

3.2.4 Selection of Belt

Power can be transferred from one point to another in an Agricultural Machinery, using V-belts (Kepner et al, 1987). The V-belt has so many advantages in power transmission. Its centre distance is smaller; it is more durable and less costly; there is no risk of falling off the pulley. Hence V-belt has been selected for this design.

3.2.5 Horse Power Determination HP

Since rated power of a tractor is = 29.1kw

Service life = 1.6

Designed power = (Pd) = 29.1 x 1.6 = 46.56kw

Belt speed, S = $\frac{3.142 \times 1334 \times 0.11}{60}$ = 7.68 m/s

Therefore, $\beta = \frac{180 - (60(dL - dS))}{L}$

(11) *Where dL = Large pitch diameter = 160 mm*

ds = small pitch diameter = 110 mm

L = distance between shaft centre = 400 m

$$\beta = \frac{180 - (60(160 - 110))}{400} = \mathbf{172.51mm}$$

The length of belt can be determined as follows:

$$L = 2C + \pi\frac{PD_1 + PD_S}{2} + \frac{PD_1 - PD_S}{4C}$$

(12)

L = Length of belt.

C = Centre distance between pulleys = 400 mm,

PD_1 = Pitch diameter of larger pulley = 160 mm.

PDs = pitch diameter of small pulley = 110 mm.

$$L = 2 \times 400 + \pi\frac{160 + 110}{2} + \frac{160 - 110}{4 \times 400} = 1867 \text{ mm} \approx 1.9 \text{ m}$$

Hence as obtained from the nearest belt length is 1224mm.

Therefore, the H – section, was selected, and width of the selected cross- section is = 16.7mm, while the depth = 1033mm.

3.2.6 Determination of Bearing properties

Rating life – Allen et al (1980) report that bearing manufacturer recommended a life of 20.000 hrs to 30.000 hours. For machines in general, in the mechanical industries where machines are fully utilized for eight hours services. It is assumed that the tractor powered sheller falls within this category and should have a rating life of 25000 hours.

Hence, rating life = 25000 hours.

Equivalent load, P can be obtained as follows.

$$P = xvFr + \Psi Fa \qquad (13)$$

Where x = radial factor = 3.3

Rating life (Ln) in revolutions becomes:

$$Ln = Lh \times 60\ (\text{min}) \times 540\ (\text{rpm}) \times \frac{1}{10^6} = 180\ \text{rev.}$$

$$\text{Dynamic load capacity } C = PL^{\frac{1}{p}} \qquad (14)$$

$$\therefore C = 117.58 \times 810^{1/3} = 1096.045\text{N}$$

The least value of, C = 360kg, which has been considered for the selection of the bearing to take care of over loads. For, bearing with inside diameter = 10mm.

Outside diameter = 26mm

.:Data Ψ = 2.31, Fa = 0.

Fr = 5.131 N, x = 3.3, V = 1.0, Ψ =2.31, Fa = 0

Vibrating effect factor F_{Tk}= 1.0 - 1.3.

Dynamic effect in machine factor Fd = 1.0 – 3.0

.: gear force (F.eff) = $F_1\ F_k\ F_d$

F.eff = 5.131 x 1.3 x 1.5 = 10 N

Equivalent load; P = xVFeff + ΨFa = 3.3 x 1.0 x 10 +0 = 33 N

Load capacity C = $PL^{\frac{1}{p}}$ = 33.018 = 31.37kg

3.2.7 Frame

The frame supports the total weight of the machine components. These weights include:

i. Weight of cylinder, blower and cam shaft combined together = 9.54 kg.

ii. Weight of cylinder, cylinder plates, cylinder support and cylinder spikes = 10.56kg.

iii. Weight of three pulleys = 10.76kg.

iv. Weight of housing, assumed to be 0.5 times the sum of weight from (i – iii) = 15.43kg.

v. Weight of hopper = 8.2 kg

vi. Weight of concave = 10.40 kg

vii. Wright of cleaner = 12.30 kg

3.2.8 Frame Design

The frame supports the total weight of the machine components.

For axially and laterally loaded frame the following expression holds:

$$\frac{Fc}{Pc} = \frac{Fbc}{Pbc} < 1 \qquad (15)$$

Where: Fc = actual direct axial stress

Fbc = actual direct bending stress

Pbc = allowable bending stress.

Pc = allowable axial stress.

But, $$Fc = \frac{F}{A}$$ (16)

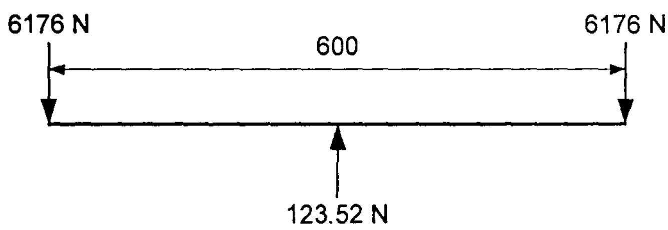
Where, *F* = axial load

A = cross sectional area of the section.

$$Fbc = \frac{M}{Z}$$

(17)

Where, M = moment, Z = sectional modulus.



Assume frame to be rectangular

Fig.1. Frame arrangement

Length, Y = 400mm, breadth, X = 800mm

M_{xx} = 123.52 × 0.3 = 37.06Nm

M_{yy} = 123.52 × 0.225 = 27.79Nm

$$Z_{xx} = \frac{bd^2}{6}$$ (18)

Therefore, $Fbc = \frac{M}{Z} = \frac{37.056}{0.053}$ = *6.99 N/m²* *(899.2)*

3.2.9 Design of Tool Bar

Tool bar is used for coupling of either implement or machine to a tractor Draw – bar. Size can be determined by size of implement or machine, while length is guided by standard recommended by ASAE usually. Tool bar is subjected to a tensile force by the tractor pull at one end and the drafts of implement or machine resisting the pull from the other end.

By the use of Euler's equation, critical load P_{cr} on the bar can be determined. The bar is a hollow section 50 × 45 × 5mm.

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

Where P_{cr} = critical load, N, E = Modules of Elasticity = 207×10^9 GN/m^2

I = moment of inertia = $\frac{B^4 - b^4}{12}$, L = Length of tool bar

But B = 50mm, b = 45mm, length = 900mm.

$$:. P_{cr} = \frac{\pi \times 207 \times 10^9 \times 0.5^4}{0.9^2} - \frac{0.045^4}{12} = \mathbf{5.02 \times 10^{10} \approx 5.02 \times 10^7\ kN}$$

Tensile strength F_s is calculated, as follows:

$$F_s = \frac{P_{cr}}{(B^2 - b^2)}, \quad \frac{N}{m^2} \qquad (19)$$

Where B^2 - Area of squared section, b^2 – area of width section.

$$F_s = \frac{P_{cr}}{B^2 - b^2} = \frac{406591.189}{0.05 - 0.045} = 0.855\ N/m^2$$

3.2.10 Length of Tool Bar

Length of tool bar can be determined by the length of P.T.O drive. According to kepner et al. (1982) standard power take off drive has one point of the universal joint connected to P.T.O shaft and other to the implement shaft. The body of the drive is Telescopic consisting of a sleeve with a square bore and a square machine inside the bore.

It is recommended that the hitch point of the tool bar should be midway between the joints of that angles would be equal for any turning position of the implements with respect to the tractor. ASAE therefore recommended standard dimensions for a P.T.O drive. This arrangement has made it possible to obtain sufficient telescoping action for sharp turns.

From table 3 below, dimension A is the distance from the tractor P.T.O to the hitch point of the draw bar and is 356mm with + 50.58 = 762mm

Table 3: Standard-power-take-off ASAES 203 5204r3141973.

	540r/min	100r/min	1000r/min
Shaft diameter (min)	35	35	45
Dimension, A	356	406	508
Dimension, B	-25 to 127	-27 to + 127	-25 to 127
Dimension, D	125 to 305	153 to 305	2290
Dimension E	Pedestal height should be adjustable for straight line possible with minimum analysis G and H		

3.2.11 **Design of the shaft of the blower (cleaning unit).**

The cleaning unit consists of a pulley at one end and it is supported on two bearing. The values of the power, speed of the blower and pulleys are chosen as 29.1kw, 540rpm and 4.91N respectively.

Forces acting on the shaft are:

a. Weight of pulley

b. Tension of the belt.

The combine effect of these forces will cause:

1. Bending moment, M_b.

2. Torsional moment; M_t (P.T.O) = $\frac{KW \times 9550}{rpm}$ (20)

$$M_{t,} \text{(Torque)} = \frac{29.1 \times 9550}{540} = 514.64\text{Nm}$$

The belt tensions were determined using:

Belt tensions, $(T_1 - T_2) = \frac{100 \times KW}{V}$ (21)

Where, T_1 = tight side tension (N), T_2 = slack tension (N), KW = power transmitted

kW

V = Belt speed (m/s), $T_1 - T_2$ = effective pull (N)

Torque, (M_t) = effective pull x radius = $(T_1 - T_2)$ R

(14)

R = Radius of pulley = 0.0725 m

:. $M_t = (T_1 - T_2) \times 0.0725 = 514.64$Nm

Since = $\frac{T_1}{T_2} = 5$ (Kepner, 1982)

(22)

$T_1 = 5\, T_2$

Substituting equation (11) into $Z_{xx} = \frac{bd^2}{6}$ we get:

$$(5T_2 - T_2)\, 0.0725 = 514.64$$

(23)

$$T_2 = \frac{514.64}{0.29} = 1774 \text{ N} = 1.77 \text{ N}$$

Since $T_1 = 5T_2$

From e equation (11) and substituting the value of T_2 we get

$T_1 = 5\ (1774.621) = 8.87$ kN

Therefore, Total pull = $T_1 + T_2 = 1.77 + 8.87 = 10.64$ kN

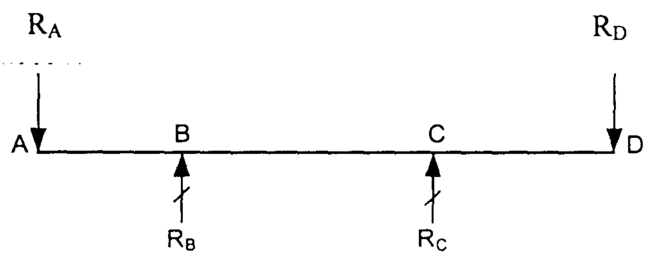


Fig.2. Free body diagram of shaft of cleaning unit

Reactions at points B & C:

$\Sigma M_{RB} = 0$

Considering vertical forces:

$- 4.905 \times 0.01 + RBO - RC \times 0.6 + 4.905 \times 0.63 = 0$

$RB = 0.04905 + 3.09051 - 0.6\ Rc = 3.1392 - 0.6Rc$

$$R_C = \frac{3.1392}{0.6} = 5.232\ \text{N}$$

Summation of vertical forces:

$\Sigma f_y = 0$

$R_B = 9.81 - 5.232 = 4.58$ N

Now, shearing force can be calculated, as follows:

At point, D, $S_{DC} = 4.905$ N

$SCB = - 4.9 + 5.23 + 4.58 = 4.9$ N

Now, bending moment can be determined, as at point, A, Bm = as follow:

At point B, $Bm = - 4.9 \times 0.01 = -0.049$ Nm

At point C, $Bm = - 4.9 \times 0.61 + 4.58 \times 0.60 = - 0.24$ Nm

At point C, B_m = -100.48 × 0.061 + 10214.67 × 0.6 = 6122.67 Nm = 6.122 kNm

At point D, B_m = - 10047.72 × 0.63 + 10214.674 × 0.62 + (-166.9496×0.02)

= 12659.823Nm. (-6330.06 + 6333.09 – 3.34 = - 0.34 Nm)

Similarly, resultant bending moment becomes:

At point B, Bm $= \sqrt{(-0.049)^2 + (-10047.72)^2}$ *= 10047.7 Nm = 10.05 kN*

Now, shaft diameter can be determined using the expression.

$$d^3 = \frac{16}{\pi Ss}\sqrt{(K_t m_t)^2 + (K_b m_b)^2}$$

(24)

But Ss = shearing stress = 40 x 10^6, MN/m^2

$$d^3 = \frac{16}{\pi \times 40 \times 10^6}\sqrt{(1\times 514.64)^2 + (1\times 477)^2}$$

d^3 = 0.00006754 (0.00008933)

d = 0.04057m = 40.57mm (0.0447m) = 44.7mm

Therefore, the diameter of the shaft of this unit selected is 45mm in diameter.

3.2.12 Design of the shaft of the Shelling unit

The shaft has a cylinder which passes through the centre of the cylinder with some spikes teeth attached to the cylinder throughout its body and it is supported by two bearings with a pulley attached to one of its end. All dimensions in mm.

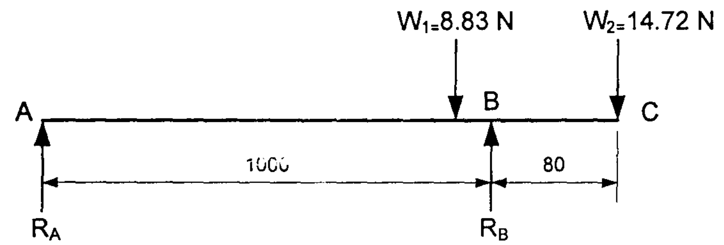


Fig.4. shelling shaft load distribution

A point B, BM $= \sqrt{(-0.4905)^2 + (-100.477)^2} = 100.48$ Nm

At point C, Bm $= \sqrt{(-0.24525)^2 + 0^2} = 0.25$ Nm

At point D, Bm $= \sqrt{(-0.14715)^2 + 0^2} = 0.15$ Nm

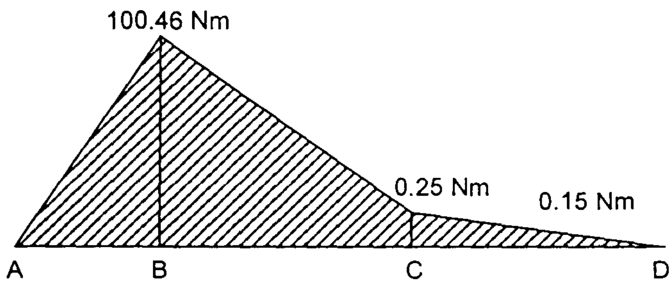


Figure 6: Bending moment diagram

From the above diagram the following holds:

Maximum bending moment Mb (Max) = 100.48Nm

Therefore, shaft diameter can be determined as follows:

Using the following the diameter of the shaft can found:

$$d^3 = \frac{16}{\pi Ss}\sqrt{(K_t m_t)^2 + (K_b m_b)^2}$$

Where, K_t = combined shock and fatigue applied to torsional moment

Mb = Maximum bending moment = 100.48Nm, Ss = shear stress = 40×10^6 Mn/m^2

M_t = Torsional moment = 514.64NM, K_b = combined shock fatigue applied to bending moment = 1.0

$$d^3 = \frac{16}{\pi \times 40 \times 10^6}\sqrt{(1\text{x}514.64)^2 + (1\text{x}100.477)^2}$$

$$d^3 = 6.6593 \times 10^{-5}$$

$$d = 0.04056 \text{ m} = 40.56 \text{ mm}$$

Hence, shaft diameter of 45 mm has been selected for this design

3.2.13 Design of shaft of transmission unit

Forces acting on the shaft are:

1. Weight of the pulley
2. Tension of belt.

Combine effect of these forces will cause the following

1. Bending moment, M_b
2. Torsional moment, Mt

The following calculations give.

The Belt tension pull becomes: $T_1 - T_2 = 1000x\frac{KW}{V}$

Where, T_1 = tight side tension (N), T_2 = Slack side tension (N), KW= transmitted power (kW)

T_1-T_2 = effective pull (N).

Torque = pull × radius.

Mt = (T_1-T_2) R

(25)

Where, R = radius of pulley =153 mm

M_t = torsional moment =514.64Nm

(T_1-T_2) × R = M_t

(T_1- T_2) × 1.525 =514.64

But

T_1/T_2=5 (Kepner et al.)

T_1 = 5T_2

Substituting equation (22) into (23) we get;

1.53 = (5T_2–T_2) × 1.53

T_2 = 1.53/6.1 = 0.25N

But T_1 = 5T_2= 5 × 0.25 = 1.25N

Total pull = $T_1 + T_2 = 1.25 + 0.25 = 1.5N$

Fig7.Free body diagram of shaft of transmission unit

$= \Sigma M_{RB} = 0$

$3.05 \times 0.01 + R_B \times 0 - R_C \times 0.6 + 3.05 \times 0.63 = 0$

$R_C = 1.952/0.6 = 3.3$

Summation of vertical forces

$\Sigma f_y = 0$

$R_B + R_C - 3.05 - 3.05 = 0$

$R_B = 6.1 - 3.253 = 2.85$ N

Sharing force

At point, D

$S_{DC} = -3.05N$

$S_{CB} = -3.05 + 3.253 = 0.203N$

$S_{BA} = -3.05 + 3.253 + 2.847 = 3.05N$

Bending Moment, at point A; Bm = 0

At point B ; Bm = $-3.05 \times 0.01 = -0.0305N$

At point C; Bm = $-3.05 \times 0.61 + 2.4847 \times 0.600 = -0.37$ N

At point D; Bm = $-3.05 \times 0.670 + 2.847 \times 0.620 + 3.253 \times 0.02 = -0.0913N = -0.208$ N

Now, considering horizontal loading caused by tension of belt

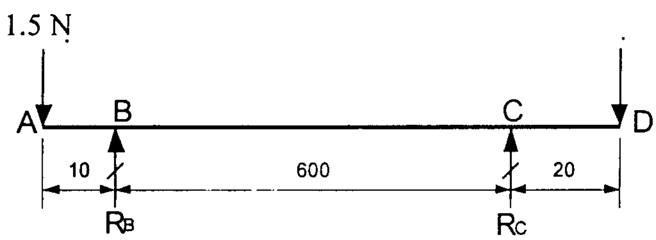


Fig.8. Transmission shaft load distribution (Belt Tension)

Taking moment about C, we get

$\Sigma MR_C = 0$

$R_C \times 0 + R_B \times o.6 - 1.5 \times 0.61 = 0$

$R_B = 1.525$ N

Summation of vertical forces

$\Sigma f_y = 0$

$R_B + R_C - 1.5 = 0$

$1.525 + R_C = 1.5$

$R_C = 0.025$ N

Now shearing force can be obtained as follows:

Shearing force at;

$S_{DC} = 0$

$S_{CB} = 0.984N$

$S_{BA} = 0.984 + 1.5 = 2.48N$

Therefore bending moments at the following points are as follows;

At point A; Bm = 0

At point B; Bm = -1.5×0.01 = - 0.015Nm

At point C; Bm = -1.5 × 0.61 + 2.847 × 0.6 = 0.79Nm

At point D; Bm = 1.5 × 0.01 = - 0.015Nm

Resulting bending moment at point B will be

$$Bm = \sqrt{(-0.0305)^2 + (-1.5)^2} = 1.5003Nm$$

Therefore, Mbmax = 1.5 Nm

Shaft, diameter can be calculated as given below;

$$d^3 = \frac{16}{\pi Ss}\sqrt{(K_t m_t)^2 + (K_b m_b)^2}$$

Where Ss = Shearing stress; K_b = combined shock and fatigue applied to bending moment.

$$d^3 = \frac{16}{\pi \times 40 \times 10^6}\sqrt{(1 \times 514.64)^2 + (1 \times 100.477)^2} = 0.000066754$$

d = 0.04057m

A shaft of 45mm has been chosen for the shaft of the transmission unit.

3.2.14 Design of Cylinder Speed

Food agency (1995) reported rotating speed can be determine as fellows:

$$N = \frac{S}{\pi D} \qquad (26)$$

Where, N = Cylinder rotating speed = 371.25 rpm

S= Cylinder peripheral speed

D = effective drum diameter

But,

Effective drum diameter, D = shelling drum diameter + height of teeth/length.

Also height of teeth= 80 mm (chosen)

Effective drum diameter = 200 + 80 = 280 mm.

Speed from tractor = 540 rpm (selected)

Hence, speed of cylinder can be determine from this equation the given equation:.

$$\frac{PDR}{PDN} = \frac{PRMN}{RPTN}$$

(27)

Where, PDR = Pitch diameter of drive pulley = 160mm

PDR pitch diameter of driven pulley = 110mm

RPMN = Speed of cylinder pulley

PTN = Speed of tractor = 540rpm.

From equation (2):

$$\frac{PDR}{PDN} = \frac{PRMN}{RPTN}$$

RPMN = 540rpm, PDR = 0.160mm

Also, diameter of cylinder drum = 200mm.

$$\therefore \text{Speed of cylinder} = \frac{\pi \times 2 \times 371.25}{60} = 38.88 \text{ m/s}$$

3.2.15 Cylinder – Blower Belt

For an adequate separation of grain from trash and other foreign materials, air velocity must be less than the terminal velocity. The following are the parameters associated with the cylinder – blower belt.

Speed of cylinder shaft (N) = 540 rpm

D = diameter of blower = 0.20m

$$\textit{Blower velocity (Vb)} = \frac{\pi DN}{60} = 5.7\text{m/s}$$

Speed ratio is given as:

$$\frac{PDR}{PDN} = \frac{RPMN}{RPMR}$$

Where,

PDR = pitch diameter of the drive pulley (cylinder)

PDN = pitch diameter of the drive pulley (Blower) = 0.110mm

RPMN = Speed of the blower pulley

RPMR = speed of the cylinder pulley

Let PDR = 0.160 mm

And RPMR = 540 rpm

Thus substituting in the above we get:

$$\frac{0.160}{0.110} = \frac{PRMN}{540}$$

$$\text{RPMN} = \frac{0.160 \times 540}{0.110} = 785.45\text{rpm}$$

3.2.16 Angular Velocity of Cylinder–Blower Pulleys

Let angular velocity of cylinder pulley be = ω_3 and angular velocity of blower pulley be ω_4. Expression of angular velocities is given as.

$$\omega_3 = \frac{2\pi N_3}{60} = \frac{2\pi \times 540}{60} = 56.56 \text{ rad/s}$$

$$\omega_4 = \frac{2\pi N_4}{60} = \frac{2\pi \times 371.25}{60} = 38.9 \text{ rad/s}$$

3.2.17 Power on Cylinder–blower pulley

The power needed to operate the blower is found as follows:

$$\text{Power} = Tc\,\omega_3 = R_3\omega_3^2,$$

Let Tc = torque on cylinder, i.e. Tc = $\omega_3 r_3$

Power derived by cylinder pulley, $Pc = \frac{56.6^2 \times 0.160}{2} = 256.3$ w.

At an of efficiency 85%, $Pc = 256.3 \times 0.85 = 217.86$ W

∴ Power required to operate the blower:

$$P_b = \omega_4 = \frac{PDN}{2} = 38.9 \text{ x} \frac{0.110}{2} = 2.14 \text{ w}$$

3.2.18 Centre distance of cylinder – blower pulleys

The centre distance (CD) between the two pulleys is calculated as given:

$$CD = \max(2R, 3r + R) \quad (28)$$

Where r = radius of blower pulley = $\frac{110}{2}$ = 55 mm

R = radius of cylinder pulley = $\frac{160}{2}$ = 80 mm

Therefore,

$$CD = \max(2\times80, 3\times55+80) = \max(160, 245)$$

From equation (24) two centre distances can be obtain but the larger one be chosen as shown below:

Let, CD = 245 mm

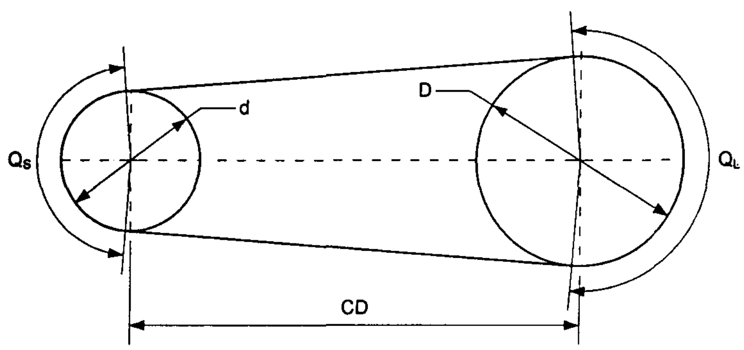


Figure 9: Angle of rap of blower and cylinder pulley

Where, Q_{RC} = angle of rap of cylinder pulley

Q_{RB} = Angle of rap of blower pulley

$$Q_{RC} = \pi + 2\sin^{-1}\left(\frac{160-110}{2x245}\right) = 14.86^o$$

$$Q_{RB} = \pi \sin^{-1}\left(\frac{160-110}{2x245}\right) = 18.40^o$$

Length of cylinder – Blower belt

Expression for length of open V-belt is as given as

$$L = 2CD + \frac{D+d}{2} + \frac{(D-d)^2}{4CD} \qquad (29)$$

Where, D = 160mm, d = 110mm

CD = centre distance between cylinder and blowers pulley.

Then, by substitution, we obtain

$$L = 2x245 + \frac{160+110}{2} + \frac{(160-110)^2}{4x245} = 627,55 \text{ mm}$$

Therefore, corrected belt length =627.55 x 0.84 = 527,142 mm

Surface speed of cylinder – Blower Belt

Circumference of large pulley = 160 mm

Circumference = $2\pi r_3$ =

$$2\pi\frac{160}{2} = 502.72mm$$

But speed = 540rpm

Length covered per second of rotation = 8.0 × π 160 = 4021.76 mm/s = 4.02 m/s.

Then, for Small pulley, diameter = 110mm = 0.11m.

Circumference = $2 \pi r = 2\pi\frac{110}{2} = 345.62$ mm

But speed = 540rpm = 9rps

Length crossed per second of rotation = 10.2 × 110 ×π = 3525.32 mm/s = 3.53 m/s.

3.2.19 Cylinder – blower belt configuration

For a blower to operate for a maximum of 12 hours/day falls under light duty load and service factor K = 0.85

Design horse power = $\frac{design\ horse\ power}{service\ factor} = \frac{29.1}{0.85} = 34.24$ kw

But 1KW = 0.8hp

Design Horse power = 34.24 × 0.8 = 27, 4 hp

From values of design horse power and that of speed of the blower, place the belt in "A" section $K_L = 0.84$, $K_{Q3} = 1.0$

Therefore, corrected horse power = K_{Q3} x K_L × design hp = 1 ×0.84×27.4hp = 23.02 kW.

3.2.20 Blower flow plate (winnower)

$$\frac{PDR}{PDN} = \frac{RPMN}{RPMR}$$

Where, PDR = pitch diameter of blows pulley (driver).

PDN = pitch diameter of winnower pulley (driver).

RPMN = speed of winnower pulley (90mm).

RPMR = speed of blowers pulley.

Substituting into equation 25 above, we get:

$$\frac{110}{90} = \frac{RPMN}{540}$$

RPMR = 660 rpm ≈ 11 rps

3.2.21 Angular velocity of Blower – Winnower pulley

Let us assume angular velocities of blower and winnower pulley to be ω_5 and ω_6.

$$\omega_5 = \frac{2\pi N_5}{60} = 82.3 \text{ rad/s}$$

3.2.22 Power on Blower – Winnower Pulleys

Torque on the blower pulley to accelerate the winnower;

Let $T_C = \omega_5 \text{ x } r_5$.

Power = $T_C \times \omega_5 = \omega_5^2 r_5$

Therefore power delivered by blower pulley will be

$$p_c = \frac{82.3^2}{2} x0.110 = 372.5 \text{ w}$$

At efficiency of 85%,

$$P_c = 372.5\frac{85}{100} = 316,63 = 316.63 \text{ w}$$

3.2.23 Centre Distance of Blower – Winnower Pulleys

Centre distance is given as CD,

CD = max (2R, 3r $\pm$ R)

Where r = radius of winnower pulley = $r_6 = \frac{90}{2} = 45mm$

R = radius of blower pulley = $r_5 = \frac{110}{2} = 55mm$

CD = Max (2 × 55, 3 × 45+55)

= Max (110, 190)

$\therefore$ CD = 190 mm

3.2.24 Angle of Rap of Blower – Winnower Belt

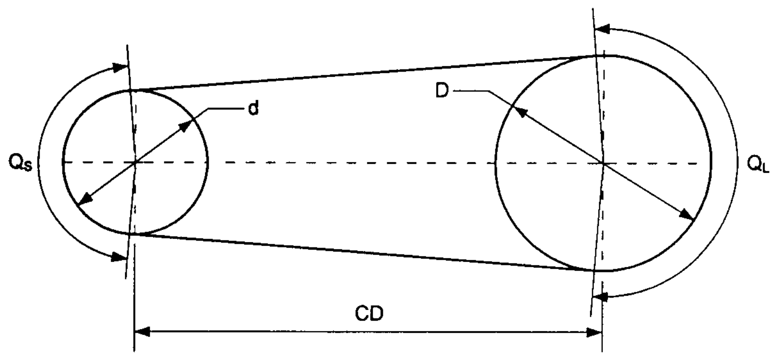


Figure 10: Angle of rap of Blower-winnower pulley

Q_L = angle of rap of blows pulley

Q_s= angle of rap of winnower pulley.

$$Q_L = \pi + 2\sin^{-1}\left(\frac{120-90}{2x245}\right) = 10.16^\circ$$

$$Q_S = \pi \sin^{-1}\left(\frac{120-90}{2x245}\right) = 11.03^\circ$$

3.2.25 Length of Blower – Winnower Belt

Length, $L = 2CD + \frac{D+d}{2} + \frac{(D-d)^2}{4CD}$

$$L = 2x190 + \frac{110+90}{2} + \frac{(160-110)^2}{4x190} = 480.53 \text{ mm}$$

From Appendix R, $K_L = 0.90$

∴ Correct length = 0.90 × 480.53 = 432.48 mm

3.2.26 Surface speed of belt

On the large pulley,

Circumference of large pulley $= 2\pi\frac{160}{2} = 502.72mm$

Speed = 540rpm = 9rps.

Then, the belt will move at the same speed on the pulley at its pitch diameter.

Length covered per second of pulley rotation = $0.160\times\pi\times9 = 4.5$ m/s

Also, diameter of smaller pulley, d =110 mm.

Circumference = $2\pi\frac{110}{2} = 345.62mm$

Length covered per second of pulley rotation will be = $0.110 \times \pi \times 9 = 3.11$ m/s

3.2.27 Belt Configuration

A winnower that operates for a maximum of 12hrs/day falls under a heavy duty load;

Therefore, K = 1.3.

Designed horse power = 29.1 x 1.3 = 37.83 hp

But, $K_{øS} = 0.95$, and $K_L = 1.0$.

Therefore, the corrected horse power = $K_{øS} \times K_L \times$ Designed horse power.

$$= 0.95 \times 1.0 \times 37.83 = 35.94 \text{ hp}$$

Hence, number of belts = $\frac{design\ horse\ power}{corrected\ horse\ power} = \frac{37.84}{35.94} = 1.053 = 1$

Therefore, only 1 belt of this configuration can be used.

3.2.28 Selection of Telescopic Shaft

A telescopic shaft with its two universal joints is called power take off drive (Kepner et at 1982). It can transmit power from the tractor P.T.O to the implement. It is a standard component of the machine which is selected based on the torque to be transmitted.

The torque to be transmitted by the telescope shaft is the torque transmitted by the tractor P.T.O. which is calculated as follows.

$$\text{Torque (P.T.O.)} = \frac{KWx9550}{rpm} \tag{30}$$

Where, KW = power developed by the tractor = 29.1 kW,

rpm = speed of the P.T.O. = 540 rpm.

$$\therefore \text{ Torque } (M_t) = \frac{29.1x9550}{540} = 514.64\,\text{Nm}$$

The telescope shaft will be subjected only to torsional stress. And the diameter of the shaft can be calculated by the use of this formula.

$$\text{Ss (allow)} = \frac{16M_t}{\pi d^2} \tag{31}$$

Where, Ss = allowable stress = 40 MN/m^2

Mt = moment torque = 514.64 Nm.

d = shaft diameter, mm

$$\therefore d = \sqrt[3]{\frac{16\,x\,514.64}{\pi\,x\,40\,x\,10^6}} = 0.0403m = 40mm$$

Hence, a telescopic shaft of 45mm diameter was selected for the sheller.

3.2.29 Blower

Blower is a device which propels air continuously against the pressure loss of a closed circuit system in which the ambient atmosphere may be a component. Blower circuit will consist of the following:

1. Casing/housing which controls and direct the general air flow.
2. Rotor or a rotating member.
3. Shaft through which power can flow.

Vanes of the rotor impact energy to the flow by venture of pressure forces in their surfaces which are undergoing a displacement as rotation takes place. When selecting a blower, few considerations are necessary:

1. Type of blower (fan) required,
2. Volume flow rate and weather any variation is required,
3. Density of air to be moved,
4. Type of drive and height of the drive from the cylinder shaft.

A straight bladed type of radial flow blower (fan) some times called paddle wheel types of blower can be used for this design. It can operate in an environment containing dust particles that may occur during shelling process.

Therefore, area of each paddle = $0.8 \times 0.1 = 0.08\ m^2$

Metal sheet thickness = 1.0 mm

Volume = $0.08 \times 1 \times 10^{-3} = 8.0 \times 10^{-5}\ m^3$

Total volume of the blades gives us:

Total volume = $3 \times 8.0 \times 10^{-5} = 2.4 \times 10^{-4}\ m^3$

Material used is mild steel and its density is = 7550 kg/m^3, blower length = 0.8 m.

Max = $7850 \times 2.4 \times 10^{-4} = 1.9kg$

Weight of blower/fan paddles = $1.9 \times 9.81 = 18.64$ N

Therefore, Load = $\frac{weight\ of\ blower}{length\ of\ blower} = \frac{18.64}{0.8} = 23.3\ N/m$

By taking into consideration a factor of safety (K) = 1.5

Then the load becomes:

$$Load = 23.1 \times 1.5 = 34.65\ N/m.$$

3.2.30 Bevel Gear Selection

Toothed bevel gears are used to transmit power between shafts located at a certain angle to each other. It is mostly used for drives with axis intersecting at an angle of 90^0. The straight bevel gear system which is the most common in use in Agriculture machines was selected and used (Hall et al., 1980).

3.2.31 Tractor parameters

The speed from the tractor P.T.O. Shaft is 540 rpm. The speed required at the spreading mechanism is about 100 rpm therefore; the P.T.O. speed has to be stepped up. The following gear wheels have been selected:

For driving gear wheel, the number of teeth = 37

For driven pinion gear the number of teeth =15

3.2.32 Design of Tyre and Spindle

Modern tractors and self propelled machine are equipped with rubber tyres which have more advantages than steel wheels. They reduce power requirement, decrease fuel consumption, permit higher speed and reduce vibration, noise and dust.

Generally, tyres used on farm fall into three categories mainly traction, steering and implement tyres. Implement tyres which are designed to support the weight of the implement and provide the least amount of rolling resistance has been selected for this design.

3.2.33 Tyre Size

Added to the selection of tyres according to the types of thread or ribs, tyres are selected according to size. Tyre size is designated by cross sectional diameters and the diameter of rims (Smith and Wilkes 1980).

A tyre size designated as 13.638 mean that the tyre cross sectional diameter is 13.6 mm and a rim diameter of 38 mm.

Major factors to be considered in the choice of tyres are the weight to be carried by the machine or implement.

3.2.34 Weight of the maize Sheller

Total weight of the machine to be carried on the wheels determines the size of the wheels to be used. Bossoi, (1988) gave the following as the formula for the calculation of the total mass of the machine as follows:

$$Msr = M_m + M_H + M_c + M_B + B_i + M_f + M_o \quad (32)$$

Where, Msr = total mass

M_m, M_H, M_c, M_B, M_i, M_f and M_o are the masses of the machine, fuel, lubricant, water, instrument, filling materials, (seeds seedlings, crop materials etc.) and service personnel respectively.

For the sheller, the above formula has been modified as follows: $Msr = M_m + M_c$

Where Msr = service mass (total mass), Mm = mass of machine,

Mc = mass of crop materials = 8.99 kg

The modified Formula now becomes: Msr =Mm + Mc (33)

But,

Mass of machine (Mm) = (Mt + Mcc + Mp + MBC + Mcon + Mclean + Mcc + Mh)

Where, Mt = mass of hopper = 10.96kg.

Mcc = Mass of cylinder, cylinder plate, cylinder support and cylinder spikes, = 10.05kg, Mcbc = mass of cylinder, blower and cam shaft together = 9.06kg, Mp = mass of all pulleys = 9.2kg, MBc = mass of blower and camshaft = 7.6kg, Mcon = mass of concave = 10.8kg, Mclean = mass of cleaner = 12.5kg, Mh = mass of housing assumed to be $\frac{1}{2}$ times sum of (Mcc +mcbc + Mp) = $\frac{1}{2}$(10.05 + 9.06 + 9.2) = 14.38 kg

$\therefore$ Total mass of machine (Mm) = 10.96 +10.05 + 9.06+9.2 + 7.6 + 10.8 +12.5 +14.38kg = 84.55 kg.

Therefore, from equation (29) the total mass (m_{sr}) now become = Mm + Mc = 84.55 kg + 8.99 kg = 93.54 kg

Therefore, the load on the two tyres = 93.54x9.81 = 917.63 N

Therefore, the load on each tyre = $\frac{917.63}{2} = 458.82N$

Tyres size = 4.00 -12= 8.0

Tyres cross sectional diameter = 124 m^2

Rim diameter = 412mm

Tyre pressure = 190kpa

Ply rating = 4 have been selected, for this design.

3.2.35 Design of Spindle

Hopper, wagon, and other load carrying implements tyres are normally carried on axes. Based on the arrangement of components of the tractor powered maize sheller, the use of axel will affect the shelling of the crop. Hence a short spindle was made which consist of a bracket for attachment to the frame with the help of some bolts.

P.T.O power is required from the engine to operate the machine and can be computed as follows:

P.T.O = a + bw + cf (34)

Where, P.T.O. = Power take off required by the machine, w = machine working width = 1 m.

f = material feed rate = 1 ton, a, b, and c are machine specific parameters.

But a = 0, b =0, c = 0.2

$\therefore$ *The power required at the P.T.O.* $= 0 + 0 \times 1 + 0.2 \times 1.3208 = 2.64 \times 10^{-4} W.$

3.2.36 Height of fall

Height of fall of the crops can be determined as follows:

Terminal velocity of maize (v) = 5.23 m/s (Paul et al 1993)

Therefore height of fall can be determined has follows

$V^2 = U^2 + 2gh$

Where, v = terminal velocity of maize, m/s.

u = initial velocity = 0 m/s

g = acceleration due to gravity, m/s

h = height of fall, m

$$\therefore h = \frac{v^2}{2g} = \frac{5.23^2}{2x9.81} = 1.39m$$

Therefore height of fall of grain h = 1.4 m.

3.2.37 Component of the shelling unit

The components of the shelling units include cylinder, cylinder end plates and steel spikes.

The volume of the shelling unit is found as follows"

Diameter of shelling unit shaft (d) = 300mm

Length of shelling unit shaft (L) = 600mm

Thickness of shaft (t) = 1mm

Volume $(V) = 2\pi rlt = 2\times3.14 \times 0.150 \times 0.600 \times 0.001 = 5.6 \text{ x } 10^{-4} \text{ m}^3$

Density of steel is = 7800 kg/m^3.

$\therefore$ Mass of the shelling unit becomes = $\rho \times V = 7800 \times 5.66 \times 10^{-4} = 4.4$ kg

3.2.38 Cylinder end plate

Two end plates has been used which is made up of mild steel sheet of the following specification.

Diameter of end plate = 300 mm, Thickness of end plate= 1mm

Volume of cylinder (Vc):

$$V_c = \pi r^2 t = 3.14(0.150)^2 0.001 = 0.000070695 = 7.07 \, x \, 10^{-5} \, m^3$$

A hole of 30 mm was made at the centre of each plate to allow the shaft to pass through and which rotates freely while in operation. Therefore, in order to obtain the volume of each plate, the following formula was used:

Volume of hole (Vh): $(V_h) = \pi r^2 t = 3.14(0.015)^2 0.001 = 7.06x10^{-7} m^3$

Hence, volume of each cylinder end plate = volume of plate – volume of hole

$= 7.07 \times 10^{-4} - 7.06 \text{ x} 10^{-7} = 7.06 \times 10^{-4} \text{ m}^3$

Mass of cylinder plate is found as follows:

$Mcp = 2 \ (volume \times density) = 2 \ (7.06 \times 10^{-4} \times 7800) = 11.03 \ kg$

3.2.39 Spikes on the cylinder

Ahuja and sharma, (1989) established spike spacing for their manually operated thresher at 30-50mm, while most existing thresher/shellers have one legged spike. In this design work, one-legged spike of 80 mm × 120 mm spacing was used. The spikes is made of mild steel with height h = 55 sin 60° = 47.63 mm, Diameter of spike = 6mm, length = 55 mm.

Volume of each spike = $\pi r^2 l = 3.142.0.003^2 x0.055 = 1.6x10^{-6} m^3$

Therefore, mass of each spike becomes:

$\therefore$ Mass of each spike (Ms) = volume × density = $1.6 \times 10^{-6} \times 7800 = 0.012$ kg

3.3 Materials Selection, Construction and Principles of Operation

The materials for the construction were source locally. Some of the materials were fabricated in the workshop; while some are standard component and therefore purchased directly based on the specification from the design calculation.

Table 4 gives the break down of the components, the materials specification; Quantity and price used in the construction.

Table 4: Break down of the constructional materials and specifications

No	Component Type	Materials for construction	Specification	Qty	Unit price	Amount (NN)
1	Hopper	Metal sheet	Gauge 18	1	1000	1000
2	Hopper support bar	Flat steel section	50x50x50m	1	500	500
3	Mainframe	Hollow steel section	50x50x2mm	1	1000	1000
4	Threshing unit,	Mild steel shaft		0		
	Cylinder shaft	Mild steel flat bar		1	200	2000
	Cylinder	Mild steel iron rod		1	300	300
	Spikes	Mild steel sheet	Gauge 16	20ps	500	1000
	Cylinder cover	Mild steel rod	Ø 8mm	1	500	500
	Concave	Ball bearing	FSP 205	1	1500	1500
	Bearing					
5	Blower unit	Mild steel shaft	Ø 22	7	150	1050

	Blower shaft Blower blades Blower housing Bearing	Mild steel metal sheet Mild steel metal sheet Ball bearing	Gauge 16 Gauge 16	1 3 2 2	2000 200 500 150	2000 600 1000 300
6	Cleaning unit Top sieve Bottom sieve			 1 1	 250 250	 250 250
7	Tyre spindle	Solid shaft	Ø 40mm	1	1000	1000
8	Tool bar	Hollow steel section	50x50x3mm	1	700	700
9		Rim, tyre and tube	Standard	2 set	1600	3200
		Bearings	Standard	8pcs	150	1200
		Bold and Nut	Standard	4 pcs	15	300
		Metal sheet	Mild steel	7	2500	5000
		Solid shaft	Sheet	2	1000	2000
		Flat bar	1000 x 45	1	400	400
		Telescopic shaft	310 x 50 x 1	1	5000	5000
		Welding electrode	Standard	1	800	800
		Pulley Ø 90	1 pkt	1	500	500
		Pulley Ø 110		1	700	700
		Pulley Ø 150		1	800	800
		Pulley Ø 180		2	900	900
		V – Belt (A		2	200	400
		V – Belt	A 57	1	150	150
		Paint (Light Blue)	A 41		1000	1000

		Welding			300	300
		TOTAL				**N40,300.00**

3.3.1 Labour Cost

It is recommended that 30 % costs of materials should be considered as labour cost.

Total cost of materials was found to be N 40, 300.00

Therefore, labour cost = $40,300\frac{30}{100} = \text{N}12,090:00$

Miscellaneous cost involves cost of transportation of the machine, taking of photograph of the machine and diesel used which amounted to N5, 000.00.

3.3.2 Standard Component Purchased

NAME	UNIT
1. Telescopic shaft	1
2. Bearing 6psc	6
3. Pulleys 3psc	3
4. Bolts 20psc	20
5. Bolts with nuts (various sizes)	15

3.3.3 Construction Method

The cylinder was constructed using a 30mm mild steel shaft. Each end of the shaft was machine to fit the bearing diameter. A key, 130 mm in length on each end carrying pulleys was produced. 50 shelling spikes, 50 mm in length were also constructed. The spikes were properly bolted at 500 mm spacing along the length of the rotating cylinder. 300mm diameter of a flat plate was machine out at centre hotels to allow the shaft to pass through. The shaft was then inserted through the cylinder and attached to the bearings at both ends. Finally the shaft was welded to the drum.

Concave. Here 8mm steel rod and 38 mm flat bar were used. Three pieces of 510.5 mm flat bar was cut out. It is then formed into a semi – circle. The concave was then line up longitudinally with 8mm mild steel rode with a 30 mm spacing between. It is then fixed to the frame.

Frame: Material used is 50 × 50 mm mild steel angle iron. The main frame was structured, forming an angle of 90^0 on each ends and joined at all points. It was given a temporary adjustment.

Shelling space and hopper. Here the materials used are gauge 16 mild steel sheet measuring 378.5 mm x 708 mm mild steel sheet to form the upper cover of the drum. A 260 mm x 330mm was cut-out to form the rectangular portion of the hopper. A 300mm x 300mm square portion was made, to pave ways for insertion of the hopper. Also a 200 mm x 200 mm mild steel was bend to form the lower part of the hopper. The lower part of the hopper was then welded to the frame.

Blowing unit: A 16 mild steel gauge was used. A 23 mm mild steel rod, 340mm in length and was cut-out to form the blower shaft. The shaft was machine at its end to allow insertion of bearings at its end and at a specified diameter. A key way was also made at the end of the shaft. Three pieces 16 mild steel gauge measuring 160 mm × 680 mm were cut according to the perceived shape. Cut out also at the centre of each involutes to serve as air inlet into the blower was a circle, 180 mm in diameter. The blower housing was then cut-out according to specifications.

Winnowing unit: A 16 mild steel sheet gauge was used. A hole 18 mm in diameter was bore at the centre of the sheet metal to form sieve plate

Drive: - The machine is equipped with V- belt pulley and drive mechanism. The pulleys and bevel gears are incorporated in the drive mechanism to transmit the power from the P.T.O of the tractor to the maize sheller.

3.3.4 Assembly of the Maize Sheller

The cylinder was positioned over the concave screen with holes corresponding to those on the main frame through slots on bearing housing and was then bolted using 20mm bolts. The hopper was also bolted on the upper cover of the cylinder to the main frame using a 15mm bolt. The main frame was welded permanently. A cover sheet sided on front and back was bolted to the main frame. A grain outlet was also welded. The blower with attached blades was also inserted into the blower unit.

Bearing housing was inserted to hold the blower shaft into position horizontally and this supports the frame. At this moment the blade should be free. The second involutes was then welded and put in place.

The winnowing unit was place under the concave. The pulleys were then attached to the drive shaft, and the belt was finally fitted.

After constructing all the necessary parts, they were assembled to form the maize sheller. At the end of this, a complete tractor powered maize sheller was produced as shown in the assembly drawing.

3.3.5 Maintenance

The maintenance of the machine is very easy and this is achieved through the following provision.

1. Bolting of the upper cover of shelling unit
2. Bolting of the bearing housing on the main frame. This gives room for changing damaged bearings.

The recommended maintenance schedules for the machine is

1. **Daily checking**

a. Check all bearing in case of damage,

b. Check all bolts, nuts and tighten if loose,

c. Run the machine for at least 10 minutes to remove the entire trapped dirt particles left over from previous operations after use.

2. **After 6 Hours of continuous usage**

   Stop the machine and re-check if the bolted components are well tighten otherwise re-tighten them.

3. **After Daily Operation**

   a. Open shelling chamber and clean all the trapped straws,

   b. Clean all the other parts of the machine.

4. **After Seasonal Operation**

   a. Properly clean all the parts of the machine,

   b. Lubricate all bolts and bearings,

   c. Keep the machine in the workshop when not in use..

3.3.6 Technical Features of the Maize Sheller

A.	Weight of machine	93.54 kg
	Total Width	1,480 mm
	Total length	1,900 mm
	Total height	650 mm

B. Shelling efficiency using maize = 98.2%

C. Cleaning efficiency using maize = 97%

D. Input capacity using maize 323.kg depending on the number of people feeding the machine.

E. Output capacity using maize 250.2 kg (depend on grain/straw ratio)

F.	Engine:	Diesel engine
	Type:	4 cylinders

Fuel:	Diesel
Fan speed	450 rpm
Fan Housing diameter	400 mm
Fan Housing width	550 mm
Number of fan blade	3
Number of spike tooth	42
Stationary concave	1
Concave clearance	40 mm
Length	300 mm
Diameter	250 mm
Speed shelling	540 rpm
Number of sieve	2

G. Losses:

i. Losses of grains during purchase 1.8%

ii. Blown grains of Maize is 0%

iii. Sieve losses of maize is 3.1%

3.3.7 Description of Maize Sheller

The maize sheller which is shown in Fig.11 consists of hopper (6) which is trapezoidal in shape. It is fixed at the top of the frame (9). The hopper forms the feeding chute through which maize ear head passes and are feed into the shelling unit. In between the hopper and the frame is the shelling unit which consists of cylinder, shaft, beater drum and a concave made of mild steel at an interval of 5mm space between. The cylinder was placed above the concave, while below the cylinder are sieve arrangement fixed at a determined angle for free flow of grains. One double grooved pulley (4) was fixed on the shelling shaft through which a shelling shaft passes and is supported by two bearings at the end of the shaft. One-v-belt (8) was used to connect the doubled grooved pulley to another pulley on the blower shaft and another v-belt from the double grooved pulley to another pulley on the transmission shaft.

The transmission shaft passes through two gear teeth (2) which was mesh together to transfer the rotary power from the P.T.O power (1) through a telescopic shaft to the shelling shaft and from the shelling shaft to the blower shaft.

The machine also consists of a blower chamber (5) with three fan blade to give a cleaning effect. The blower chamber is attached to the lower part of the frame. On the blower chamber is an opening for chaff removal (7) in line with the fan and below the blower chamber is an outlet through which clean maize grain can be collected by a sack. The whole machine is supported on a four leg support – bars (10).

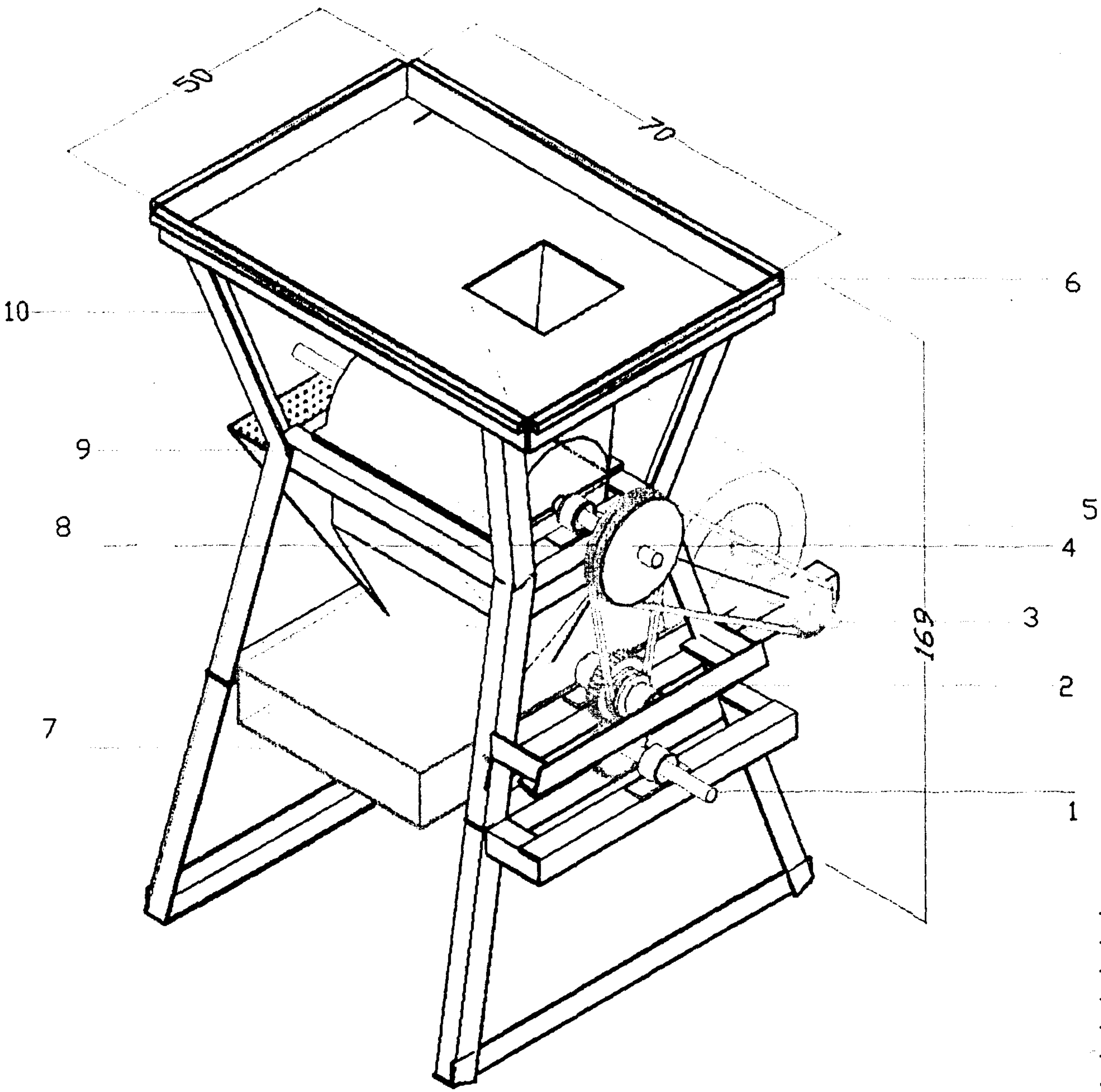


FIG 11 ISOMETRIC PROJECTION OF A TRACTOR POWER **MAIZE** SHELLER

S/NO	COMPONENTS
	LEGEND
10	SUPPORT BAR
9	MAIN FRAME
8	V-BELT
7	CHAFT OUTLET
6	HOPPER
5	BLOWER
4	DOUBLE GROOVE PULLEY
3	BLOWER SHAFT
2	GEAR MESH
1	SPLINE FOR P.T.CONNECTION

PROJECT	DESIGN & CONSTRUCTION OF A TRACTOR POWERED MAIZE SHELLER
NAME	ZUBAIRU MUSTAFA
REG. NO	M. ENG /SEET / 03 /04 /1005
TITLE	ISOMETRIC PROJECTION
SUPERVISOR	DR. DONALD ADGIDZI
DEPT.	AGRIC. ENGINERING
INSTITUTION	FED. UNIVERSITY OF TECH. MINNA
SCALE	1:10
DATE	JANUARY 2007

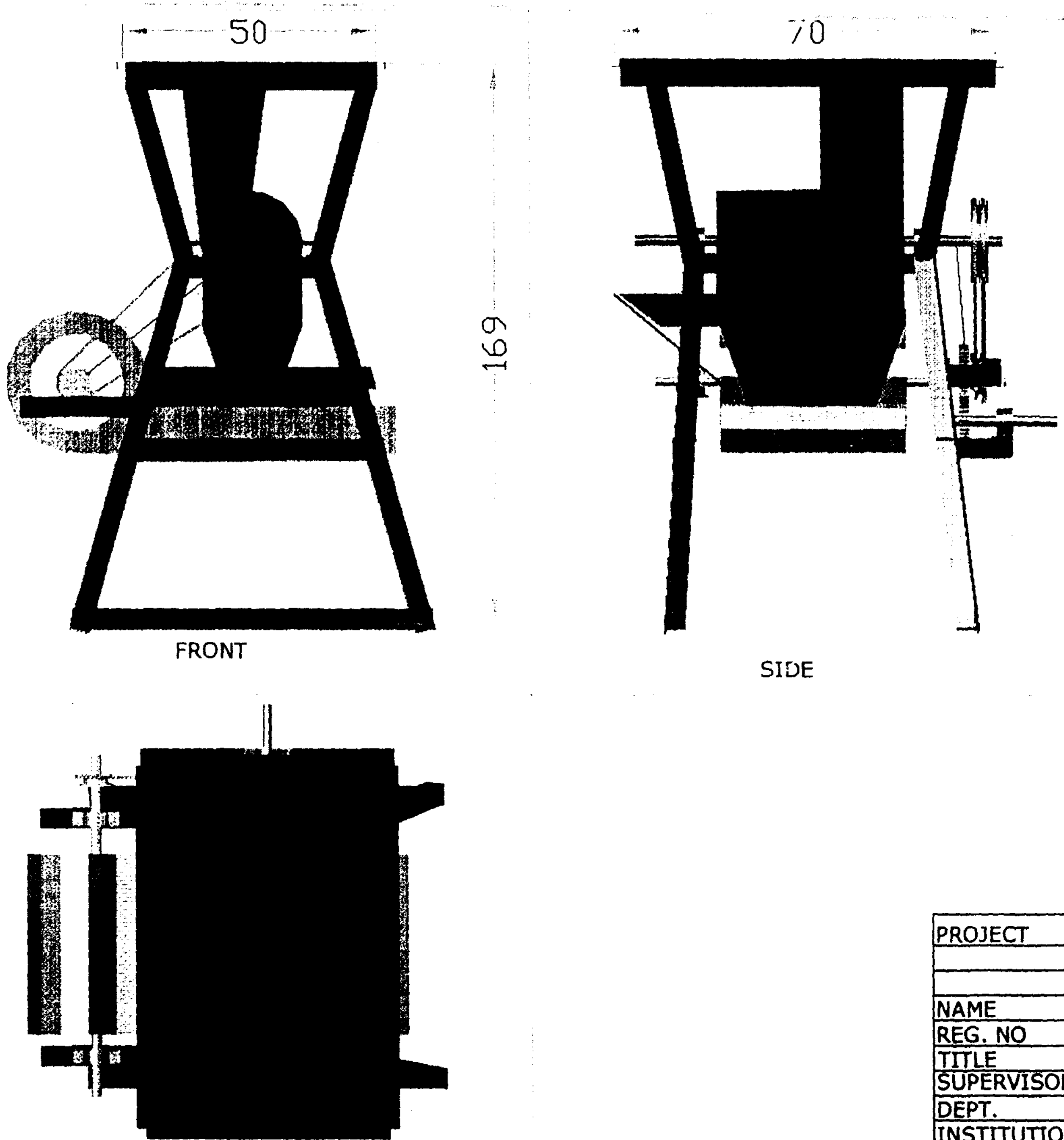


FIG 12 ORTHOGRAPHIC VIEW OF A TRACTOR POWERED **MAIZE** SHELLER

PROJECT	DESIGN & CONSTRUCTION OF A TRACTOR POWERED MAIZE SHELLER
NAME	ZUBAIRU MUSTAFA
REG. NO	M. ENG /SEET / 03 /04 /1005
TITLE	ISOMETRIC PROJECTION
SUPERVISOR	DR. DONALD ADGIDZI
DEPT.	AGRIC. ENGINEERING
INSTITUTION	FED. UNIVERSITY OF TECH. MINNA
SCALE	1:10
DATE	JANUARY 2007

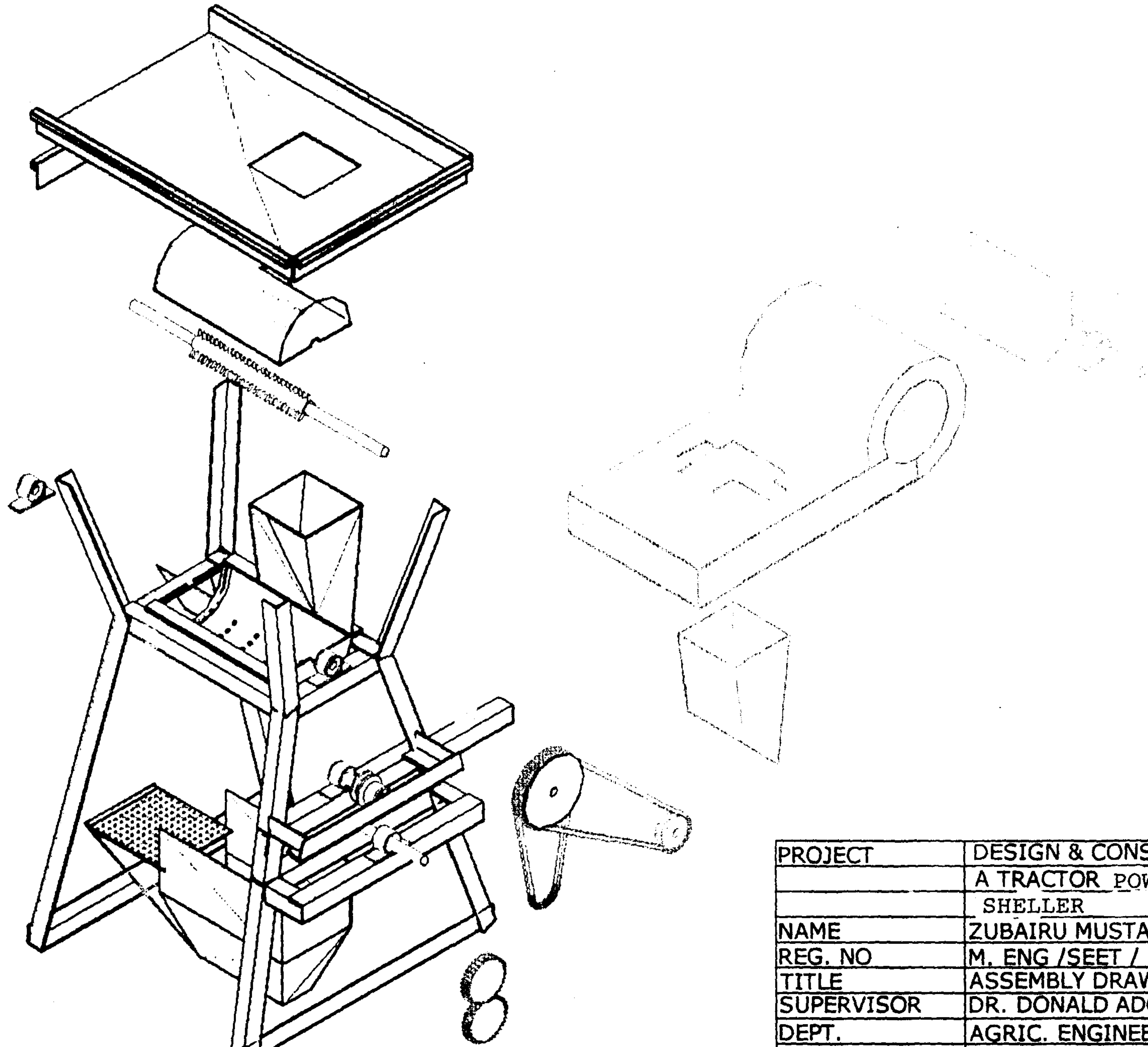
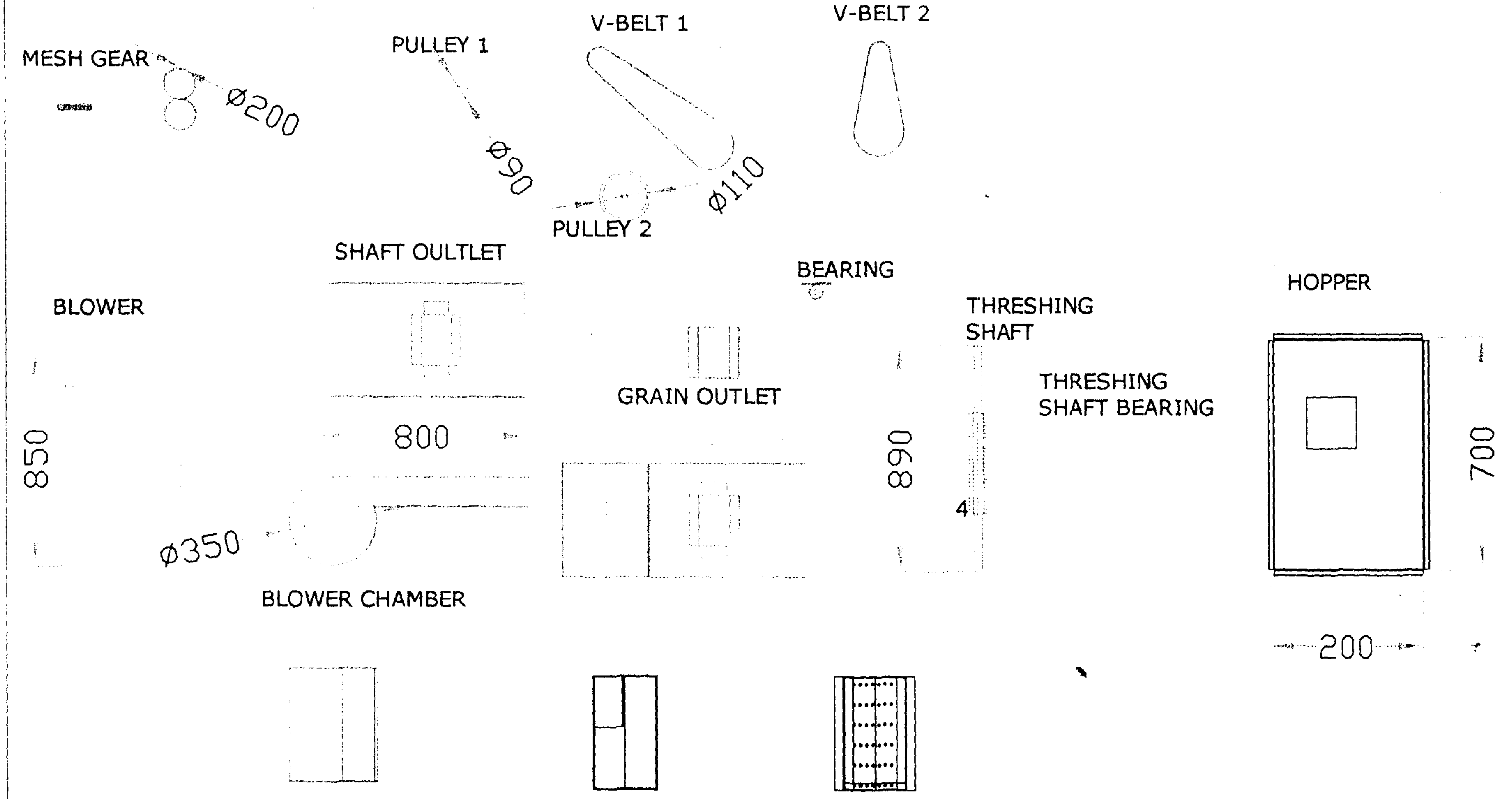


FIG 13 **ASSEMBLY DRAWING OF A TRACTOR** POWERED **MAIZE** SHELLER

PROJECT	DESIGN & CONSTRUCTION OF A TRACTOR POWERED MAIZE SHELLER
NAME	ZUBAIRU MUSTAFA
REG. NO	M. ENG /SEET / 03 /04 /1005
TITLE	ASSEMBLY DRAWING
SUPERVISOR	DR. DONALD ADGIDZI
DEPT.	AGRIC. ENGINEERING
INSTITUTION	FED. UNIVERSITY OF TECH. MINNA
SCALE	1:10
DATE	JANUARY 2007



PROJECT	DESIGN & CONSTRUCTION OF A TRACTOR POWERED MAIZE SHELLER
NAME	ZUBAIRU MUSTAFA
REG. NO	M. ENG /SEET / 03 /04 /1005
TITLE	PART DRAWING
SUPERVISOR	DR. DONALD ADGIDZI
DEPT.	AGRIC. ENGINEERING
INSTITUTION	FED. UNIVERSITY OF TECH. MINNA
SCALE	1:10
DATE	JANUARY 2007

FIG14 PART DRAWING OF A TRACTOR POWERED MAIZE SHELLER

3.3.8 Principle of Operation of Sheller

The principle of operation of the maize Sheller (Fig. 15) is as given below. Power transmitted to the transmission shaft through Telescopic shaft to the shelling unit where maize head passes through the hopper and passes down to the shelling unit where they are shelled. The shelling unit consists of spike which is made of a semi – circle with 10mm spaced between. Cylinders were then place above the concave and connected with 10mm rows of flat bars. This arrangement was made to air conveyance of straw to the straw outlet. As the shelling process continues maize cob are then removed through an outlet 1 above a sieve arrangement. The shelled grain with chaff then passed down through a sieve to the concave. Stationed below the concave is a blower chamber which consists of a fan with three blades to a give a cleaning effect. As the maize grain with the chaff passes down the blower chamber, the fan then blows off the chaff through an outlet 2 located in line with the fan. While clean maize grain comes out through another outlet 3 located below the blower chamber and are being collected by means of sack.

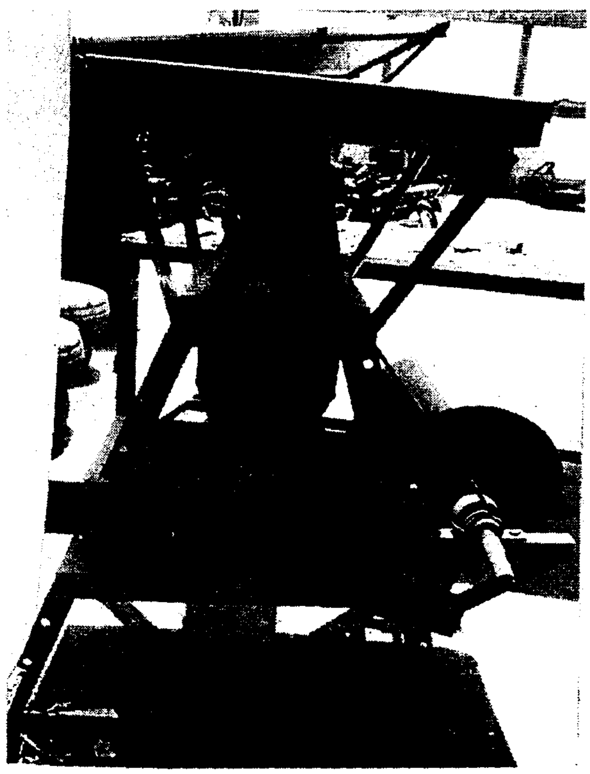


Figure 15: Pictorial view of maize sheller

3.3.8.1 Mechanisms of Operation

To operate the machine effectively, the operator should be able to identify the major component parts and understand the basic working principles of each component.

3.3.8.2 The Hopper

The hopper forms the opening through which dry head maize is fed into the shelling unit. It is rectangular in shape and the head falls into the shelling unit under the effect of gravity.

3.3.8.3 Shelling Unit

The shelling unit consists of the shelling spikes, shelling drum and the concave. There is a cover over the shelling drum to prevent grain scattering. This cover together with the concave section forms the shelling space, the shelling drum is cylindrical in nature and is made of 38.5mm flat bars, it is also provided with side boards made of gauge 16 metal sheets at both ends. A shaft drive 30mm in diameter is installed, which is supported by bearings.

The shelling teeth made of hard steel bars are fitted to the shelling drum. The rotating track interval of the shelling teeth is 40mm. the concave is provided under the shelling drum to separate grains and assist shelling simultaneously. It is made of steel bars 15mm diameter arranged 30mm in between.

3.3.8.4 Winnowing Unit

This consists of sieves arranged at intervals to promote excellent grain separation. Grain that have passed through the concave drop and on the way they are separated into whole grains and chaff.

3.3.8.5 Blower Unit

The blower unit consists of the fan made of three blades, housing and a shaft supported by bearings. The air flow is directed to the sieve and this separate the grain effectively. Adjusting the volume of exhaust air will regulate the air flow rate.

3.3.8.6 The Transmission

The transmission unit is the drive mechanism, which transmits power from the engine P.T.O to the shelling drum. The unit consists of pulleys, belt, bearings, telescopic shaft and a bevel gear. Four different pulleys were used in the design of the sheller-cleaner. One pulley attached to shelling shaft 160mm in diameter, (double grooved). One double grooved pulley attached to a shaft through which is welded Bevel gears from P.T.O (110mm in diameter). The third attached to the blower shaft; 110mm in diameter (double grooved pulley). The fourth pulley 90mm in diameters was also place on the blower shaft in case a petrol engine or motor can be used to power the machine. Three V-belts were properly fixed to connect the driver pulley from transmission shaft with the help of a telescopic shaft to the drum through Bevel gears. The shelling shaft is connected to the shaft blower.

3.3.8.7 Description of Frame and its uses

The structural frame forms the mounting support for all the units of the sheller-cleaner. It is rectangular in shape and made of 50 × 50mm angle iron. Four pieces of angle iron 850×1700mm were cut form the rectangular frame. Arc welding was used to join the pieces using gauge 10 and 12 electrodes.

3.3.8.8 Clean Grain Ejecting Unit

Having passed through the air stream from the blower and the sieve, the clean grains were collected below through a positioned outlet.

3.4 Formulas used in calculating shelling capacity, shelling efficiency, cleaning efficiency sieve loss and visible damage

3.4.1 Shelling Capacity

Shelling capacity can be calculated from weight of shelled grains and the time taken for the crop materials to be shelled completely at different feed rate, moisture contents and cylinder speeds. Formula for calculating it is stated below:

$$\text{Shelling capacity} = \frac{\text{weight of shelled grains,(kg)}}{\text{time, (hr)}}$$

3.4.2 Shelling Efficiency

The shelled samples contain both the clean grain and the unclean grains. The unclean gains, these were later separate from the clean grain and use to weight, separated for different shelling operations. Mass of unshelled samples and the total mass of the crop materials input can be used for the calculation of shelling efficiency.

Shelling efficiency can be calculated according to Kebede and Mishra (1990) as follow:-

$$\text{Shelling efficiency (\%)} = \frac{100 - mass \quad of \quad unshelled \quad grains(kg)}{total \quad mass \quad input(kg)} \times 100, \ \%$$

3.4.3 Cleaning Efficiency

Cleaning efficiency is the ratio of the weight of threshed sample and the total weight of crop materials input, multiplied by one hundred and expressed as:

$$\text{Cleaning efficiency (\%)} = \frac{(w_1 - w)}{w_1} \times 100, \ \%$$

Where w_1 = total weight of crop materials input, w = weight of chaff at the main outlet of the thresher (kg).

3.4.4 Sieve Loss

Sieve loss is the ratio of weight of free grains collected that are not from the thresher outlet and total weight of the crop material input per unit time multiplied by one hundred. Sacks are to be provided, underneath the thresher so as to collect the free grains that are not from the outlet of thresher. The free grains on the sacks were then to be packed and weighted. Sieve losses can be obtained from the following expression (Kebede and Mishra 1990).

Weight of free grains collected could be found as:

$$\text{Sieve-loss} = \frac{sieve \quad sample \quad per \quad unit \quad time}{total \quad weight \quad of\, crop \quad input \quad per \quad unit \quad time(Kg)} \times 100, \quad \%$$

3.4.5 Visible Damage

It is ratio of mass of broken crop materials and the total mass of the input materials. The expression for the calculation of visible damage is as stated below.

$$\text{Visible damage (\%)} = \frac{weight \quad of \quad broken \quad grains}{total \quad weight \quad of \quad crop \quad materials(Kg)} \times 100, \quad \%$$

3.5 Performance Evaluation

For an objective evaluation of the maize machine sheller, type test was done. Type test is a test carried out to prove machine conformity with the requirements of relevant standards. Generally, type text includes general test, test at no load and test at load.

3.5.1 General test

I. checking of specification

Ii. Checking of materials

iii. visual observation and provision for adjustment

3.5.2 Test At No Load

This is running the sheller at no load for at least half an hour at the rotational speed of the sheller unit using the P.T.O power from the tractor and recording the reading at an interval of five minutes (NCAM, 1990). The difference between two consecutive readings gives power consumption. The following observations were made and recorded:

a. Presence of any materials oscillation during operation,

b. Presence of undue knocking or ratting sound,

c. Frequent slippage of belts,

d. Other observation if any.

3.5.3 Test at load

Test at load is of two types:

a. short run test,

b. long run test.

Short run test helps to get the following;

1. Total losses,
2. Shelling efficiency,
3. Cleaning efficiency.
4. Power consumption,
5. Input capacity,
6. Output capacity.

The final sample obtained is analyzed for cracked and broken grains. Analysis of cracked and broken grains is made only from the samples taken at specified grain outlets. Grain losses during shelling and cleaning efficiencies are also determined.

3.5.4 Determination of total losses using maize grain

a. Percentage of unshelled grain = $\frac{\text{Quantity of unshelled grain from straw (kg)}}{\text{Total grain received at grain outlet (kg)}} \text{ x } 100$

$$= \frac{4.4}{250.2} x100 = 1.8\%$$

b. Percentage of cracked and broken grains =

$$= \frac{\text{cracked and broken grains from outlet } (kg)}{\text{total grain received at grain outletinreceived at grain outlet } (kg)} x100$$

$$= \frac{0}{245.5} x100 = 0\%$$

c. Percentage of blown grains =

$$\frac{quantity\ of\ clean\ grains\ obtained\ from\ outlet\ (kg)}{total\ grain\ input\ (kg)} x100$$

$$= \frac{0}{278.6} x100 = 0\%$$

d. Percentage of sieve losses =

$$= \frac{clean\ grains\ at\ sieve\ over\ flow - under\ flow\ x\ stuck\ grain\ (kg)}{total\ grain\ input\ (kg)} x100 =$$

$$= \frac{0}{278.6} x100 = 0\%$$

Major component of sieve loss is the sieve under flow. Loss grain under sieve was obtained using a bag spread under the machines to collect and check the losses. Grain obtained was weighed. Sieve over flow and stuck grain was weighed.

Clean grain obtained at sieve over flow	= 3.2
Clean grain obtained at sieve overflow	= 2.0
Stuck grain	= 2.5
Total sieve losses	= 7.7kg

$$\text{Percentage of sieve losses} = \frac{7.5}{250.2} x100 = 3\ \%$$

e. Total losses = sum of losses obtained from a, b, c, and d.

$$= 1.8 + 0 + 0 + 3 = 4.8\ \%$$

3.5.5 Determination of efficiencies using maize

a. Shelling efficiency is the ratio of the total weight of grains shelled to the total weight of grains fed into the sheller for shelling expressed as a percentage. It can also be expressed as the differences between 100% and the percentage of un-shelled grain.

Shelling Efficiency (SE) = 100 % - percentage of unshelled grain

$$= 100 - 1.8 = 98.2\%$$

b. Cleaning efficiency: The ration of the weight of clean grains that passes through the cleaning unit to the total weight of grains at the outlet of the grain retainer expressed as a percentage.

Therefore, cleaning efficiency $= \dfrac{clean\ grain\ weight\ at\ grain\ outlet\ (kg)}{total\ grain\ weight\ at\ grain\ outlet\ (kg)} x100$

$$= \frac{242.5}{250.2} x100 = 97\%$$

3.5.6 Determination of output capacity using maize

This can be determined by weighing of shelled grain at a specified grain outlet.

3.5.7 Long run test

This involves operating the machine for at least ten to fifteen hours, which allows us to know the major breakdowns so as take care of them. Here, long run test was carried out.

3.5.8 Routine test

Routine test is carried out on a machine to check the requirement, which is likely to vary during production or use. It is grouped into essential and optional test. Essential routine test include visual observation and provision for adjustment and testing at no load. But optional test involves checking of specifications and materials. The test observation here include, determinations of grain-straw ratio, moisture contains, grain length, breath and length of ears of maize crop.

3.5.9 Input capacity and output capacity

Grain recovery range (GRR) = 100 - percentage of total losses

$$= 100 - 4.9 = 95.1\%$$

$$Capacity\ utilization\ (CU) = \frac{Output\ capacity}{Input\ capacity} x100$$

$$= \frac{250.2}{323.3} \times 100 = 77.4\%$$

Shelling Index (Tix) = GRR × CU × SE (decimal)

= 0.51 × 0.774× 0.982

= 0.388

Where, GRR = Grain Recovery Range, CU = Capacity Utilization, SE = Shelling efficiency.

$$\text{Shelling intensity } S_{in} = \frac{\textit{Power consumed by sheller (kw)}}{\textit{Output capacity of sheller (kg)}}$$

$$= \frac{29.1}{250.2} = 0.12 \frac{kw}{kg}$$

Test results are shown in Tables 5 and 6.

Table 5: TEST DATA SHEET

S/N	Date	Starting Time	Stopping Time	Duration of operation	Speed rpm/min	Feed rate kg/hr	Power Required (Kw)	No of primary sample	Quantity (kg) of primary sample from		Total quantity of grain outlet	Total quantity al sleve under flow (kg)	Total quantity of material stuck in sheller (kg)
									Grain outlet (s)	Screw cutlet			
1	2	3	4	5	6	7	8	9	10	11 12	13	14	15
1	17/1/2007	7PM	8PM	1hr	540rpm	300	29.1	1	230.5	60		2.1	2.0
2	18/1/2007	7PM	8PM	1hr	540rpm	320	29.1	2	240	85		2.7	2.2
3	18/1/2007	8PM	9PM	1hr	540rpm	350	29.1	3	25.7	94.5		3.0	2.1

Table 6: DATA SHEET FOR ANALYSIS OF FINAL SAMPLE

S/N	Feed (kg)	Shelled (kg)	Sample form	Weight		Clean grain (kg)
				Un shelled grain (kg)	Cracked and broken grain(kg)	
1	2	3	4	5	6	7
1	300	230.5	I grain outlet	-	-	242.5
			ii. straw outlet	-	-	-
2	320	240	iii. sieve overflow	2.o	-	3.2
			iv. sieve underflow	-	-	2.0
3	350	275	v. material in sheller	2.4	-	2.5
	323.3	Ave 242.5		4.4		Total 250.2

CHAPTER FOUR

4.0 RESULTS

The result of the performance evaluation of the tractor powered maize sheller is presented in table 7 as shown below.

Table 7: Result of performance evaluation of the maize sheller

S/NO	Parameters	Values Obtained
1.	losses	
a)	Un-shelling	1.8 %
b)	Cracked and broken grain	0 %
c)	Sieve loss	3.1 %
b)	Blown grain	0 %
2.	Power requirement	29.1 kw
3.	Moisture content of crops	12.69 %
4.	Grain/straw ratio	1:2
5.	Shelling efficiency	98.2 %
6.	Cleaning efficiency	97 %
7.	Input capacity	323.3 kg/hr
8.	Output capacity kg/hr	250.2 kg/hr
9.	Grain recovery range (GRR)	95.1 %
10.	Capacity utilization (CU)	77.4 %
11.	shelling index (S_{ix})	72.3 %
12.	Shelling intensity (kw/kg)	0.12 kw/kg

4.1 Observations affecting performance of the maize sheller

1. Number of workers required

2. Moisture content of maize crop and straw

3. The machine requires a continuous feeding.

CHAPTER FIVE

5.0 DISCUSSION OF RESULTS

The sheller developed is a hand fed type mainly for shelling maize; but has the potential of shelling other grain crops. The results presented in table 7 represent evaluation of the maize sheller .grain condition and environment conditions were uniform since shelling in Nigeria is mainly carried out between December and January and grain conditions are almost the same.

An unshelled grain of 1.8 % was obtained from the machine performance and implies that there are some maize cob that bears un – shelled grain after the shelling processes. Cracked and broken grains 0f 0 % was determined. This signifies also that the machine shelling components is good, since there are no cracked and broken grains obtained at the grain outlet. A sieve loss of 3.1 % was obtained as a result of sieve over flow and sieve under flow. This implies that the arrangement of the sieves is good. There were no blown grains obtained while the machine was operating and this shows that the blower speed and terminal velocity of the grain determined is also significantly good. A power requirement of 29.1 kW, used.

Shelling and cleaning efficiencies of 98.2 and 97 % respectively were determined and there was no belt slippage as a result of the power transmitted. This also implies that the power transmitted is sufficient.

A moisture content of 12.69 % was obtained as compared to a grain moisture content of 14.5 % wet basis by (Kebebe and Mishra, 1990) who developed a power operated threshing machine for threshing sorghum and this implies that the moisture content of the grain is uniformly satisfactory. A grain/straw ratio of 1:2 obtained after the machine operating time shows that the ratio is good.

A shelling efficiency of 98.2 %, cleaning efficiency of 97 % respectively were determined and compared to shelling efficiency of 99 % and cleaning efficiency of 90 % determined by (Thiestain, 1987) who developed a maize Dehusker sheller (motorized one) also show that the shelling and cleaning processes are sufficient. An input capacity of 323.3 kg/hr was fed into the machine and an output capacity of 250.2 kg/hr shelled grains were obtained and compared to (Yavini, 2002) result who improved an IAR multi crop thresher which having threshing capacity of 237 kg/hr (sorghum) and 79 kg/hr millet.

The result obtained is within expected period. A grain recovery range (GRR) of 95.1 % (using maize) was computed for the maize sheller and compared with a rice sheller developed by Solomon (2002) of 95.22 %. A capacity utilization (CU) of 77.4 % (using maize) was also obtained and compared to capacity utilization of 57.69 % by Solomon (2002) (using rice) All these indicate that the maize sheller is good.

The developed tractor powered maize sheller can shell maize grains effectively if the number of operator is two. Optimum result can be obtained if the moisture content of grain is at 12.69 %.

The maize sheller has a shelling efficiency of 98.2 %, cleaning efficiency of 97 % respectively.

5.1 Conclusions and Recommendations

5.1.1 Conclusions

The Maximum output of the maize sheller was 250.2 kg/hr at a designed cylinder speed of 540 rpm. The power required to power the sheller was 29.1kw. A shelling efficiency of 98.2% was obtained. Cleaning efficiency of 97 % was also determined. And total percentage looses of 4.9% was obtained. Hence the machine can be best utilized for shelling maize effectively.

Condition of crop grains such as moisture content, grains/straw ratio, length of crop, head of crops, grain length, cylinder speed, concave clearance, size of sieve are some of the machine parameter which can affect the performance of the tractor powered maize sheller. Thus the use of this maize sheller can reduce the hard labour encountered during shelling.

5.1.2 Recommendations

i. The sheller is recommended for use by both small and large scale farmers.

ii. More efforts should be done to develop many of this sheller to reduce the labour encountered by the farmers

iii. Government should improve the tractor hiring unit, to enable the farmers hire the tractor to power the maize sheller.

iv. Optimum result can be obtained when maize sample is well dried.

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APPENDICES

The following parameters are necessary when designing a tractor powered maize shelling machine.

Concave clearance: - Maximum gap clearance between shelling cylinder and concave.

Concave: - A concave shaped stationary element adjacent to a shelling cylinder rotor, attched to promote shelling.

Grain damage: - refers to as percentage by weight of damaged kernels in the sample

i. Visible grain damage: - kernel damage where the seed coat appears broken to the naked eyes.

ii. Invisible grain damage: - Kernel damage which requires instrumentation.

Moisture content: Ratio of weight of water production to total weight of production express in percentage.

Tractor powered maize sheller: - a machine powered by a P.T.O of a tractor to separate the clean-grain from chaff using spiked on the drum.

Shelling:- Detachment of grain from the head element fiftted to promote shelling.

Shelling efficiency:- Percentage by weigh of shelled grains from all outlets of the sheller with respect to total grain input.

Shelling index:- Product of grain recovery range (GRR) in percentage, capacity utilization (CU) expresses in percentage and shelling efficiency (SE) in percentage.

Grain Recovery Range: - = 100 – percentage total losses

Capacity Utilization:- $\frac{\text{Output capacity}}{\text{Input capacity}} \times 100\%$

Shelling intensity: - **power** consumed by a sheller per unit output of grains expressed in kw/kg.

Winnowing: - **Pneumatic** cleaning of shelled grains

Cleaning efficiency: - Clean grain received at specified grain outlets with respect to total grain receive at grain outlets expresses as percentage by weight.

Input capacity: - Fed rate at which the power requirement and total losses is minimum, where efficiencies are within specified limits.

Feed rate: - weight of grain fee into the sheller per unit time

Prime motor: - An engine or tractor required to power the maize sheller

P.T.O Power: - Power obtained from the tractor to powered the sheller

General test: - This is the checking of specifications, checking of materials. Observation and provision of necessary adjustment