DESIGN OF AN APPROPRIATE SUNFLOWER THRESHING AND CLEANING MACHINE FOR SMALL SCALE FARMERS

BY

KABUTETSI CHARITY

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16/A/BME/0916/G/F

AN INDIVIDUAL PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING, FACULTY OF ENGINEERING, TECHNOLOGY, APPLIED DESIGN AND FINE ART. (FETADFA) OF KABALE UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A BACHELOR DEGREE OF MECHANICAL ENGINEERING

SUPERVISOR

MR. KAKEBE SEKAJJA ROBERT

FEBRUARY, 2021

DECLARATION

I declare to the best of my knowledge that this final year project report is as a result of my research and effort and it has never been presented or submitted to any institution or university for an academic award.

Signature..˙~ …….. **Date**

08/02/2021……

KABUTETSI CHARITY

APPROVAL

This project report was compiled and submitted to the Department of Mechanical Engineering under the approval of;

Supervisor

……………………………………… **Date:** 08/02/2021

KAKEBE SEKAJJA ROBERT

DEDICATION

This report is dedicated to my beloved parents, siblings and friends for their selfless care and support provided to me since childhood, and for the spirit of hard work, courage and determination instilled into me, which attributes I have cherished with firmness and which have indeed made me what I am today

ACKNOWLEDGEMENT

First and foremost, I would like to thank the ALMIGHTY GOD for my **life** and good health I am living today. Thank you, Father, and may your name be glorified.

Great thanks to my supervisor, MR.KAKEBE SEKAJJA ROBERT for his time, and guidance he has rendered to me making it a success in compiling this report.

Lastly, I warmly thank all my lecturers,friends and course mates for all their support and assistance that has been a positive contribution to the success for this report.

ABSTRACT

Sunflower growing has become an important activity used to reduce food insecurity and improve **on** income of farmers. The objective of this study was to design an appropriate sunflower threshing and cleaning machine for small scale farmers. To achieve the objective of this study the following specific objectives had to be achieved: determining the design considerations of the sunflower thresher, sizing and selecting components and developing a layout of the machine.A survey of the existing threshing technologies and methods was carried out through observations.desk research from different sources and interviews in order to obtain data to help in specifying the design requirements, sizing and selecting components as well as generating a layout of machine. The different sources that were used include: text books, journals and websites.The study found out that sunflower threshing is mostly done manually though a few sophisticated machines have been employed in developed countries. The limitations of the existing sunflower threshing methods were found to be: expensive, large space requirement by the mechanized systems, labor-intensive, time consuming and tiresome for the case of manual threshing. Basing on the data collected through literature review, it was concluded that an appropriate sunflower thresher should be designed. The major components of the proposed machine were threshing chamber, threshing rotor, sieve, motor, blower, pulleys and frame. The layout of design was developed using solid works 2016 CAD software as per the dimensions of the individual components. The researcher, however, recommended that the fabrication of the machine needs to be done based on the individual part parameters developed and performance testing of the machine to embrace the new technology for effective threshing.

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NOMENCLATURE

S'N	ABBREVIATION	DESCRIPTION
1	NaSARRI	National Semi-Arid Resources Research Institute
2	Mm	Millimeters
3	Rpm	Revolution per minute
4	2-D	Two dimensional
5	3-D	Three dimensional
6	CAD	Computer Aided Design

CHAPTER ONE
INTRODUCTION

LI Background

,.=;lower (majorly originated from Eastern North America) was introduced in Uganda in 1920s ind serves as a basic raw material in the oilseed processing sector and source of food. Sunflower-Helianthus annulus L is one of the species that was originated from North America. Farmers mainly in North-Eastern Uganda account for the biggest percentage of vegetable oil production in the country and its production has since increased and is now a major cash crop under NaSARRI

Sunflower threshing varies widely depending on the scale of production. The threshing methods 51Ilall scale farmers use in Uganda include, beating the sunflower heads with a stick, Rubbing the heads on each other and rubbing the heads on a stone. The seeds are massively mixed with significant amounts of chaff and hence cleaning is quite another load in manual threshing. These methods require much labor in a large-scale farm and consume more time. Beating the sunflower on a bare ground subjects them to contamination by foreign materials. Hand threshing is suitable for small amounts and causes the least damage of the seeds

The threshing efficiency of the traditional methods depends on the person performing the activity, the more the beating, the more the number of broken seeds. Since there is no recommended force for beating the sunflower, a reasonable percentage of broken seeds is usually produced as result of impact loading[l]. These methods also require additional operations of cleaning and sorting thus increasing the total time required.

The mechanical methods farmers use in Uganda include, sunflower threshing machines for example **PAU sunflower thresher[2].** This machine is sophisticated. Therefore, this study is aimed at designing a sunflower threshing and cleaning machine, with the ability to efficiently thresh and clean sunflower simultaneously

2 Problem Statement

ganda, a moderate percentage of small-scale farmers grow sunflower but use traditional methods of threshing for example; the sunflower is dislodged from the pods by stick beating. However, this method is time consuming and leads to the production of poor-quality seeds;

here some seeds are broken and contaminated with soil as the threshing is done on a bare ground. The production of broken seeds affects agriculture since they are not viable and are difficult to store for a long period of time thus causing a potential threat of food insecurity. The already existing sunflower threshing machines are sophisticated and complex. Hence the need to design an appropriate sunflower threshing and cleaning machine for small scale farmers

Figure 1.1 Traditional ways of sunflower Threshing [4] 1.3

Objectives

1.3.1 General Objective

To design an appropriatesunflower threshing and cleaning machine for small scale farmers

1.3.2 Specific Objectives

1. To determine the specifications of the machine
2. To size and or select the components of the machine
3. To develop the layout of the machine

4 Justification of the study

implementing the project will help to;

_ Reduce postharvest losses in sunflower

Improve food security in the rural setting and the country at large

- Reduce human high labor and fatigue faced in the current threshing and cleaning methods.

  Improve rural farmers' livelihood through increasing their income from sunflower

1.5 Significance the study

The purpose of the study is to develop a machine which is efficient and affordable by all local farmers in Uganda which;

a. Threshes and cleans a reasonable capacity of sunflower in a short time with minimal or no human fatigue.

b. Threshes and cleans sunflower with minimal losses and damage to the seeds

c.Combines the threshing cleaning and sorting operations to reduce time requirement and overall cost of the process.

1.6 Scope of the study

The study will be only limited to modeling and simulation of an appropriate sunflower threshing and cleaning machine for only the common varieties in Uganda.

Chapter Two LITERATURE REVIEW

2.l Sunflower production in Uganda

lower is a living annual plant in the family of Asteraceae with a large yellow flower heads. **eeds** full sun to grow well and grows best in fertile, wet, well- drained soil with a lot of ch. It was introduced in Uganda in1920s and it is majorly grown in eastern and northern

2.2sunflower Oil extraction process

se solvent to extract oil from sunflower oil cake inside oil extractor, and the final products are **:=...xed** oil and wet meal, and then well mixed oilpass through two evaporators to make solvent ,;-side transform into gas, and solvent will be recovered through condensers and reused. These **two** evaporators are not with same size; first evaporator is bigger than the second one because there will be more solvent inside and mixed oil in the beginning. After evaporating, the oil will *e* pump into the stripping tower. Finally, we will get crude sunflower oil ready for oil refining

The wet metal will be delivered to desolventizer to dry and be separated with solvent. The dry meal will be packaged for sale as animal feed, in which oil residue inside meal is less than 1 %.

Hydrated degumming mainly is to remove phosphatide inside crude sunflower oil in order to reduce oil loss and improve quality of oil. Alkalis refining using alkali to neutralize free fatty acid with by-product of soap stock, which is used for making soap.

2.3. Common varieties of sunflower grown in Uganda

There are two types of sunflower grown in Uganda;

a. Taiyo sunflower: it is most suitable sunflower with high oil content and majorly grown in both east and Northern Uganda.

b. Super snack mix: It is the best sunflower to eat and they attract pollinators easily. [5]

2.4.Physical properties of sunflower in Uganda

Physical properties of sunflower seeds and kernel were evaluated as a function of moisture content. At 6.2% moisture content dry basis, the average length, width, thickness and unit mass of the seeds were 9.52mm, 5.12mm, 3.27mm and 0.049g respectively diameter and sphericity of the seed were 5.39mm and 0.57 respectively, while corresponding values for the kernel were 4.32mm and 0. 53mm.In the moisture range from 4-20% dry basis, the bulk density of the rewetted seed decreased from 462 to 434kg/m', true density increased from 706 to 765kg/m^3, porosity increased from 34.3 to 43.3% and terminal velocity increased from 5.8 to 7.6m/s, 45.4 to 50.2% and 3.5 to 5.8m/s. In the same moisture range the static coefficient of friction varied from 0.40 to 0.58 for seed and from 0.43 to 0.81 for kernel on different surfaces, while the angle of response varied from 0.43 to 0.81 for kernel on different surfaces, while the angle of response varied from 34 to 41 ° for seed and 27 to 38 for kernel[l].

2.5. Mechanical properties of sunflower seeds

Mechanical properties of seeds are essential parameters considered in various engineering designs for various machine components. The major mechanical sunflower seed parameters include; Friction angle (degree), coefficient of friction, angle of repose (degree), hardness (N) and terminal velocity (m/s)[3].

a) Friction angle (degree) ('P)

It is the angle between seeds and any contact material like metal or wood surface at which maximum friction between them occurs. It is used in the design of slanting surface angles, like for sieves

b) Angle of repose, degree (0)

It is the angle between the horizontal base and the inclined side of the formed cone due to free fall of seeds sample. This is basic in designing feed hoppers, collection troughs and storage silos for the seeds.

c) Terminal velocity *mis* (Vt)

This is the velocity of the air streani at which the body seed remains suspended. This parameter is essential in designing cleaning components of seeds like blowers, screens and reciprocating speed for separation screens.

d) Hardness

This is the maximum amount of force a sesame seed can withstand without cracking, breaking and bruising. This is helpful in the design of threshing and shelling components and forces of sesame.

2.6. Existing threshing methods in Uganda

Threshing methods are categorized into two; manual and mechanical. Here, the corresponding techniques of each method are analyzed for strength and weakness in effectively performing the :.nreshing of sunflower. The factors that limit the wide adoption of the improved methods is also included.

2.6.1 Manual Threshing

This is the most common method used by small scale farmers. It involves beating the harvested crop with sticks so as to dislodge the seeds from the pods or hand threshing is at times used for smaller quantities. Manually threshing takes following forms:

a) Caning on ground

According to personal observation, small scale farmers employ this method in threshing sunflower. It requires no machinery, it is environmentally friendly, and does not require technical knowledge. It is best suited for small scale production as it would require much labor in a large scale farm and consume more time. Beating the sunflower on a bare ground subjects them to contamination by foreign materials. The threshing efficiency of this method depends on the person performing the activity i.e. the more the beating, the lesser the losses through unthreshed seeds. Since there is no recommended force for beating the sunflower, a reasonable percentage of damaged seeds is usually produced as result of impact loading. The method also requires additional operations of cleaning and sorting thus increasing the total time required to accomplish the threshing job. [4]

b) Caning in jute bags

This method is related to the previous method, but its advantage is that it limits contamination of the seeds with foreign material. The damage on the seeds is minimal as there is little or no interaction between the stick and surface on which the jute bag is placed. It becomes expensive as the farmer has to replace the jute bags due to damages caused by the beat [4]

c) Threshing racks

This consists of wood arranged on a platform with a wire mesh tray on the bottom to catch the threshed seed. It has high wooden sides which prevent seed scattering during threshing. The method incorporates cleaning of the seeds, an operation which is done separate in other methods like stick beating in jute bags or on a given platform. However, it is time consuming and suitable for small amount of sun flower.[4]

2.6.1.1 Challenges facing manual threshing

a) Manual threshing cleaning of sunflower is labor intensive operations

b) High costs are involved since many people are required in the processes

c) They are both time consuming techniques

d) Manual winnowing is wind dependent.

e) There is incomplete removal of sunflower seeds from the husk.

f) High post-harvest loses are experienced during the manual threshing and cleaning.

NOTE: Currently in Uganda, mechanical threshing and cleaning of sunflower is still on a very negligible scale as about 95% of the famers employ the manual methods. The few who employ mechanical techniques use manually operated home-made inefficient machines for threshing and cleaning according to[4]. Some of these machines include manually operated wood threshers, motors and pistons and manual winnowing fans, blowers and shaking mechanisms.

2.6.2Mechanical Threshing

There are several kinds of equipment involved ranging from manually operated to engine powered and motor powered[5]. Some of the machines include the following;

1. Self-propelled sunflower combine

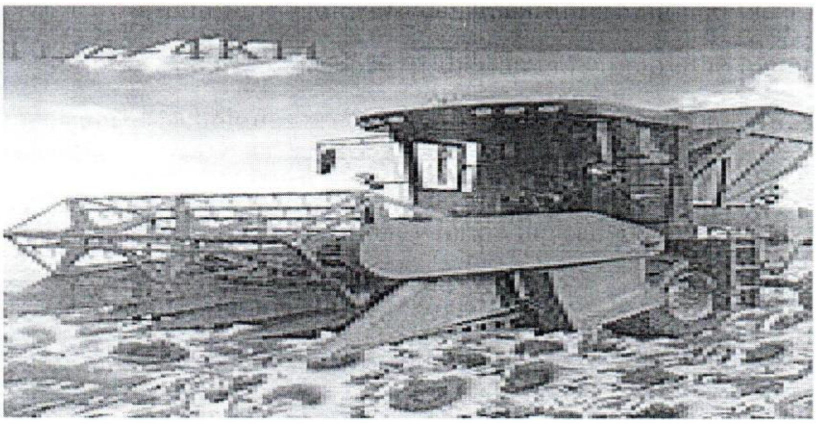


Figure 2.1 Self-propelled sunflower combine [5]

Features

s: Extra-large dirt and foreign matter screening area

- Spring tooth cylinders
- Disc separators
- Bucket elevator
- Auger

Advantages

- It has high capacity and produces high quality samples with minimal damage
- The closed loop threshing system recirculates unthreshed pods for maximum production
- The bucket elevator gently conveys beans without smearing
- The low impact threshing reduces product damage
- The large, spring tooth cylinders with high clearance easily handle rocks

Working operation

As the heads move below the deflector, the stems contact the cutter bar and are cut just below the head. A small reel mounted directly behind the deflector moves the heads into the combined feeder. The header of the combined usually runs 0.3 to 0.6 m above the soil surface depending on how the stalks are standing

2. 5hp vidhata thresher

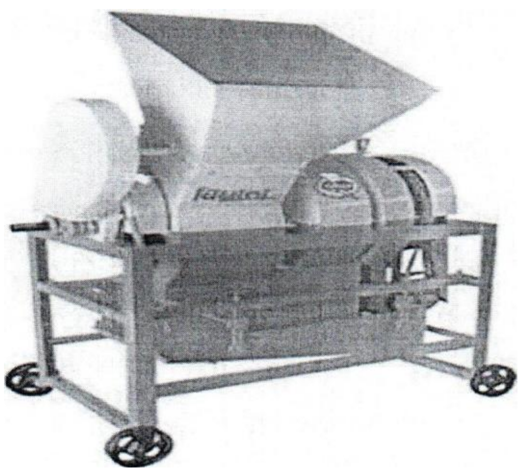


Figure 2.2 5hp vidhata threshers

Features

a) It is capable of running with an electric motor as well as diesel engine

b) It is capable with tractors from 2 to 40 HP

c) It is capable of threshing of more than one type of crop

Construction

This machine uses a drum and a concave surface to thresh and is capable of processing multiple crops by changing the distance between drum and the concave and increasing or decreasing the threshing drum speed. The cleaner is fitted with variable screen sizes for different crops that is coarse for corn and fine for amaranth.

2.7 Work done on Existing threshers in Uganda.

Threshing is the operation of detaching grains or seeds from ear head, cob or pod. Threshing has evolved right from ancient methods including treading the crops under animal feet and tractor tires, striking the grain with sticks, rubbing the crop between stones or wooden rollers on a threshing surface, to recent methods that combine threshing and cleaning operations. [6]

2.7 .1 Functional components of threshers.

a. Feeding unit

There are basically two types of feeding units; throw-in and hold-on feeding units. In throw-in, the crop is wholly pushed into the threshing cylinder whereas in hold-on, only the heads of the crop are pushed into the machine and the twigs and sterns are held mechanically or by hands. These can either be in terms of feed in hopers or chutes.

b. Threshing unit

This is where threshing is accomplished by the impact of rotating bars on the crops which opens the pods or head. This unit basically consists of a cylinder and a concave sieve. The different types of cylinders are; spike tooth or peg type cylinder, rasp bar, angled bar, wire loop, cutter blade or syndicator and hammer mill cylinder types.

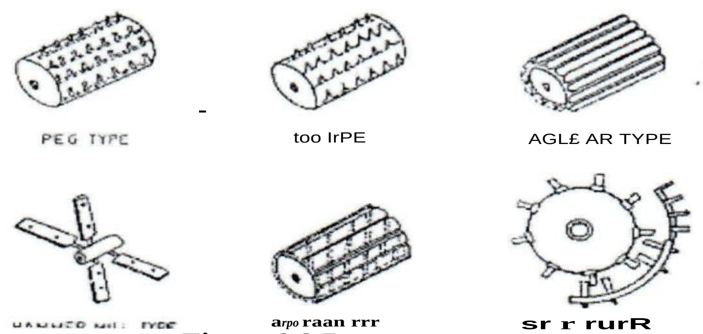


Figure 2.3 Beater types

c. Cleaning unit

This unit is provided to separate grams and seeds from chaff. It further uses subunits like aspirators or blowers, sieves and sieve shaking mechanisms. The blowers are installed to blow off lighter material and chaff. Screens are oscillated by a crank wheel and shaft which changes the rotary motion of the main shaft into linear reciprocating motion.

2.7.2 Existing Work done on threshers.

Mechanical engineering team, ohio university designed and fabricated a community scale thresher. Thresher was designed to thresh multiple crops including millet, sorghum, spelt, buckwheat beans and amaranth. It was designed basing on the angle bar type cylinder mechanism[4].

It was also designed with an adjustable concave sieve to allow adjusting space between the drum and th concave, this was intended to adapt the design to multiple crops as intended.

The machine achieved an a verage effecience of 80% when tested with various crops

However, it was recommended that a cleaning unit should be incoperated on to the machine, the space between the ceilling and th drum should be made as small as possible, and also recommended verticel loading of the crops into the machine.

Soybean Paddle Thresher was designed, fabricated and evaluated the performance of a with a Blower. The thresher was designed basing on the improved tumbler mechanism with a combination of impact, compression and shear. [7]

It consists of a hopper, drum, shaft on bearings, frame, beaters, blower, chain, and sprocket power transmission, pedal and seat. In their evaluation, two levels of moisture content level were combined to evaluate the performance of thresher in terms of its capacity, threshing efficiency and percentage grain damage. The combination of dried and wet sample mixture at a feed rate of 25kg yielded maximum threshing capacity of 96 kg/hr., 98.6% maximum threshing efficiency and minimum percent grain damage of 3.5% results was recorded, which was very satisfactory.

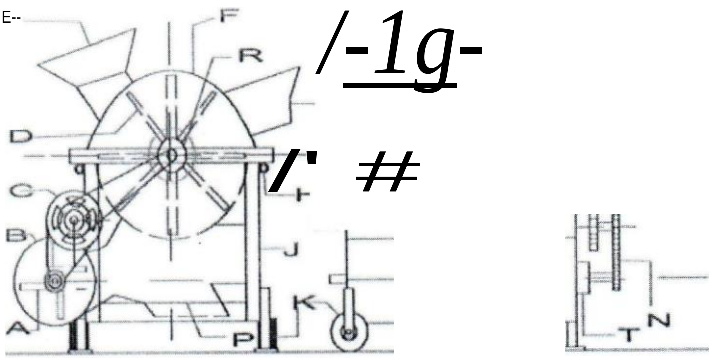
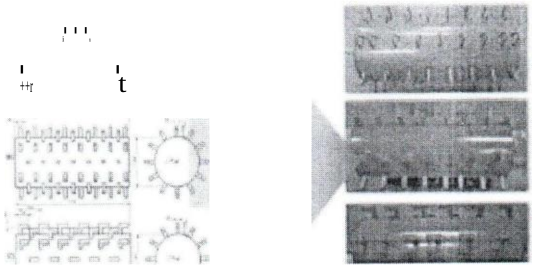


Figure 2.4 Design of soya bean paddle thresher

Results showed that there is a strong relationship between the machine through put, efficiency and breakage rate and the threshing speed. The optimal throughput was found to be 96kg/hr. at a speed of 71 m/min when tested with dry mixture.

The optimal threshing efficiency was found to be 98.6% at a threshing speed of 71 m/min when tested with the dry mixture.The percentage breakage was least at 3.5% at 71 m/min of the machine speed when tested with the wet mixture while at 1.3% and at 71 m/min high when tested with dry mixture.

Shatter-Resistant Sesame threshing machine was developed[8]. Three types of serrated bars were designed and evaluated through performance tests, in terms of the ratio of unthreshed sesame. Results: In the case of conventional sesame, the ratio of unthreshed sesame did not show any difference with bar type or cylinder rotation speed. For shatter-resistant sesame, however, the ratio of unthreshed sesame decreased with increased cylinder rotating speed for all three types of bar.



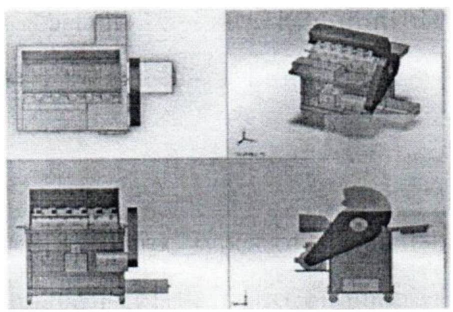


Figure 2.5 Serrated bars for shatter resistant sesame thresher

These results are useful for the construction and utilization of an efficient threshing harvester. The type-L bar showed the best result in the energy equation. The evaluated threshing cylinders are shown in the figure above.

For shatter-resistant sesame, however, the ratio of unthreshed sesame decreased with increased cylinder rotating speed for all three types of bar. The L-type serrated bar (blade) showed the best results: 0.9% at 500 rpm cylinder speed. As the impact area of the bar increased, the kinetic energy of the cylinder also increased. As a result, the unthreshed ratio of sesame decreased.

2.8 Design of different standard machine parts

2.8.1 Design of sieves

a. Designing for the capacity of the sieves

Productivity of sieves used in the cleaning and sorting processes is dependent on the size of the sieve and the feed rate on to the sieve. The productivity is quantified using theequation below according to [9].

$= + = * +$ $+B$ 0.1

2.8.2 Design Analysis of solid Shafts

A shaft is a circular cross section rotating machine element that transmits power from one place to another [10]. When the shaft is subjected to combined twisting moment and bending moment, then the shaft must be designed on the basis of the two moments simultaneously. The shafts subjected to both bending and torsional moments without any axial forces can be designed according to the maximum shear stress and the principal stress theories. For the design of shafts,

the following two methods are adopted

2.8.2.1Design Based on Strength

In this method, design is carried out so that stress at any location of the shaft should not exceed the material yield stress. No consideration for shaft deflection and shaft twist is included while using this method of design.

Here, design depends on the allowable deflection and twist of the shaft. This is implemented by thorough knowledge of the loading conditions and the power requirements of the shaft in a particular design. The method is based on various theories which include,

1. Maximum shear stress theory or Guest's theory. It is used for ductile materials such as mild steel;

2. Maximum normal stress theory or Rankin's theory. It is used for brittle materials such as cast Iron.

According to maximum shear stress theory;

ɢ = ~3 ·J (Mb)² + crf ……………………… 0.2
rd

Where;

T- Torque transmitted by the shaft (Nm)

M- Bending moment

d- Diameter of the shaft (m).

In actual practice, shafts are subjected to fluctuating torque and bending moments. In order to design such shafts, the combined shock and fatigue factors K and k must be taken into account for the twisting moment (T) and bending moment (M) respectively.

Tableshows the recommended values of Kb and K for different nature of load on shafts.

Nature of load	⌢	4,
I. Stationary shafts		
(a) Gradually applied load	1.0	1.0
() Suddenly applied load	15to20	1.5 to 20
2. Rotating shafts		
(a) Gradually applied or steady load	1.5	1.0
(b) Suddeuly applied load with munor shocks only	I.S to 2.0	l.S to 2.0
() Suddenly applied load with heavy shocks	20to 3.0	1.5to 3.0

Table 2.1 Showing kt and kb values for different shafts

Source: [10, p. 532]

2.8.2.2 The torque transmitted by a shaft.

$$T = \frac{power}{angular\ velocity} = \frac{P}{\omega} \quad \ldots\ldots\ldots\ldots\ldots\ldots 0.3.$$

Where p is the power transmitted by the shaft (N/m)

Maximum bending stress is given as;

$$\sigma_{max} = \frac{4T}{\pi r^3} = \frac{32T}{\pi d^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots 0.4$$

Where,

T- Torque per turn (Nm/ turn)

d- Diameter of the solid shaft (m) *r*-

Radius of the solid shaft (m)

On choosing the material of the shafts, their yield and ultimate strengths should be known. The shafts will be under the influence of the driving torque so the shearing stress is needed and it is given by:

$$\tau = \frac{T_D}{J} \ldots\ldots\ldots\ldots\ldots\ldots 0.5$$

Where,

τ– Shear stress (N/m^2) T,-

Driving torque (Nm)

I- Polar second moment of area (m')

According to E. J. Hearn, maximum principal stress is given as,

Where;

O ma- Maximum principal stress

o,- Stress applied on a shaft in horizontal plane 0,-

Stress applied on a shaft in vertical plane

t- Resultant shear stress

2.8.3 Bearing Selection

Shaft assemblies generally require two bearings to support and locate the shaft both radially and axially.Bearing dimension selection shall be based on the operating load and the bearing's life expectancy requirements[l 1].

Ball Bearings with pressed cages, light in weight and with high elasticity are suitable at normal speed. Bearings are selected from the manufactures catalogue according to purpose and diameter of the shaft.[1 O]Stated that, the ball bearings are used for light loads and the roller bearings are used for heavier loads. The rolling contact bearings, depending upon the load to be carried, are classified as: radial bearings and thrust bearings.

The selection of ball and roller bearings for a given installation depends upon the following factors;

The load-carrying capacity and the nature of the load,

a) The speed of shafts in revolutions per minute,
b) The conditions under which they will operate, such as temperature, dustiness, and acidity.
c) The anticipated life of the bearing,
d) Magnitude and direction of loads.

2.8.4 Design of the key

A key is defined as a machine element which is used to connect the transmission shaft to rotating machine[l 0]. Keys are made from plain carbon steels in order to withstand shear and compressive stresses resulting from transmission of torque.Flat keys will be selected due to their stability as compared to the square keys.

For flat, the thumb-rule dimensions are as follows:

$b = \frac{d}{4}$ 0.7

b=width of key (mm)

$h = \frac{2b}{,} = \frac{d}{,p}$................................0.8

h=height of thickness (mm)

d=diameter of shaft (mm)

l = 1.Sd 0.9

l = length of the key (mm)

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The methodology adopted in this study was for the purpose of obtaining relevant information and data necessary to come up with an effective design of an appropriate sunflower threshing and cleaning machine that would improve the threshing process. The methods and tools adapted to accomplish the objectives of this study were: interviews, observations and desk research

3.1 Data collection tools and techniques

3.1.1 Interviews

Formal oral interviews were conducted with the aim of finding out challenges faced by sunflower growers while carrying out threshing and some of their expectations from a threshingmachine when one is to be designed.

3.1.2 Desk research

Information from textbooks, existing reports, journals, articles and websites related to this research was obtained and studied in order to come up with an appropriate design solution for the problem at hand. This was also used to develop the drawings of the machine through the use of Solid works 2016 CAD Software.

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Methods and Tools used

SPECICIFIC OBJECTIVE		OUTCOMES
To determine the specifications of the machine to be designed	• Desk research; obtaining information from text books and journals • Interviews on the customers	+· Information about the customer requirements for the machine to be designed
To size and select components of the machine	• Desk research • Observations	+%· Materials and their corresponding sizes and properties
To develop the layout of the machine	• Desk research • Block diagrams • Solid works \	•• Modeled and simulated system

3.2 Determination of Machine Designed Specifications a)

Desk Research

Textbooks and journals explaining what sunflower is and the customer needs and wants were reviewed to understand the concept of' sunflower growing" in the world and determine the design considerations for the machine

b) Interviews

Formal oral interviews were conducted on some sunflower growers and sunflower threshing machine operators in MBALE district. The traditional methods used and the challenges they face

-

while using these methods, the disadvantages and advantages for the existing machines, opinions for what they need to be better and successful were discussed to come up with the design considerations for the proposed machine.

3.3 Selecting and Sizing of the Machine Components a)

Desk Research

Textbooks and several journals were reviewed to understand the principle, construction, materials and operation of the existing sunflower threshing machines and other related threshers. Formulas and graphs were obtained to calculate the required sizes and material grades respectively

b) Observations

Visual observations were carried out in Mbale district on the used existing sunflower threshing machines to identify the components used and their arrangement to make the assembly. This helped to know how the proposed machine would be designed.

3.4 Development of Machine Layout

a) **Desk Research**

Several tutorials were viewed to understand how different soft wares work and to choose the most appropriate one which would help in the design and simulation of the proposed machine

b) Solid Works Software

This was used to develop 2D, 3D drawings for the proposed machine components and the assemblage of these components.DS solid works was used

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.0 Introduction

This chapter presents the findings and results of the research that was carried out. It gives a detailed description and discussion of the data acquired in the research in line with specific objectives.

4.1 Design specifications

The following design considerations and assumptions were made;

a)Strength of design materials should withstand the forces acting in the various component of the machine

b) Physical and aerodynamic properties of sunflower seeds and the chaff as a falling body will be considered

c) Size and form of the machine based on human ergonomics

d) More efficient use of power, space and time in unit operations involved.

e)Economic considerations; the proposed design of the machine will be in consideration of the costs involved. The costs involved will include transport etc.

f) The terminal velocity of the chaff will be taken as 4 to 5 m/s.

4.1.1 Working structure

The engineering components were assembled and the arrangement of this structure is represented on the block diagram shown below:

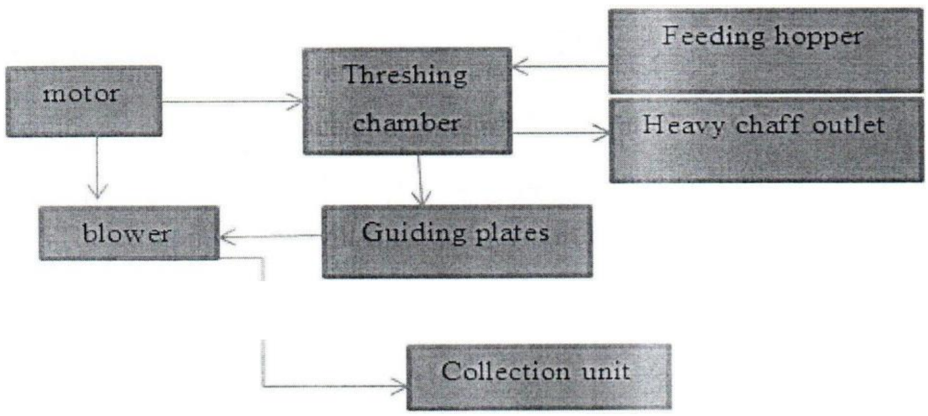

Figure 4.1 Block diagram of the proposed sunflower thresher

The machine is made of a number of components for its adaptability to the intended purpose. The major components include;

a) The threshing rotor. This is made up of round pipe, shaft and angle bar beaters

b) Sieve. This separates the seeds from coarse chaff.

c) Blower. This is used to separate the small and light chaff from the seeds basing on differences in densities and terminal velocity.

d) Collection chamber. This collects the mixture of seeds with chaff and directs them to respective destinations according to the air flow.

e) Driving mechanism.This transfers power from the prime mover to the all moving parts of the machine.

4.2 Sizing and Selection of machine components

The sunflower threshing and cleaning machine has the following components:

4.2.1 Feed hopper.

Its capacity is got from the volume of a trapezium

$$V = A * L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$A = \frac{1}{2}h(a+b) \ldots\ldots\ldots\ldots\ldots\ldots 2)$$

Where ***a*** and ***b*** are the sides of the trapezium, ***h*** is the height and A is the cross-sectional area The diameter of sunflower ranges between l 5-30cm

The length of the gate =the average length of sunflower heads $a = \frac{15+30}{2} = 22.5$

$$v = \frac{m}{p} = \frac{10}{434} = 0.023 \quad \mathbf{b = a+2x}$$

Where $x = (21.15- 212)/2 = 2.5$cm

$$b = 22.5 + 2 * 2.5 = 27.5\text{cm}$$

From $v = \frac{1}{2}h(a+b)$+L;0.023 = -+21($\frac{1}{2}$2.5 + 27.5) L

L = 0.45cm

4.2.2 Sieve

The sieve was selected basing on the size of the seeds, availability, and cost

From the table showing the physical properties of sunflower seeds, a sieve with perforations of diameter 2.0 mm was selected since the seeds and kernels cannot pass through.

The screen is cheap and locally available on local market.

4.2.2.1 Weight of the sieve

w = 0.5 *(rrdl)xtxpxg* .... (3)

w = 0.5 x b(Tx 0.18 x0.469)x0.0015 x 7850 x9.81 = 15N

4.2.3 Threshing chamber

This is where the shearing action takes place. 8 beaters in form of longitudinal conveyors made of square bars of mild steel 7.5mm x 7.5mm

Inside the threshing chamber is a circular cylindrical section with a detachable 2.5mm thickness sieve underneath and enclosed with 2.5mm thick mild steel metal sheet cover was chosen due its malleability and ductility making it easy to be folded and joined

It houses the shaft cylinder and the attached beaters that thresh the sunflower

The capacity of the threshing chamber was calculated from

v = $(nR^2 - nr^2)1$ .... (4)

v= (a90?- rt60)400 = 5.7x 10°mm?

Mass accommodated in the threshing chamber = 5.7x 107°x337.1= 1.9Kg

mass of the beaters(M) = volume x density = 4 x 0.0075 x 0.0075 x 0.4 x7850 = 0.7kg

Mass of the drum; Md = ndl lp5 ....(5)

= Ix 0.120.64 0.0027850= 2.7 **kg**

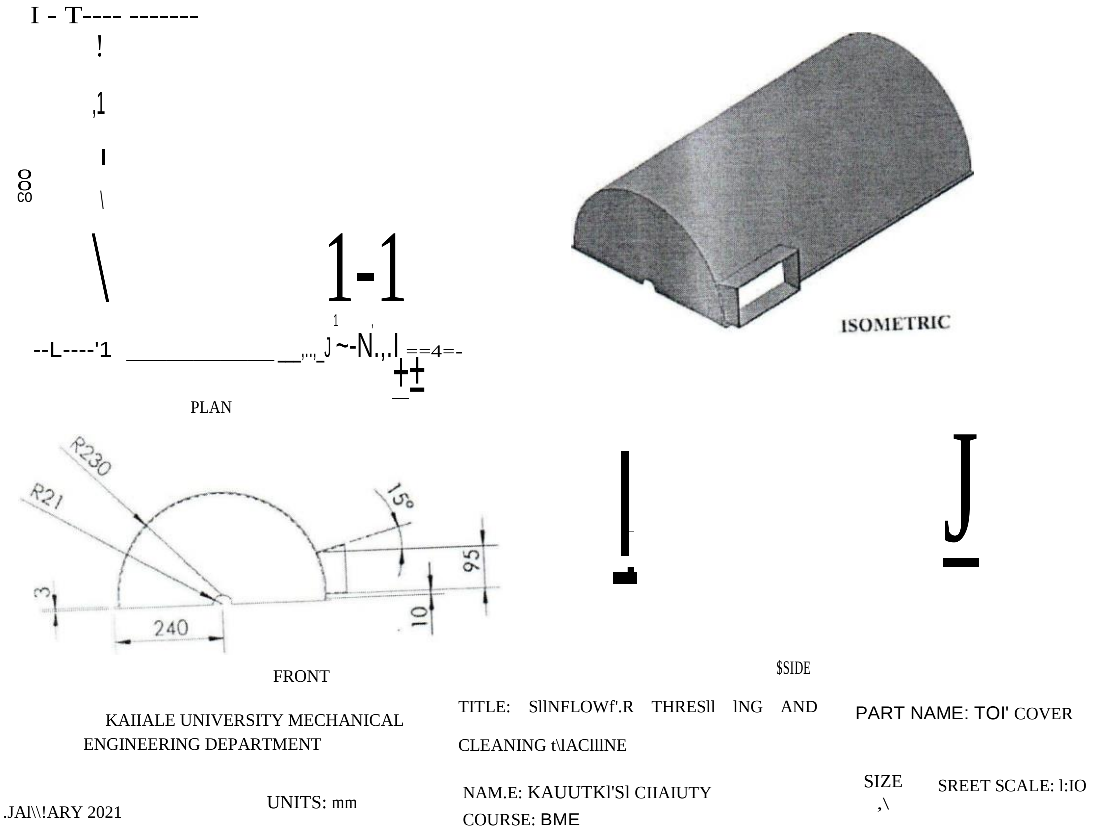

Figure 4.2 2-D Drawing for Threshing Cylinder Cover

SIDE

FRONT

KA BAU'. UNIVERSITY TITLE: SUNFLOWER THRESHING AD
MECIIANICAL £NGlNEELUNG DEPAlrfi\lENT CLEANING MACUlNE PART NAME ROTOR WITll llEATl!:RS

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Figure 4.3 2-D Drawing for Rotor with Beaters

4.2.4 Determination of pulleys diameters

The pulley of steel material is selected due to its strength. Diameters were determined using the expression[l OJ

$$Dz = \frac{N, +D,}{N,} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

N_1 = Speed of driving pulley (1400rpm)

D,=Diameter of driving Pulley (3 inch) N

z=Speed of driven pulley (600rpm) Dz =

Diameter of driven pulley

$$Dz = \frac{1400 * 0.075}{600} \quad 0.2175$$

4.2.5 Determination of belt length

The nominal belt length was determined to know its length to drive the threshing drum and the fan. The length of the belt (L) is to be determined using the expression

$$L = \frac{\pi}{2}(D_1 + D_2) + 2c + \frac{(D_2 - D_1)^2}{4c} \quad \text{.......................... (7}$$

Initial data	Calculations and sketches	Results
Determination of belt length		
$D_1 =$ 0.075mm N = 600rpm. D_2 = 0.2175mm N_2 = 1400rpm.	• **Length of the belt** $c = \frac{D_2}{\pi} + D_1$ (0,2175) $c = \frac{0.075}{\pi} + 0.075 = 1.53mm$ 2 $L = (0.2175 + 0.075) + 2 * 1.53 + \frac{(0.2175 - 0.075)^2}{4 * 1.53} = 3.52mm$	**L=3.52mm**

Angle of contact lap

$$\theta = \{180 - 2\sin^{-1}\left[\frac{D_2 - D_1}{2c}\right]\} * \left(\frac{\pi}{180}\right) \quad \text{...(8)}$$

θ Is the angle of lap between the motor pulley and the threshing pulley

$$\theta = \{180 - 2\sin^{-1}\frac{0.2175 - 0.0751}{2 * 1.53}\} * \left(\frac{\pi}{180}\right) = 3.05rads$$

4.2.5 Power required by the machine.

The power required by the thresher helped in choosing the motor.

Centripetal force resulting from the rotation of the cylinder breaks the hull and separates it from the seeds using the blower attached to the extreme end of the machine. This force was determined [11]

$$P, = F * V \quad ....(9)$$

$$F = m * w^2 * r \quad ....(10)$$

Initial data	**Calculation**	**Results**
Ms = 7.243Kg	$O= \frac{2n * 500}{60} = 52.7 \frac{rads}{s}$	rads o- 52.7- s
Ps = 7850 Kg/m^3 r=0.015m	$V_m = \frac{\pi D_1 N_1}{60}$ $= \frac{+\ 0.075 * 500}{60}$ = 5.59m/s	V,, = 5.59m/s
	MT = M,+M + M + Ma = 0.7+ 1.5 + 2.7 + 0.96= 5.86Kg F = 5.86 * 62.8^2 * 0.015 = 346.7N Ft = F + threshing force F,= 346.7 + 23.1 = 369.8N P, = 369.8 * 5.59 = 2067.182watts lHP = 746 watts Thus P, = 2.77HP A three phase 3 Hp motor was selected suitably for the machine	P, = 3HP

4.2.6 Determination of belt tensions

The belt tensions were determined using the expressionlnvalid **source specified.**

$$P=T,-T)V.................(11)$$

$\frac{T_1}{T_2} = e^{\mu\theta}$ ....(12)

μ- Friction coefficient, Vm- the velocity of the belt in m/s, θ- Angle of contact, T,- Tension in the tight side of the belt, T,- Tension in the slack side

solving for the belt tensions		
o =0.23 for leather belts on aluminum cast pulley	T, / Tz = eo.23•1.87 = 1.537 **T, = 1.537 +T,** 3+0.746 + 1000 = (T, - T,) +5.6 T, = 1143.7N T, = 744.1N Total tension T= 1143.7 + 744.1 = 1887.8N	T,= 1143.7N T_2 = 744.lN

4.2.7 Belt selection

- tends to cushion shock
- requires no lubrication
- it is less likely to become misaligned than any other type of belt
- operates at a high speed as 33m/s
- transmits a given amount of power with less overall shaft pull than a flat belt drive
- V -belt has a long and free life. with efficiency ranging from 70 % - 90 %

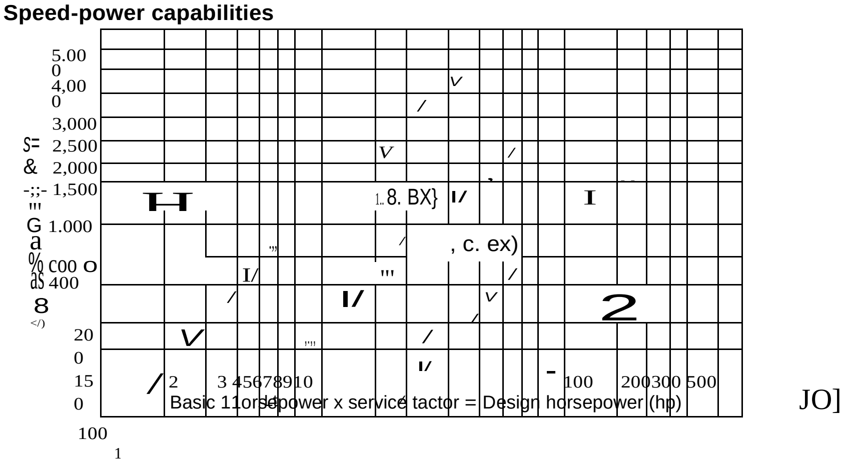


Figure 4.1 Shows speed power capabilities for leather v-belt 27

rom the design, the beltis transmitting 3hp at a speed of l 450rpm; therefore from the table bove,

v-belt type A was selected

~.2.8 The Blowing Fan

:entrifugal fan type is selected for this design work because it is relatively inexpensive and self-leaning as well as its ability to produce high volume and pressure air stream at relatively low

power requirement. [10]

The velocity of the cleaning air must be less than the terminal velocity of seeds to be cleaned in order not to blow them away[16]. Assuming sunflower kernels to be spherical,

The terminal velocity, Vt was reported[17]

$$Vt= -- \frac{3gDnP}{Pa} \text{ ....(13)}$$

$$Vt= \frac{3 \times 9.81 \times 0.00736 \times 33.7}{1.225}$$

V,5.7 m's

Vis the terminal velocity, D= Geometric mean diameter, g = gravitational pulls, and

p,and,are particle and air densities respectively

The air discharge is given by

$$Q=V \, x \, A \text{ ....(14)}$$

Q=Airflow rate

A = Outlet cross sectional area

Taking the outlet to be of a rectangular cross section

$$A= 0.105x0.075 = 7.875x10?m$$

$$Q=5.5x\ 7.875x10\text{-}^{3} = 0.0433m^{3}/s$$

Therefore, a fan that blows an air velocity of 3.5 m/s and discharges 0.0433m^3 /scan separate

chaff from sunflower kernels

4.2.8.1 Weight of the blower

$$M= p * v \text{ ....(15)} \; M,=$$

$$4.4»107°4\ 7850 = 3.45kg$$

4.2.9 Shaft Diameter

Due to the strength, toughness, reliability on resistance to shock and repeated loading, steel material was selected for the shaft to accommodate the loads that would be impacted on it.

The maxnnum allowable shearing stress can be obtained as the lower value of 18% ultimate tensile stress (St) and 30% yield stress (Sy). They further stated that the allowable shear stress is reduced by 25% when there is a keyway in the shaft.[18]

4.2.9.1 Design Assumptions for shaft design

a. The material is homogeneous.

b. The material is elastic.

c. The stress does not exceed the elastic limit or limit of proportionality.

d. Circular Sections remain circular.

e. Cross-sections rotate as if rigid i.e. every diameter rotates through the same angle.

Table 4.1 kt and km values for different shafts

Nature of load	┸	***K,***
1. **Stationary shafts**		
(a) Gradually applied load	1.0	**1.0**
(b) Suddenly applied load	1.5 **to**2.0	1.5 **to 2.0**
2. **Rotating shafts**		
(a) **Gradually applied or** steady **load**	1.5	**1.0**
(b) **Suddenly applied load with minor shocks only**	**1.5to2.0**	**1.5 to 2.0**
() Suddenly **applied load with heavy shocks**	2.0 **to 3.0**	**LS to 3.0**

The shafts sizes was determined using the equation below;[l O]

$$d^3 = \frac{16}{\pi\tau_S}((K_b M_m)^2 + (K_t M_t))^{\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Where: *d* = Shaft diameter (m)

rs= the allowable stress of the steel shaft (N/m2)

Kb andKt = Combined shock and fatigue factors for bending and torsional moment respectively

-

9.2 Determination of torsional moment p M,=7 "' .... (17)

= Revolution per minute, 1 ==

Power delivered

l = **Z** rd = **1. 57d ..'" ....(18)**

l = **15cm**

:.9.3 Determination of the diameter of the shaft

mputation of the angle of wrap **(a)**

m; cos a= -- D-DA / 2€

- 1 (0.2175 - 0.075) 0
= cos- ------ = **87. 3** 2 * 1.53

2.9.3 Calculating the forces on the shaft due to belt tensions F,

=T,cos«

F, =1144co0s87.**3**° = **53. 3N** FA

=T,cos«

F2y =744.1cos87. **3°** = **35. 3N** Total

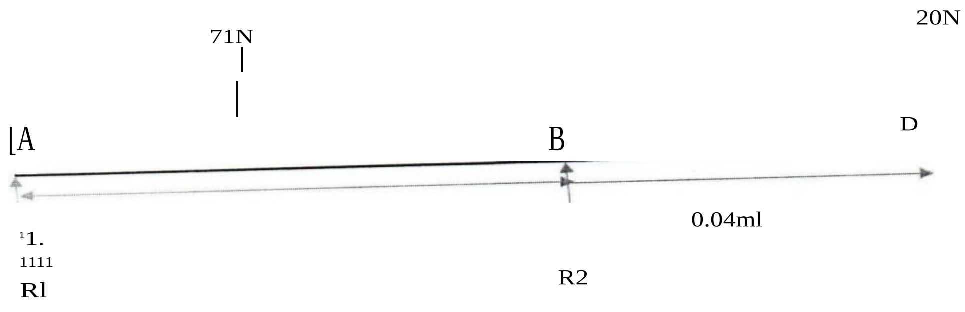
verticle force(F) = F 1y + Fay

Total verticle force(F) = 53.3 + 35.3 = 88.6N

otal vertical force (F) on the shaft at the pulley point

Ty= Fy + weight of the pulley = **88.6+ 25.5 = 114.lN**

f.2.9.4 **Shaft loading and determination of bending moments**



-

tal weight= 48. lN

reight of the fun= 9.4N

$\wr_1 + R_2$ 961.5

'aking moments about R_1

71 * 1.1) + (20*0.04) = (l. 1 R)

l= 55N

±,-36N

rhe bending moment at:

tON load= 0

R_1 load= (71 *0.55) +(55* 1.1) +(20* **1.14)** = 122.35Nm

$5N load = (36*0.55) + (55*0.55) = 50.95Nm

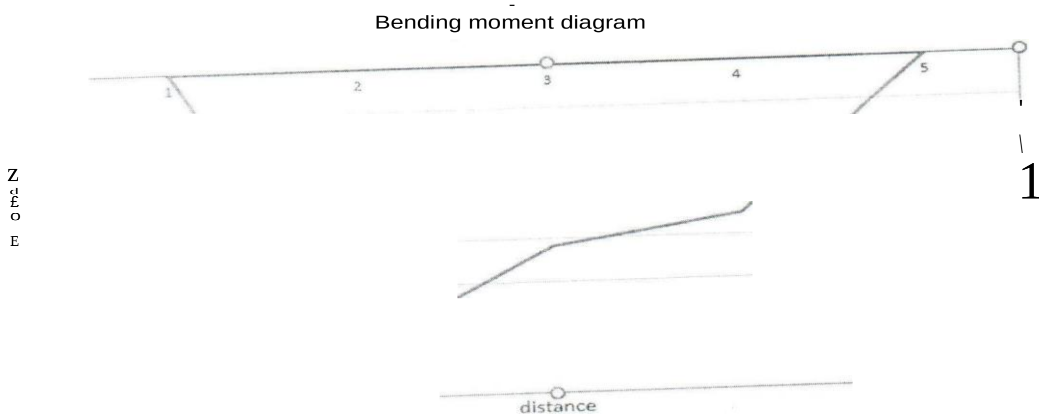


Figure 4.2 bending moment diagram

Torsional moment (M) = -- 3•746 = 400Nm 5.59

d 3 - [11 * 90.3 * 16 106 x [(1.5 * -126.56) + (400) 2 F 2 1

d = 0292m

factor of safet = ultimate tensile stress / working stress = 668.8 / 90.3 = 7.4

Thus, a shaft of 30mm diameter was selected with a factor safety of 7.4

[0 **Frame**

main frame supported the whole weight of the prototype. The total weights carried by the main frame ded the weight of the hopper, housing, hulling unit, bearing and pulleys.[10]

$$\frac{F}{nA} \quad \text{..................} \quad (19)$$

±re; o = stress on the column

number of legs (n=4)

total supported by the frame cross

sectional area of the column

masshoper = 3.4kg

masSearing = 0.9 * 4 = 3.6 kg

massune,25 = kg

masssnars = 30kg

masssieve = 3.2kg

masseaters = 7.243kg

masScover = 4kg

massnotor = 25kg

masscylinder = 4.5kg

massn = 4.5kg masSrun

duct = 2.4kg

masSsunflower heads = 5kg

UTS = 35MN/m^2

• Design for the main support frame.

From equation 3-24;

$$F = \frac{\text{total weight on the frame(WE)}}{\text{Number of supports(n)}}$$

n=4

W= W,+ W +W, +W,+ W+ Waters t Wa + +W, + W+ W.a + Wa« seeds

W, = (3.4 + 3.6 + 25 + 30 + 3.2 + 7.243 + 4 + 25 + 4.5 + 4.5 + 2.4 + 5) x 9.81

W,= 117.843X 9.81 **W,= 1156.04N**

Force (F)on each support= $\frac{1156.04}{4}$

= 289.0N

Force (F)on each support= 289. ON Cross sectional area of the support

$$= \frac{2}{} \left(\frac{1.5}{1000} * \frac{4}{100}\right)^2 m$$

Cross sectional area of the support =1.2%10m

Compressive stress, $a = \frac{F}{A}$

$$a - \frac{152.4}{1.2 \times 10^{-4}} - 1.3\ MN/m^2$$

W, = 609.8N.

Force = 152.4N

e the compressive stress of 1.3 MN/m^2 is less than the ultimate tensile strength of 35MN/m^2, failure snot occur at normal loading.

-

veloping the layout of the machine

orks 2016 CAD software was used to draw 3D models and obtain 2D drawings of the selected and sized e components, assembly and simulation of sunflower threshing and cleaning machine.

Labeled Assembly of sunflower threshing and cleaning machine

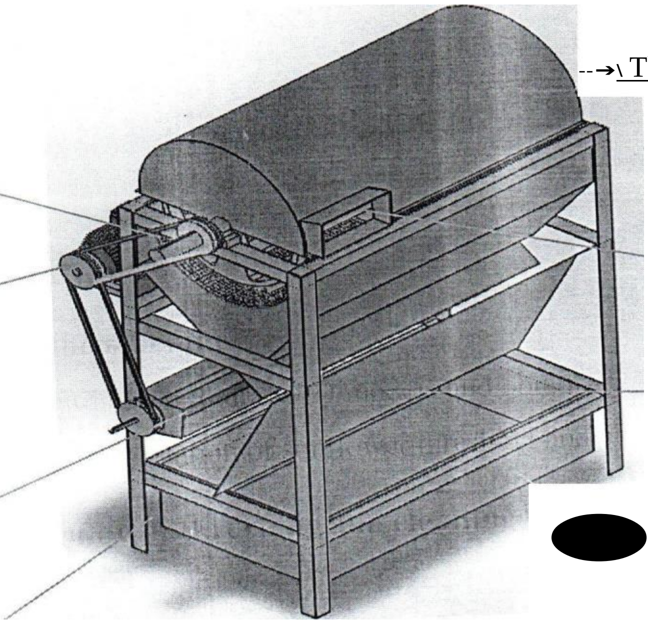


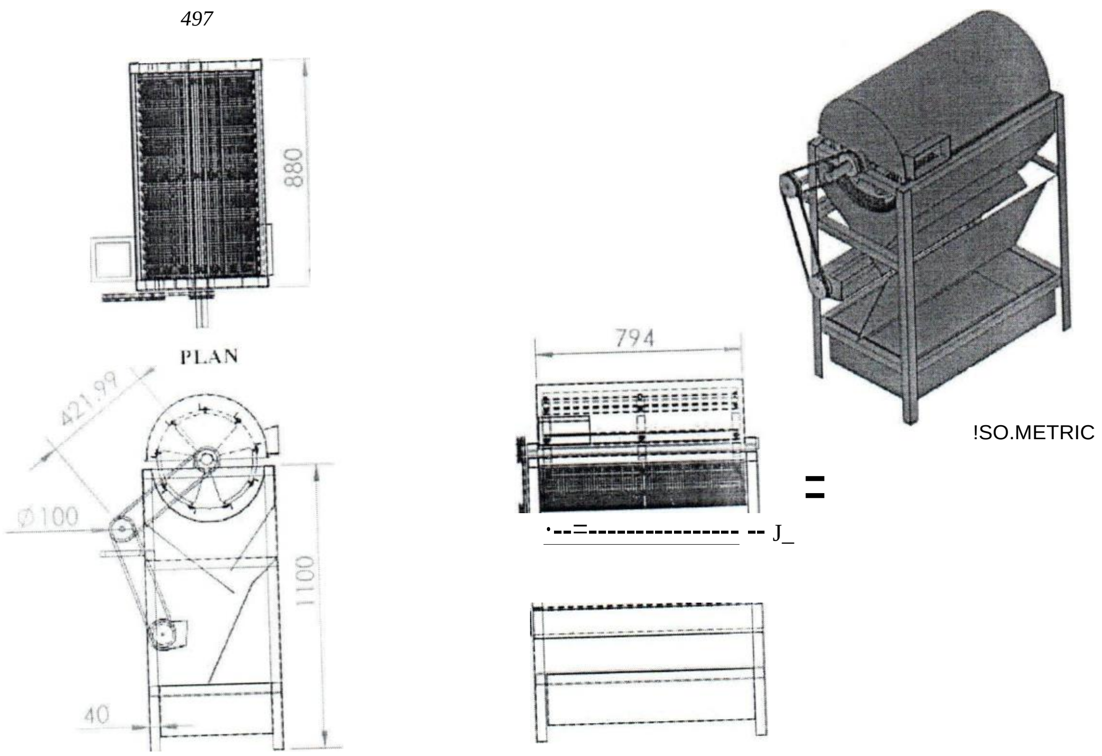
Figure 3.3 3-D drawing of sunflower threshing machine

ing the operation of the machine, un-threshed sunflower is fed into the feed chute to enter the threshing mber.

he threshing chamber, the rotating angle bar-beaters beat the sunflower against the sieve and the top cover : to centripetal and impact forces developed during rotation. These forces open the sunflower pods. The seeds l small, light chaff pass through the sieve while coarse chaff is conveyed by the beaters to the chaff outlet ute. The seeds and light chaff fall on the guiding plates which lead them into an air stream from the blower. 1e to differences in density terminal velocity between the chaff and seeds, the light chaff is suspended in the stream and flow upwards outside through the light chaff outlet as illustrated. The seeds, being denser than the

aff continue down by gravity to the collection point.

-



TITLE: SUNFLOW'ER TIIRESII ING AND CLEANING MACHINE

KABAI.E IINIVERSITY
MECHANICAL ENGINEERING DEPARTMENT

l'ART NAM.£: MACHINE ASSEMDLY

.J.-\NUAll\' 2021 | UNITS: 111111 | N.-\ME: KABUTETSI CHARIT\' · | COURSE: ME | SIZE A | SHEET SCALE: 1:20

Figure 4.4 2-D Drawing for the Machine Assembly

Chapter Five

CONCLUSION AND RECOMMENDATION

onclusion

,fferent components were designed with a **threshing capacity** of **200kg/h r, with the slating angle (Angle of**

Ase)= **26** and the volume of the hopper as 0.023.

1e prototype can be **fabricated from any workshop if the materials are readily available and its affordable**

1e methods that can be used are machining, welding, milling, drilling, cutting and gridding.

or better and high efficiency, the machine should be tested with dry sunflower heads

ecommendations

~ Cam follower to provide a shaking mechanism

[he plate to the blower adjustable to match different speeds

The machines efficiency could as well increase further more when the clearance volume is **altered with**

eased speeds of the threshing unit

-

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Appendix