DEVELOPMENT OF A LOCUST BEAN PROCESSING PLANT
(DESIGN AND CONSTRUCTION OF A LOCUST BEAN DECORTICATOR)

BY

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2000/9480EA

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A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG.) AGRICULTURAL ENGINEERING.
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NOVEMBER, 2006.

DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree, diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

07/11/2006

Aderoju .A. Adedotun

Date

DEDICATION

This project is dedicated to my late father Alhaji B.L Aderoju, my mother Mrs. T. Aderoju and to my loved ones.

CERTIFICATION

This project entitled ''Design and construction of locust bean decorticator'' by Aderoju .A. Adedotun meets the regulations governing the award of the degree of Bachelor of Engineering {B. ENG.} of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

_______________ 02/11/2006

Engr. Dr. M.G Yisa Date

Supervisor

_______________ 02/11/2006

External Examiner Date

_______________ 14/11/2006

Engr. Dr. (Mrs.) Z.D. Osunde Date

Head, Department of Agricultural Engineering

ACKNOWLEDGEMENT

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I wish to acknowledge with sincere gratitude the tireless support of my loving mother Mrs. T. Aderoju, My brothers Aderoju Monsor and Aderoju Basit, My sisters Taiwo and Kehinde Aderoju, and also Igoudala Segun, Olajide Kafayat, Nurudeen Sala, Saba Zainab, Atolagbe Azeez and Aiyedogbon Yemi, you have been wonderful, I really appreciate your effort.

I thank you Mrs. T. Aderoju for having me, May God repay you in abundance.

ABSTRACT

A locust bean decorticator was designed and constructed using readily available and affordable materials. The decortication is achieved by feeding the seeds in the vertically rotating rollers. The rollers rotating at low centrifugal force rub the seeds against the decorticating drum. A decorticating efficiency of 68% was obtained at 100kg/hr feeding rate. The machine was designed to mechanize the existing traditional method of locust bean decortication in order to reduce the time and labour involved.

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ABBREVIATIONS AND NOTATIONS

A = area (m^2)

F = force (N)

L = length of specimen (m)

L_n = bearing fatigue life (h)

M = mass (kg)

M_b = bending moment (Nm)

M_t = torsional moment (Nm)

N = motor speed (rpm)

P = power (kW)

T = torque (Nm)

V = volume (m^3)

ρ = density (kg/m^3)

σ = shear stress (N/m^2)

CHAPTER ONE

1.0 INTRODUCTION

The African locust bean tree which belongs to the family of mimesacease and is of leguminosae group and clappertoriana, *parkia fillicoidial and parkia biglobosa.* Beaumont, (2002). Locust bean seed is an important protein based fermented food produced from African locust bean.It is of high quality and of very high nutrients for human and animal feeds. It is produced and consumed throughout Nigeria and West Africa. Its production is at the cottage industry level. It is called various names in various Nigerian language “Iru” (Yoruba) “dawadawa” (Hausa), and “ogiri” (Ibo).

The locust bean fruit consist of pods which form edible part of the plant, each pod contains a yellow pulp which envelopes the thin membrane that covers the brownish-black seed coat to be removed.

Today, the production of food condiments has been carried out mainly by farmers and those in the rural areas. The processing is mostly done by women. The consumption of these food condiments has really declined due to the task involved in the local processing but with a decorticating machine, the processing will be done faster and good quality product would be achieved. A decorticator is a machine which is used to safely remove the softened coat of the seed without affecting the quality of the seed been decorticated.

1.1 Aims and objectives

The aim of this project is to mechanize decortication of locust bean seed.

In order to achieve this broad aim, the specific objectives are:

i. To design and fabricate a decorticating machine for locust bean seed.

ii. To fabricate the machine from locally available materials

iii. To test the machine for efficiency, capacity and durability.

1.2 Justification

In this country, many people in the rural environment and majority of the poor really depend on the local food condiments like locust bean seed. Processing of locust bean seed especially decorticating is really tasking and time consuming. There is therefore the need for a machine which saves time, reduces drudgery and is affordable. Hence, the need for a decorticating machine.

1.3 Scope

This work covers design, fabrication and performance evaluation of the locust bean decorticator which can be useful either for domestic or commercial purpose.

1.4 Limitation

The machine designed and fabricated in this project can handle only cooked locust bean seed.

CHAPTER TWO

2.0 LITERATURE REVIEW

Decortication is the process of breaking open of pods to reveal the seeds contained in them. Decortication as a processing unit operation is applied mainly to pulse (groundnut e.t.c). The term is also used to describe the process of removing the outer hard coatings of some crops such as locust beans.

Makanjuola (1975) conducted a study on decorticating (shelling) of melon seeds by impact force. The impeller with four slots was found to be most effective in the seed from 1867 to 2154 m/min.

Yadav and Singh (1991) developed a centrifugal (vertical impeller type) sunflower seed decorticator –cum cleaner. The decorticating efficiency and cleaning efficiency were 82.20% and 91.22% respectively, with 15.04% kernel damage. Earlier on Nag *et al.* (1983) developed a centrifugal impeller type sunflower seed decorticator, which was rotated in a horizontal plane and decortication, was done by subjecting the seeds to high centrifugal force and then striking them on hard surface. A decorticating efficiency of 35% to 65% and seed damage of 18% to 25% were observed in the optimum speed range of 2000 to 2600 rpm.

In another development, Oni (1990), in his work on decorticating (shelling) machine related properties for African locust bean fruit inferred that the cylinder speed and interaction between cylinder speed and moisture content been significant at 5% level are indicative of the importance of drying pods prior to machine decortication.

He also observed that some husk fibres entangled the decorticating (shelling) studs as mechanical shelling progressed. This he said was more pronounced for high moisture (11.83%) pod samples.

Rajvir *et al.* (1996), reported on centrifugal decortication of sunflower seed and said that the peripheral speed was observed as the most effective parameter which affects the decorticating efficiency and kernel damage. They observed that increase in decorticating efficiency was greater in the range of 140309. 40 to 169530mm/sec at peripheral speed beyond this range, the rate of increase in decortication efficiency was reduced.

The present study was undertaken to maximize decorticating efficiency by varying machine and system parameters.

2.1 Locust bean processing

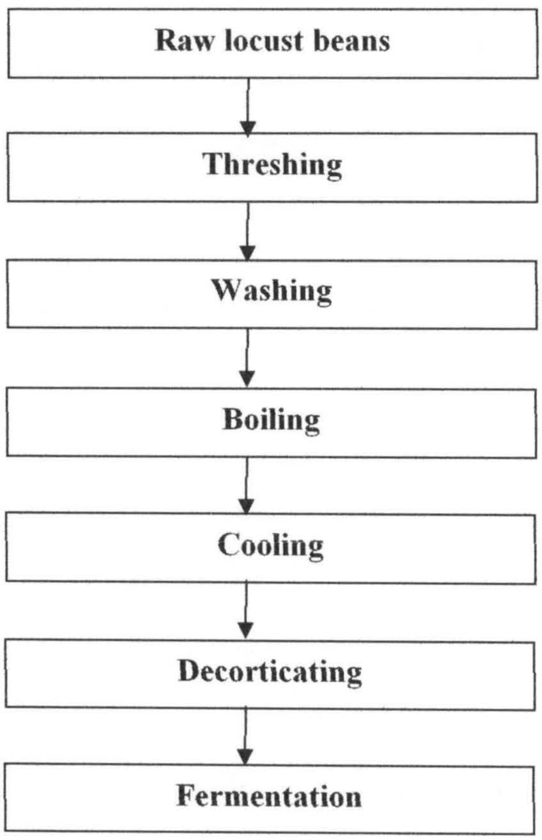


Fig. 1 Locust bean processing chart

Threshing process which is the separation of the pods from the seeds is followed by thorough washing. After washing the seeds will be boiled (cooked) for some hours so as to make the seeds soft which will be allowed to cool down before decorticating which is the removal of the outer hard coatings of the cooked locust bean before fermentation process takes place.

2.2 Locust bean decortication

This is the process of removing the outer hard coatings of the cooked locust bean seeds. This could be done by peeling or rubbing the outer coatings by either twist, impact or compressing forces.

2.3 Decortication by traditional method

This is done after the locust bean seeds have been cooked for a long period of time in order to make the hard outer coatings soft so that the outer coatings are peeled with bare hands in order to get the seeds for several purposes. Though it is tedious and time consuming, but the end result will still be achieved.

2.4 Mechanical decortication of locust bean seed

This is accomplished mainly by rubbing the cooked locust bean seeds falling into the decorticating unit against the rotating end part by the impact of the shaft on falling unshelled seeds. The screw contains some slight flanges on its surface to ensure and enhance easy shelling (decorticating)

CHAPTER THREE

3.0 DESIGN CALCULATIONS

3.1 Design considerations

In this design, the following conditions were considered.

Conditions considered for design are as follows:

i. The machine is a food processing unit which requires hygienic materials for the constructions i.e. stainless steel, galvanized mild steel etc.

ii. Through put of the machine estimated at 100kg/hr.

iii. Leakages must be highly minimized.

3.2 Power requirement

Power requirement for the locust bean decorticating machine can be modelled into three separate sections listed below:

(a) The bulk of the power input is power required to decoat the locust bean

(b) Power required to drive the inner cylinder mounted on the shaft and the whole assembly mounted on the shaft.

(c) Power required to drive the pulley on the motor is also considered

We have the total power requirement calculated by summing up the power break down as listed below

Taking P = total power

P_d = Power required to decoat

P_a = Power to drive shaft assembly

P_p = Power required to drive the pulley

$$P = P_d + P_a + P_p \tag{1}$$

P_d (decorticating power)

This is given from the power and torque relationship

$$P = T\omega \qquad (2)$$

$$p_{\text{d}} = T\omega \qquad (3)$$

$$T = \frac{\pi D^3 t}{16} \quad : \quad \omega = \frac{2\pi N}{60} \qquad (4)$$

where

P_d = power to decoat

T = torque

π =3.142

t = shear stress for boiled locust beans is given as 9086.86 N/m^2 (Oloso, 1988)

ω = angular velocity

N = rpm (number of rotations per minute) of the shaft assembly

D = diameter of cylindrical roller

Given that

D =29 cm = 0.29 m

t = 9086.86 N/m^2

N = 700rpm

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 700}{60}$$

ω = 73.3 rad/sec

$$T = \frac{\pi D^3 t}{16} = \frac{\pi \times 0.29^3 \times 9086.86}{16}$$

T = 43.515 Nm

Hence the decoating power P_d is given by

$P_d = T\omega$

$P_d = 73.3 \times 43.515$

$= 3189.64\,\mathrm{W}$

$P_d = 3.190\,\mathrm{kW}$

Power require to drive shaft assembly P_a

This is given by

$$P_a = T_a \omega \qquad (5)$$

$$T_a = \omega_a R \text{ and } \omega = 73.3 \text{ rad/sec} \qquad (6)$$

T_a = torque required by the shaft assembly

ω_a = total weight of shaft assembly (4.422 kg)

R = radius of inner cylinder assembly (14.5mm)

$T_a = 4.422 \times 145 \times 10^{-3}$

$T_a = 0.64119$ Wm

$P_a = T_a\omega = 0.64119 \times 73.3$

$P_a = 46.999$ W

Power required to drive the pulley, P_p

$$P_p = T_p \omega \qquad (7)$$

$$T_p = \omega_p R \qquad (8)$$

ω_p = mass of motor mounted pulley (smaller pulley)

R = radius of pulley = 0.05 m (smaller pulley)

= 0.10 m (large pulley)

$$\omega = \frac{2\pi N}{60}$$

$N = 1435$ rpm for small pulley

$N = 700$ rpm for large pulley

For the smaller pulley P_{p_1}

$R = 0.05$ m

Thickness (t) = 20 mm = 0.02 m

Volume of pulley $v = \pi R^2 t$ (9)

$$= \pi \times 0.05^2 \times 0.02$$

$$v = 1.57 \times 10^{-4} m^3$$

Density of mild steel $= \dfrac{mass}{volume}$ =7850kg/m^3

mass $= \rho \times v$

$$= 7850 \times 1.57 \times 10^{-4}$$

mass $= 1.233 Kg$

$T_p = 1.233 \times 0.05$

$T_p = 0.0617$ N/m

$$\omega = \frac{2\pi N}{60} = \frac{2 \times \pi \times 1435}{60}$$

Taking into consideration motor efficiency of 85%

$$\therefore \omega = \frac{2 \times \pi \times 1435(85\%)}{60} = 127.7 \text{ rad/sec}$$

$$P_{p_1} = T_p \omega \qquad (10)$$

$$P_{p_1} = 0.0617 \times 127.7$$

$$P_{p_1} = 7.88 \text{ W}$$

For the large pulley

$R = 0.10\text{m}$

The shear thickness of the pulley is 0.02m

The weight of the pulley was determined by weighing to be 1.5kg

$$T_{\mathrm{P}_1} = \omega_p R$$

$$T_{\mathrm{P}_1} = 1.5 \times 0.10 = 0.15 \text{ N/m}$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 700}{60}$$

$$\omega = 73.3 \text{ rad/sec}$$

$$P_{p_2} = T_p \omega = 0.15 \times 73.3$$

$$P_{p_2} = 10.99557$$

$$P_{p_2} \approx 11 \text{W}$$

Total power to drive pulley is $P_p = P_{p_1} + P_{p_2}$

$$P_p = 7.88 + 11$$

$$P_p = 18.88 \text{ W}$$

Total power required by the decorticating machine is given by

$$P = P_d + P_a + P_p$$

$$= 3189.64 + 46.999 + 18.88$$

$$= 3255.52 \text{ W}$$

$P = 3.256\,\text{kW}$

Therefore an electric motor of rated power 5hp is chosen

Motor selection

Considering the power required result that was deduced from the power analysis which was calculated to be 3255.52W

A 5hp motor was selected for the decorticator (3730W motor).

Belt selection

From belt selection table (Douglas, 2005). Based on power requirement and rpm; a type 'A' SPZ belt was selected suitable for the decorticator.

3.3 Analysis for shaft assembly

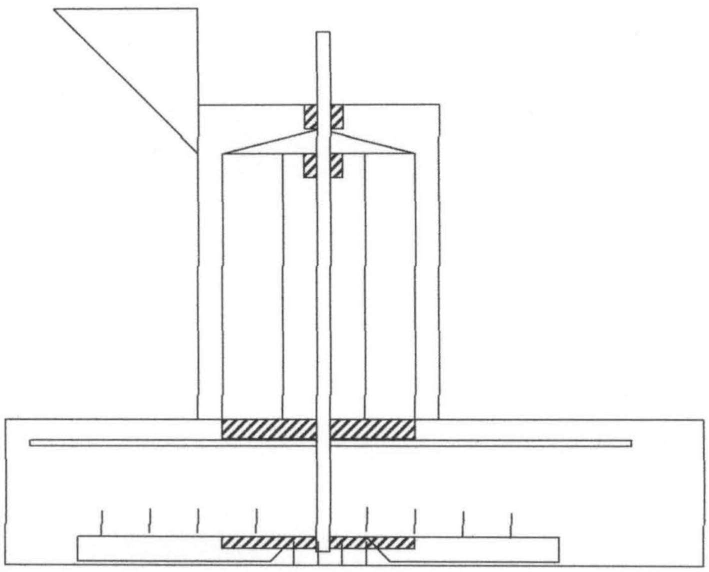


Fig. 2: Diagram of the locust bean decorticator

Volume of the cylinder plate is given by

$$v = \pi D \times h \times t + (volume\ of\ top\ and\ bottom\ \text{covers})$$

$$= \pi \times 100 \times 10^{-3} \times 350 \times 10^{-3} \times 1 \times 10^{-3} + 2\left(\frac{\pi D^2}{4} \times 1 \times 10^{-3}\right)$$

$$= 1.099557 \times 10^{-4} + 1.57 \times 10^{-5} \tag{11}$$

$$= 1.256557 \times 10^{-4} m^3 \times 2\ cylinders = 2.513 \times 10^{-4} m^3$$

$$v = 2.513 \times 10^{-4} m^3$$

Volume of Disc plates

$$v = 2\left(\frac{\pi \times (280 \times 10^{-3})^2}{4} \times 2 \times 10^{-3}\right)$$

$$= 2.46 \times 10^{-4} m^3$$

Top flat blade

$$volume = 550 \times 10^{-3} \times 20 \times 10^{-3} \times 2 \times 10^{-3}$$

$$= 2.2 \times 10^{-5} m^3$$

Lower flat blade

$$volume = 550 \times 10^{-3} \times 40 \times 10^{-3} \times 2 \times 10^{-3}$$

$$= 4.4 \times 10^{-5} m^3$$

Total volume (v) of assembly is given as

$$= 2.513 \times 10^{-4} + 2.46 \times 10^{-4} + 2.2 \times 10^{-5} + 4.4 \times 10^{-5}$$

$$= 5.633 \times 10^{-4} m^3$$

Density of mild steel $= 7850 \text{kg/m}^3$

$$\rho = \frac{m}{v}$$

$$m = \rho \times v$$

$$= 7850 \times 5.633 \times 10^{-4}$$

$$= 4.422 \text{kg}$$

Power transmission shaft Analysis

We can model the shaft as rotating at constant angular velocity using statics since it is known from dynamics that when angular acceleration equals zero $\sum T = 0$.

Knowing the speed of rotation of the shaft to be 700 rpm we can convert between torque 'T' and power 'P' using equations below.

$$T = \frac{P}{\omega}; \qquad \omega = 2\pi f \tag{12}$$

$$T = \frac{P}{2\pi f} \tag{13}$$

$$\therefore\ T = \frac{P(kW) \times 9550}{rpm}$$

Where ω and f are angular velocities usually in rad/sec and rps respectively

f = frequency given in rpm (revolution per minute)

So if we take electric motor efficiency to be 85%

$$\therefore\ T = \frac{3.730 \times 9550}{1435 \times 0.85}$$

$$= 29.204\,\text{Nm}$$

The net driving force F

$$F = F_1 + F_2 = \frac{T}{R} \tag{14}$$

F_1 and F_2 are the belt force transmission on the tight and slack sides of the V-belt respectively

F = Net driving force

T = Torque

R = Pitch radius of the driving pulley (50×10^{-3})m

$$F = \frac{29.204}{50 \times 10^{-3}}$$

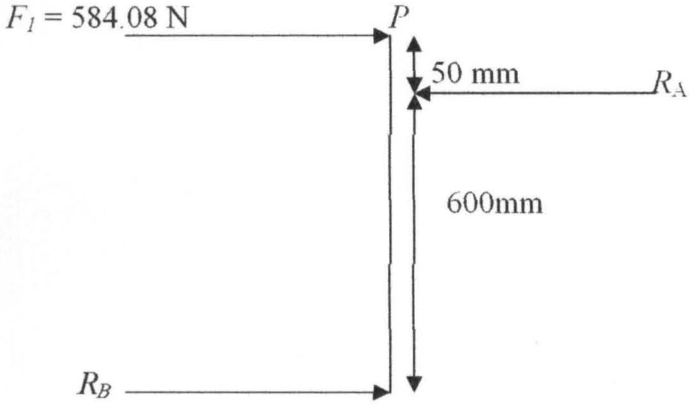
$$F = 584.08 \text{ N}$$

Taking the following points into consideration

1. That torque is transmitted in the horizontal plane
2. The shaft is under a combined bending (due to belt tension) and torsional moment

Then the maximum bending moment can be determined as follows

From the force diagram below,



If moments are taken about point B

$$\sum M_B + \curvearrowright = 0$$

$$F(650 \times 10^{-3}) - R_A(600 \times 10^{-3}) = 0$$

$$\frac{584.08(650 \times 10^{-3})}{600 \times 10^{-3}} = R_A$$

$$R_A = 632.75 \text{ N}$$

For uniform or balanced loading

$$\sum F \overset{+}{\rightarrow} = 0$$

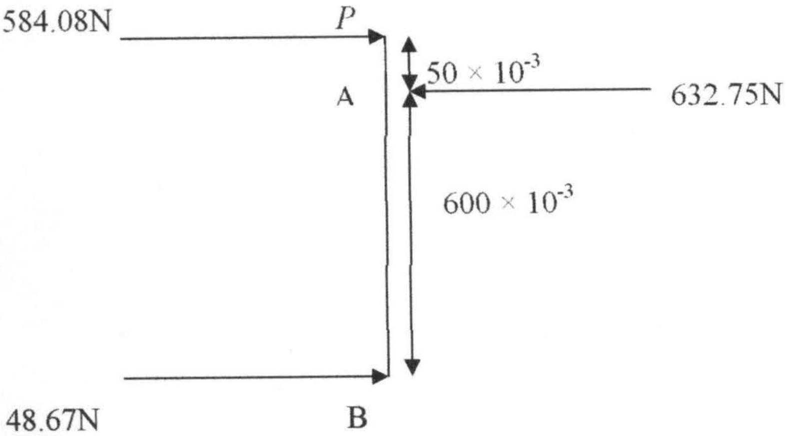
$$F - R_A + R_B = 0 \qquad (15)$$

$R_B = R_A - F$ (16)

$= 632.75 - 584.08$

$= 48.67$

Redrawing the force diagram we have it as shown below.



To determine the bending moment using the equation

$$m_b + F - R_A(x - 50 \times 10^{-3}) + R_B(x - 600 \times 10^{-3}) = 0$$

$$m_b + 584.08x - 632.75(x - 50 \times 10^{-3}) + 48.67(x - 600 \times 10^{-3}) = 0$$

$$m_b = -584.08x + 632.75(x - 50 \times 10^{-3}) - 48.67(x - 600 \times 10^{-3}) = 0$$

At point where x =0, i.e. point P

Where x =0

m_p= -584.08x

m_p= 0

At point A,

When $x = 50 \times 10^{-3}$m

$$m_A = -584.08x + 632.75(x - 50 \times 10^{-3})$$

$$= -29.204\text{Nm}$$

At point B,

When $x = 650\times 10^{-3}$m

$$m_B = -584.08x + 632.75(x - 50\times10^{-3}) - 48.67(x - 600\times10^{-3})$$

$$m_B = -379.650 + 379.650 - 2.4335$$

$$m_B = -2.434\,\text{Nm}$$

The maximum bending moment is 29.204Nm at point A

$$\therefore m_b = 29.204\,\text{Nm}$$

Torsional moment $m_t = (F_1 - F_2)R$ for belt drive system

$$m_t = (F_1 - F_2)R \tag{17}$$

$$= F_R$$

$F = 584.08$N

R = Radius of driving pulley = 50×10^{-3}m

$$m_t = 29.204\,\text{Nm}$$

To calculate for the diameter of the required shaft

From the formula

$$d^3 = \frac{16\left[(k_b m_b)^2 + (k_r m_t)^2\right]^{1/2}}{\pi S_s} \tag{18}$$

Where

Ss = Allowable combined shear stress for bending and torsional for steel shaft with keyway = 40×10^6 N/m^2

K_r = combined shock and fatigue factor applied to torsional moment (1.5) for minor shock

K_b = combined shock and fatigue factor applied to bending moment (1.5) for minor shock

m_b = maximum bending moment = 29.204 Nm

m_t = maximum torsional moment = 29.204 Nm

$$d^3 = \frac{16\left[(1.5\times 29.204)^2 + (1.5\times 29.204)^2\right]^{1/2}}{\pi\times 40\times 10^6}$$

$$d^3 = \frac{16[3837.93]^{1/2}}{\pi\times 40\times 10^6}$$

$$d^3 = \frac{991.22}{\pi\times 40\times 10^6}$$

$$d^3 = 7.888\times 10^{-6}$$

$$d = \left[7.888\times 10^{-6}\right]^{1/3}$$

$$= 0.01991\,\text{m} = 19.91\,\text{mm}$$

$$d \approx 20\,\text{mm}$$

From the shaft diameter calculation a shaft diameter of 20mm was chosen for the decorticating machine.

3.4 Bearing fatigue life

Given that the bearing operation under favourable condition i.e. maintained, lubricated and utilized correctly, the life of the bearing will reach and even exceed the calculated life

$$L_n = \frac{16667\times a_1\times a_2\times a_3}{N}\left[\frac{F_B\times C_E}{P}\right]^3 \quad \text{(h)} \qquad (19)$$

For simple rollers bearing where a_1, a_2, and a_3 can be considered equal to one, then the above equation is simplified to be

$$L_n = \frac{16667}{N}\left[\frac{C_E}{P}\right]^3 \qquad \text{(h)} \qquad (20)$$

where

L_n = life in hours

C_E = Extended basic dynamic load rating for the radial ball bearing in (Newton)

F_B = Dynamic load rating adjustment factor for number of adjacently mounted bearings.

a_1 = life adjustment factor for reliability

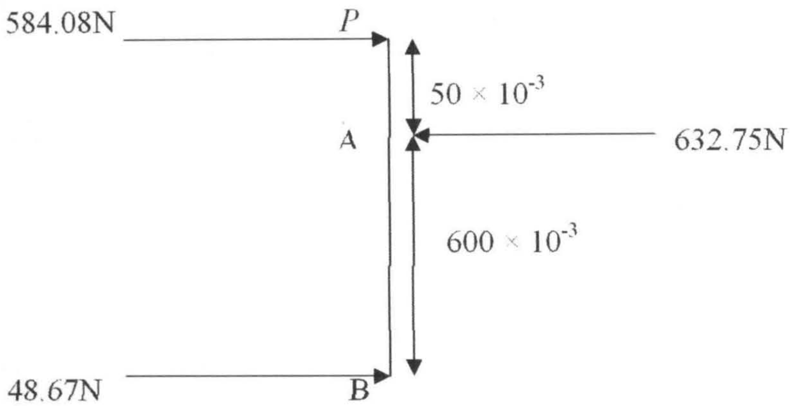
a_2 = life adjustment factor for ball bearing material

a_3 = life adjustment factor for application conditions

N = Operating speed

P = Equivalent radial load on bearing (Newton)

(Engineering edge 2000)



Bearing fatigue life (bearing at P+A)

An S 6204 sealed bearing was selected, which has a bore of 20 mm diameter and an outer diameter of 47 mm.

The selection was done to suit the bearing application requirement and the shaft diameter.

The life (fatigue life) of the bearing can be calculated from the formula

$$L_n = \frac{16667}{N}\left[\frac{C_E}{P}\right]^3 \text{ (h)}$$

Where C_E = 2220lbs = 1006.975 kg = 9868.355N

P = 632.75N

N = 700 rpm

$$L_n = \frac{16667}{700}\left[\frac{9868.355}{632.75}\right]^3 \qquad \text{(h)}$$

$$L_n = 90322.766 \text{ (h)}$$

For bearing at P+ B;

$$L_n = \frac{16667}{N}\left[\frac{C_E}{P}\right]^3 \text{ (h)}$$

C_E = 9868.355N

P = 48.67N

$$L_n = \frac{16667}{700}\left[\frac{9868.355}{48.67}\right]^3 \text{ (h)}$$

$$L_n = 198476754.3 \text{ (h)}$$

3.5 Hopper design

Before designing a hopper, there are some parameters to be considered

For coarse particles (particle > 500 microns in diameter). We use Johansson's Equation (mass flow rate)

$$\dot{m} = \dot{\rho} A \sqrt{\frac{Bg}{2(Hm)\tan\theta}} \qquad (21)$$

Where θ = Semi inclined angle of the hopper

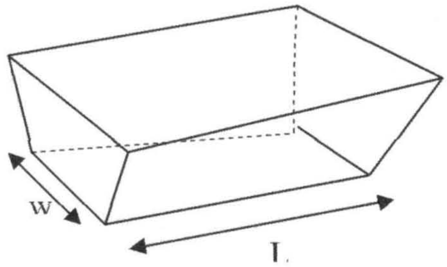
$\dot{m}$ = Discharge rate (kg/sec)

$\dot{\rho}$ = bulk density (kg/m^3)

g = Gravity (9.807 m/s^2)

B = Width of hopper outlet (m)

A = wl



Since the Johansson's Equation for mass flow is given as

$$\dot{m} = \rho A \sqrt{\frac{Bg}{2(1+m)\tan\theta}}$$

Given that

$\dot{m}$ = 100 Kg/hr = 0.0278 Kg/s

ρ = 0.59g/cm^3 = 590 Kg/m^3

g = 9.807 m/s^2

B = 120 mm = 120 × 10^{-3} m

θ = 40 °

$$A = \frac{\dot{m}}{\rho\sqrt{\frac{Bg}{2\,(1+m)\tan\theta}}}$$

$$A = \frac{0.0278}{0.59\sqrt{\frac{120\times10^{-3}\times9.807}{2\,(1+0.0278)\tan 40^\circ}}}$$

$$A = \frac{0.0278}{0.59\sqrt{\frac{1.17684}{1.7248}}}$$

$$A = \frac{0.0278}{0.682305}$$

$$A = 0.0407$$

$$A = wl$$

$$A = Bl$$

$$l = \frac{A}{B}$$

$$l = \frac{0.0407}{120 \times 10^{-3}} = 0.34\,\text{m} \tag{22}$$

The Hopper outlet Dimensions are

$B = 120$ mm

$L = 340$ mm

$H = 300$ mm

3.6 Frame design

For axially and laterally loaded frame;

$$\frac{F_C}{P_C} + \frac{F_{bC}}{P_{bC}} < 1 \tag{23}$$

Where F_c = actual direct axial stress

F_{bc} = actual direct bending stress

P_{bc} = allowable bending stress

P_c = allowable axial stress

P_{bc} =165N/mm^2 for steel

P_c =128N/mm^2 for steel

But $F_C = F/A$

where

F = axial load

A = Cross-sectional area of the section

$$F_{bC} = m/z \tag{24}$$

where

m = moment

z = Sectional modulus

Cross-sectional area = 2mm×50mm

= 100mm^2

Since F = (Total weight resting on frame) ×9.81m/s^2

= (molar weight + machine weight + Locust bean weight ×9.81m/s^2

=28kg+25kg+25kg×9.81m/s^2

$= 73 \times 9.81$

$= 716.13N$

The six legs of the frame share a load of $716.13N$

$$= \frac{716.13}{6} = 119.355$$

$$= \frac{119.355}{100} = 1.19355\,\text{mm}^2$$

$$F_{bC} = m/z \tag{25}$$

$$m = 119.355 \times 450$$

$$= 53709.75\text{N/mm}^2$$

$$= \frac{50^4 - 2^4}{6 \times 50^4} = 6.5 \times 10^{11}$$

$$F_{bc} = \frac{53709.75}{6.5 \times 10^{11}} = 8.2 \times 10^{-8}$$

Design is safe if

$$\frac{F_C}{P_C} + \frac{F_{bC}}{P_{bC}} < 1 \qquad (26)$$

$$\frac{1.1935}{128} + \frac{8.2 \times 10^{-8}}{165} < 1$$

$$9.32 \times 10^{-3} + 4.96 \times 10^{-10} < 1$$

$$= 0.009 < 1$$

CHAPTER FOUR

4.0 MATERIAL SELECTION, COST ANALYSIS AND TESTING

4.1 Material selection

Material selection is the process of choosing the right type of material in the construction of engineering structures and components

When selecting the materials used for relevant parts relating to the functions coupled with the stress condition and service life, considerations were made. Below are the properties considered in selecting the materials for the fabrication of the decorticator

Mechanical properties such as strength, toughness, stiffness, fatigue, hardness and wear resistance. Chemical properties such as resistance to oxidation and all forms of corrosion. Since the machine in question is a food processing machine.

The material selection for the construction of the decorticator was based mainly on the

1. Material availability
2. Suitability of the material for the design
3. Cost of the material

4.2 Material costing and analysis

The material costs listed in the table below are the costs of the materials as at October, 2006. These values may change depending on the market situation.

Table 1: Material costing and analysis

S/no	Materials	Specification	Quantity	Unit cost ₦	Cost ₦
1	Galvanized metal sheet	Mild steel gauge 20	2 sheets	6800	13600
2	Angle bar	Mild steel	2 lengths 2"	2000	4000
3	Disc plates	Mild steel	2 plates	1000	2000
4	Shaft	Steel	1	1500	1500
5	4" pipe	Galvanized 2 ft	1	800	800
6	Thin rods	12mm dia.	2	200	400
7	Exit valve	Plastic	2	1500	3000
8	Bearings/housing	ID 20mm, OD 47mm	2	1000	2000
9	Pulley	250mm dia. A type	1	500	500
10	Paint	Enamel	1	860	860
11	Thinner	Enamel	1	640	640
12	Roller cylinder	29mm dia Galvanized	4	600	2400
	Total				31,700

The total material cost is ₦ 31,700

Labour cost

The cost of the various jobs performed on the machine is as shown below. Labour cost involves the cost of machining, cutting, welding, turning and painting. It is taken as 25% of the material cost.

Therefore,

$$\text{Labour cost} = (25/100) \times 31{,}700$$

$$= ₦\,7{,}925$$

Overhead cost

This cost includes cost incurred during production such as transportation, Lubrication as well as other consumables. The overhead cost is taken as 20% of the labour cost.

Therefore,

Overhead cost = (20/100) × 7,925

Overhead cost = ₦1,585

Total cost

The total cost of the decorticator is the sum of the material cost, labour cost and overhead cost

Total cost = material cost + labour cost + overhead cost

Total cost = 31,700 +7,925 +1,585

Total cost = ₦ 41,210

4.3 Construction procedure

After the design has been accomplished, the following steps were followed for construction of the decorticator.

1) Marking out the dimension required for the tank from the galvanized metal sheet of gauge 20:- the equipments used are scriber, try square, meter rule and divider.
2) Cutting of the marked out galvanized metal sheet:- the equipment used is the metal sheet cutter.
3) Rolling of cut galvanized metal sheet to the desired shape:- the equipment is the metal sheet rolling machine
4) Bending of the rolled galvanized metal sheet:- the equipment is the metal sheet bending machine.
5) Welding of the both rolled and bent galvanized sheet into the cylindrical tanks the equipment used is the welding machine
6) Cutting of the internal cylindrical decorticating rollers:- the equipment used is the hack saw
7) Welding of the rod to the roller for coupling: - the equipment used is the welding machine.
8) Cutting and machining of the shaft to the required size:- the equipment used is the lathe machine.
9) Coupling of the disc plates on the shaft
10) Grinding of weld joint to a smooth finish and filling the rough surface:- the equipment used are the handing grinding machine and auto body filler
11) Cutting of angle iron of required dimension for the frame: - the equipment used is the hack saw.
12) Welding the angle iron to form the frame:- the equipment used is the welding machine

13) Assembly of all component to a unit using bolts and nuts

4.4 Operating principle of the locust bean decorticator

The boiled or cooked locust bean was loaded through the hopper Fig.8 into the decorticating chamber, and then the boiled locust bean was spread on the wall of the decorticating drum Fig.8, then the rotating rollers Fig.2 rub the locust bean against the decorticating drum which gives a clearance between the decorticating drum and rotating rollers for the bean to pass through. The shearing force between the decorticating drum and rotating rollers cause the locust bean to peel while the seeds fall into the base tank in which separation takes place.

4.5 Performance evaluation of the locust bean decorticator

The test performed to evaluate the performance of the machine was basically the decorticating efficiency and it is done on weight basis.

The decorticating efficiency was assessed by loading 5kg of boiled locust bean into the machine while it was running, then after the operation, the decorticated locust bean were separated from the undecorticated locust bean and they were weight as follows

Decorticated locust bean =3.4kg

Undecorticated locust bean =1.6kg

Therefore, the efficiency of the decorticator is

$$\% \text{ efficiency} = \frac{\text{weight of decorticated locust bean} \times 100}{\text{Weight of total locust bean}}$$

$$\% \text{ efficiency} = \frac{3.4 \times 100}{5}$$

$$\% \text{ efficiency} = 68\%$$

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The design and construction of a locust bean decorticator was done to mechanize the existing traditional method of locust bean decortication in order to reduce drudgery, timeliness and increase output. The machine was also designed considering the low cost and can be affordable to the rural community.The machine was tested and has an efficiency of 68%, easy to maintain and replacement of parts can be done with ease.Although faced with time and financial challenges, each component of the machine was made from materials readily available.

5.2 Recommendations

The results obtained after testing the locust bean decorticating machine necessitates the following recommendations for a more efficient model.

i. The results obtained from the design calculation can be used for the construction of a locust bean decorticating machine.

ii. The machine could be improved upon to be of a continuous flow operation instead of the batch system.

iii. Aluminum could be better used in place of a galvanized steel to avoid rust because it is a food processing machine.

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