THE DESIGN AND CONSTRUCTION OF A MELON SHELLER WITH BLOWER

BY

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PGD/AGRIC ENG/2003/179

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A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE

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IN THE DEPARTMENT OF AGRICULTRUAL ENGINNERING,

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,

MINNA, NIGER STATE.

CERTIFICATION

This is to certify that this project titled melon shelling was designed and fabricated by Isyaku Aliyu Mohammed (PGD/AGRIC.ENG./2003/179) under the supervision of Engr (Dr.) D. Adgidzi and submitted to the Agricultural Engineering Department, Federal University of Technology, Minna in partial fulfillment of the requirement for the award of Post –Graduate Diploma in Agricultural Engineering

------------------------------	4.07.05 ------------------------------
Engr. (Dr) D. Adgidzi Project Supervisor	Date
------------------------------	4.07.05 ------------------------------
Engr. Dr D. Adgidzi Head of Department	Date

DEDICATION

This project is dedicated to Almighty Allah for His Guidance and Protection throughout the duration of this programme. Also dedicated to my beloved son (Aliyu Muntuqah Isyaku) and my family (Mrs. Salamatu Isyaku and Mohammadu-Amin Isyaku).

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Isyaku Aliyu Mohammed

ABSTRACT

A design and fabrication has been made of a melon sheller with a blower mainly from locally available but suitable materials. The design involved the determination of volume of hopper, power to shell melon seeds, terminal velocity of melon seeds as well as the blower capacity. The machine shelled by impact using a rotating drum and separate melon seed from shell through the terminal velocity of melon seeds. The design shell melon seeds better at a moisture content of 12.33%. It has a Shelling efficiency of 88% and Separation efficiency of 30%. The Grain recovery range (GRR) of the machine is 98%, Percentage Breakage of 4% and Mass flow rate of 90kg/hr.

TABLE OF CONTENT

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

1.0 Introduction

The removal of the outer pericarp and hull during the processing of cereal grains, legumes, nuts and oil seeds is known as shelling or dehulling (**Deshpands et al, 1982**) as referenced by **(Oyewo, 2004).** Shelling enhance the nutritional and aesthetic properties, and reduces the bulk density of the plant material. Thereby facilitating better temperature management and control

Melon which is an oil seed, belong to the family of vegetable crop known as cucurbitaceae, belief to originate from Africa and now widely distributed throughout the tropics. It produces fruits with fleshy green, often edible porp carp. The fruits are of variable sizes and shape, globular or oblong, smooth or furrowed with many seeds. The melon are harvested by collecting the fruits which are later cut and fermented to get out the seeds **(Akinsammi, 1975; Tindall, 1983)**

The most common varieties are small, flat, black, red-brown, white or cream, smooth, oval seeds with a margin defined as the apex with a varying length of about 5 to 15mm. The seed have flat cotyledons enveloped on the thin walled shells usually a relatively thickening around the edge. The edible seed kernel contain approximately 46% oil and 36% protein, approximately 30 seed/g **(Tindall, 1983).**

Melon is grown for the seeds which are very nutritious, rich in protein, oil and unsaturated fatty acid, and very important in the Nigeria diet. The seed can be used in preparing soup, vegetable oil and the residue is prepared for livestock's feed as cake.

1.1 Statement of Problems

One of the major limiting factors in the production of melon seed is the post-harvest processing problems particularly seed shelling and cleaning. The traditional methods are tedious, time and energy consuming with small quantity of shelled melon seeds. On the other hand, the mechanical methods available are yet to meet the required efficiency from the consumers, as well as the cleaning effect of the machines. Both these are against the realization of the full potential of this indigenous Africa seed as veritable staple food, in spite of its widespread popularity and acceptance.

1.2 Justification

When a large quantity of melon seeds is required for consumption and for industrial purposes they should be shelled mechanically. Traditional methods are physically tiring and are time consuming. The output using these methods is very low both in quality and quantity.

Therefore, there is the need for mechanical sheller. In the recent past, researches were continued on the design and fabrication of a melon sheller to have full utilization of the crop. Many of which stopped at the trial prototype stage due to low efficiency realised from trials. The most outstanding one is the Odigboh's sheller, that too does not incorporate the seed cleaning and not yet commercialised for the public.

The use of melon seed from which oils and fats can be extracted are important not only from the standpoint of meeting human food and animal feed needs but also from the point of view of industry, which requires vegetable oils and fat for many manufactured products (medicines, cosmetics, paints etc.). In considering alternative energy source, the prospect of using vegetable oil, a renewable source of energy in place of diesel fuel, a non renewable some of the energy look promising **(Bishop et al, 1982)**.

Consequently, the society still finds it difficult to satisfy the requirements of the farmers in this wise. A need therefore exists to provide machinery that fits into the present need of farmers to enhance food production and processing.

1.3 Objectives of the Projects

1. To design and construct machine that is capable of shelling and cleaning melon seeds.
2. To reduce labour requirement in the processing of melon seeds.
3. To evaluate the performance of the sheller.
4. To improve adequately the efficiency compared to the existing designs.

CHAPTER TWO

2.0 Literature Review

Shelling is defined here as the removal of seeds from their encasement. There are two broad methods of achieving this, the traditional methods and the modern methods. Traditional methods have been in use long before the advent of any machinery development (Adewopo, 1986 as referenced by **Ajisegiri, 2000**).

2.1 Traditional method of melon shelling

2.1.1 Twisting and pulling method

This is the most popular and widely used by any individual. It involves holding the ends of the seeds between the fingers and twisting in the opposite direction and finally pulling the seed out of the shell. This is made possible by the torsional cracking of the shell, proper twisting and subsequent removal of the seed (kernel) from the shell.

This produces the highest percentages of clean and unbroken seed, and cause the least damage to the shelled seeds. Although, it is use by most people to pass time, especially at night and other leisure times, it is tedious, slow and leads to permanent deformation of the fingers or pain on the finger tips. Large quantity may not be shell over time.

2.1.2. Bulk-Sack impact method

It involves the gathering of the seeds in a sack and impacting the sacks against a fixed hard surface or beating the sack with a piece of wood. Shaking of the sack is done at intervals to rearrange the seeds in the sacks. This brings about the reorientation of the content with the probability that some unshelled seed may be shelled in the process **(Adedokun, 2003).**

This method is quicker than the twisting and pulling method and no serious damage to the fingers. Larger quantity may be shell overtime. However, already shelled seed may be destroyed due to excessive force applied more than once on the seeds. Continuous shelling is not possible since it is a batch process.

2.2 Mechanical methods of melon shelling

As technology continue to grow, mechanised shelling of melon seed is necessary to remove the tedium involved in manual shelling of the seeds. Various attempts to come up with a machine to shell melon seeds have been made with little success.

The mechanical methods of shelling melon seed could be trace back to the Engineer Olowus moves which was highly rated and complex in nature **(Ayanda, 2000)**. This being the first attempt and due to its complexity was immediately followed by several attempts.

Fashina (1997), as referenced by **Adedokun (2003),** design and develop a melon seed sheller by feeding seeds through a set of rollers which have ridges on their surface. It's observed that the shelling was based on bending principle and moisture content had no effect on the performance of the machine.

By the year 1987, a manually operated melon seed sheller was introduced by the research unit of National Centre for Agricultural Mechanisation (NCAM), Ilorin. The machine consists of two cylindrical rollers; one adjustable and the other fixed. This in effect altars the gap between the rollers in other to suit the melon seed size to be shelled. The rollers are rotated by means of a pulley to which a handle is attached **(Adesina, 2001)**.

According to **Oyewo (2004), Adedokun (2003)** and **Ayanda (2000)**, the most outstanding and foremost attempts within the shore of Nigeria is the prototype developed by Odigboh (1997). This makes use of a disc which spines and propels the melon seed against the circular guard and shell by impact. Efficiency of up o 65% was reported.

Various attempts to come up with a machine to shell melon seeds continue though with little success. These include **Ayanda (2000), Falaye (2002) Adedokun (2003) and Oyewo (2004)** (Fig. 1, Fig. 2, Fig. 3 and Fig. 4 respectively, see appendix A) all of which are of the impact type with a rotating drum powered by an electric motor. Their write-up claimed shelling efficiency range of 45% to 70% and output capacity range between 48kg/hr and 68kg/hr. As at the time of this review, none of the sheller was functioning due to lack parts, removed or damaged component.

In view of the foregoing, there is need for effort to be intensified towards developing a more efficient melon sheller that is durable and can be able to carry out a separation of the shell (chaff) from the melon seed.

2.3 Factors Affecting Effective Shelling

The efficiency of shelling is affected by the moisture content (M.C) of the crop, peripheral speed of the shelling drum, the concave teeth and clearance, as well as the rate of feed.

2.3.1 Moisture Content of the Seed.

This refers to the amount of water remaining in a product at a condition. Little moisture will lead to more breakages while when too much, shelling efficiency will be reduce. According to **Falaye (2002)** melon should be shelled at moisture content of 8.6%

while Odigboh (1977) as referenced by **Adedokun (2003)** a moisture content between 12 and 12.5% is recommended.

2.3.2 Peripheral speed of shelling drum.

According to **Makajoula (1975)** drum speeds of 1950 rpm give the best shelling percentage with low breakages percentage after using different speeds of 1350, 1565, 1950 and 2250 rpm.

2.3.3 Concave clearance.

This plays a major role in the effective shelling of melon. Too wide clearance can lead to very low shelling efficiency while at very small clearance breakages, clogging and even bending of the members may occur. Josh (1981) as referenced by **Ayanda (2000)** recommended the concave clearance of 2cm to 3cm for a peripheral speed between 750 rpm and 1,220 rpm.

2.3.4 Rate of feed

The amount of seed pushed into the shelling chamber over time affect the efficiency. When the feeding rate is high, clogging may occur and low shelling efficiency.

2.3.5 Uniformity of the seeds

Odigboh (1997) as referenced by **Adedokun (2003)** observed seeds of different sizes and shape affect the effectiveness of the shelling operations.

2.4 Physical Properties of Melon Seed

The effective performance of many types of agricultural machines is influenced decisively by the physical properties of the object participating and so in order to study given process (the melon shelling) they must be described accurately **(Sitkei,1986).**

These physical properties include shape, size, surface area, volume, density, porosity, colour and appearance. Melon seeds are small, flat-oval seeds which have flat cotyledon enveloped in a thin walled shell, usually with a relatively thick ring around the edges.

The shape of a melon seed can be characterised by their length, width and thickness. According to **Tindall (1983)**, the length of a seed varies between 5 and 15mm depending on variety. And investigation reveals that the width is about two-third of the length while thickness range between 2 and 3mm. The length, width and thickness are also regarded as the major, intermediate and minor diameter respectively.

Tindall (1983) approximated that 30 seeds weigh a gramme. Therefore, a seed will weigh 0.033g. The density can be obtain depending on the other parameters. Although, **Ayanda (2000)** reported a unit density of melon to be 0.62g/cm^3.

Falaye (2003) expressed that the melon seed can be red-brown, white with black ring around the edge.

2.5 Aerodynamics Properties of Melon

The aerodynamics properties of agricultural products are important and required for designing of air and water converging systems and the separation equipment (**Sahaya and Singh, 1994)**. The two most important aerodynamic characteristics of a body are its drag coefficient and the terminal velocity.

Separation of the shell (chaff) from shelled seeds will be by air stream. According to **Mohsenin (1970)** when any mass is introduce into an air stream a definite flow pattern occurs around the mass depending on their physical properties. That is size, shape, surface area, density and texture . These factors determine the mass reaction to the equation.

Classical equations, using dimensional analysis and the Buckingham theorem, has been developed to determine the lift and drag forces for particle submerged in a fluid this is used to determine the separation properties of melon seeds shell/chaff. The equation is of the form **(Sahaya and Singh, 1988)**

$$V_t = \frac{2w(P_P - P_F)}{P_P P_F A_P C_D} \text{--(1)}$$

where V_t = terminal velocity, m/s

w = weight of the particles, kg

P_P, P_f = densities of the particle and fluids

Ap = projected area

C_D = drag coefficient

The drag coefficient of the melon seed will be obtained using the formula **(Sahaya and Singh, 1988)**

$$F_R = CA_P \frac{\rho_P V^2}{2} \text{--(2)}$$

where F_R = resistance drag force (kg) or weight of particle at V_t

C = overall drag coefficient

P_f = mass density of fluid, kgs^2/m^4

A_p = projected area of particles normal to direction of motion

V = relative velocity between main body of fluid and materials m/s

CHAPTER THREE

3.0 METHODOLOGY

3.1 Design Consideration

The design of this machine was based on certain factors which will affect the performance of the machine. These factors were taken into consideration after careful analysis of information obtained from literature. These are the engineering properties of both engineering and biological materials such as physical properties, mechanical properties and aerodynamic properties. Of all these properties, the geometrical characteristics and aerodynamic properties of the melon seed were considered for effective shelling and separation in the design of this machine.

The physical characteristics that were examined which assisted the study on the aerodynamic characteristic are shape, size, density, weight while the aerodynamic characteristics studied are the drag coefficient and the terminal velocity of melon.

On the engineering materials used which include shaft, sheet of metal, pulleys, belts, bearings and others. Other consideration like compactness, machine ability, maintenance ability as well as human physiological consideration. The dimensions of the various components were chosen so as to minimize size, weight and cost of the machine and at the same time not to compromise the efficient operation of the components. The height of the machine has been made in such a way that the operator may not bend down too frequently so as to reduce fatigue.

3.2.0 Design Calculations

3.2.1 Determination of Density of Melon Seed.

Considering the shape of a melon seed having three areas with intercepts Q_1, Q_2 andQ_3. Where Q_1, Q_2, and Q_3 are the major, intermediate and minor diameter of the seeds.

$Q_1 = 0.015m$ $\quad\quad$ $Q_2 = 0.008m$ $\quad\quad$ $Q_3 = 0.003m$

Equivalent diameter, de = $[Q_1 \times Q_2 \times Q_3]^{1/3}{}_m$ **(Sitkei, 1986)**--------------------------- (3)

$= [0.36 \times 10^{-6}]^{1/3}$

$=0.0071m$

Equivalent volume, $V_e = \frac{1}{6\pi}(de)^3$ **(Sitkei, 1986)**---(4)

$$= \frac{(0.0071)^3}{6x3.14}$$

$$= 0.18x10^{-7} m^3$$

According to **Tindall (1983)**, 30 seeds weigh a gramme, therefore mass of a single seed will be 1/30 = 0.033g. Hence,

$$density = \frac{mass}{volume} \quad \text{...(5)}$$

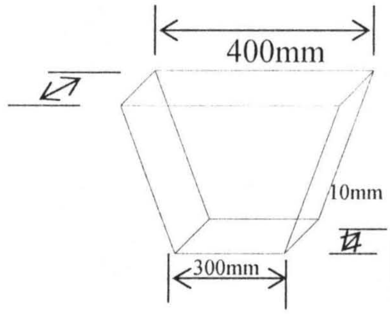
$$= \frac{0.033x10^{-3}}{0.18x10^{-7}}$$

$= \underline{1833.33kg/m^3}$

3.2.2 Hopper Capacity

The shape, location and dimensions of the hopper were selected to ensure mass outflow of melon seeds and to minimize arcing and funnelling. The dynamic angle of repose of melon seed was determined using the angle of repose apparatus (Akande, 1998) in the department, taking into consideration factors affecting the determination of angle of repose. This was found to 33°, it then follows that the angle of inclination of the hopper to the horizontal is 43° according to **Mohsenin, (1970), Chukwu, (1987)** and **Sitkei, (1998).** Hence, dimension below and avoid frequent loading of the hopper, 25kg of unshelled melon seed is chosen as the equivalent hopper capacity.

$$volume of hopper = \frac{mass}{density} ---------------------------------- (3)$$



$= 25/1833.33 = 0.013m^3$

$L_1 = 400mm, b_1 = 400mm \quad A_1 = 160,000mm^2 = 0.16m^2$

$L_2 = 300mm\ b_2 = 100mm \quad A_2 = 30000mm^2 = 0.03m^2$

Volume of the hopper, Vh $= 1/3\{(L*B)h - [l*b(h - x)]\}$ ------------------------------ (7)

$= 1/3\ \{(400*400)350 - [300*100(350 - 255)]\}$

$= 0.016m^3$

3.2.3 Determination of Power for Shelling Melon

Span of the hopper, L_2 = length of the shelling mechanism = 0.3m. Assume the aperture width is such that can take a layer of melon seed at a time and using the intermediate diameter of the melon seed.

Then, $N_S = \frac{L_2}{Q_2} = \frac{0.3}{0.008} = 37.5 seeds$

37 seeds will be used. The perpendicular distance to the axis of rotation = the radius of the shelling drum = 0.11m.

Circumference of the drum, $C_r = 2\pi r = 2 \times 3.142 \times 0.1$

$= \underline{0.691m}$

For effective shelling, the impellers, 25mm wide, are to be equally spaced at 20mm and arranged at an angle of 45^0 on the circumference of the drum. The total number of impeller required = circumference of the drum/20mm, N_I

$$= \frac{0.691}{0.02} = 34.55 \text{ impeller.}$$

35 impellers will be used in this design.

Mass of seed on the shelling drum at a time = $N_S * N_I * M$................................(8)

$= 37 \times 34 \times 0.033 \times 10^{-3}$

= 0.0415kg

Force = mass of seeds x acceleration due to gravity

= 0.0415 x 9.81 = 0.4071N

Torque = force x perpendicular distance from the neutral axis.

T = 0.471 x 0.11 = 0.0448Nm

$$\text{Angular velocity } W = \frac{2\pi N}{60} \quad \text{..(9)}$$

N = 1950 rpm (Makanjoula, 1975 as referenced by **Ayanda,2000)**

$$\text{Angular Velocity, } W = \frac{2x3.142x1950}{60} = 204.23 rad/s$$

Power = torque x angular velocity

= 0.0448 x 204.23

= 9.12W= 0.0092 kW

This is the power required to shell 0.0415kg of melon

3.2.4 Determination of diameter of driven pulley

Speed of the electric motor, N_m = 1450rpm

Diameter of the pulley on motor, D_m = 70mm

Speed of the shelling drum, N_D = 1950 rpm **(**Makanjoula, 1975 as referenced by **Ayanda,2000)**

Diameter of the pulley on shelling shaft, D_D = ?

From the expression, $\frac{N_1}{N_2} = \frac{\Delta_2}{\Delta_1} \Rightarrow \Delta_2 = \frac{N_1 \Delta_1}{N_2}$ ....(10)

$$D_D = \frac{1450x70}{1950} = 52mm$$

3.2.5 Determination of a Centre Distance

C_D = centre distance between two pulley

D_2 D_1 = diameter of the pulleys

$C \geq 3(D_2 + D_1)$--(11)

$C < D_2$ ---(12)

$C_{min} = 0.55(D_1 + D_2) + t$ ---(13)

(Shama and Aggarawal 1998)

$C_{max} = 3((D_1 + D_2) = 3(122) = 366min$

$C_{min} = 0.55(\Delta_1 + \Delta_2) x\ 3t = 0.5\ (122) + 3(8) = 85mm$

$C_{min} < C < C_{max}$

Using $C = 2.5\ (D_2 + D_1)$ = $2.5\ (70 + 52) = 305mm$

Therefore $C_{min} < C < C_{max}$. The condition is satisfied

3.2.6 Determination of Length of the Belt.

$L = 2C + \pi\left[\frac{\Delta_1 - \Delta_2}{2}\right] + \left[\frac{(\Delta_1 - \Delta_2)^2}{4C}\right] mm$ --(11)

Where L = length of the belt , mm

C = centre distance between the two pulleys = 214mm

D_2 = diameter of the layer pulley = 52mm

D_2 = diameter of the smaller pulley =70mm

$$L = 2(305) + 3.142\left[\frac{70-52}{2}\right] + \left[\frac{(70-52)^2}{4(305)}\right] mm$$

= 610 + 191.66 + 0.2656 = <u>801.93mm.</u>

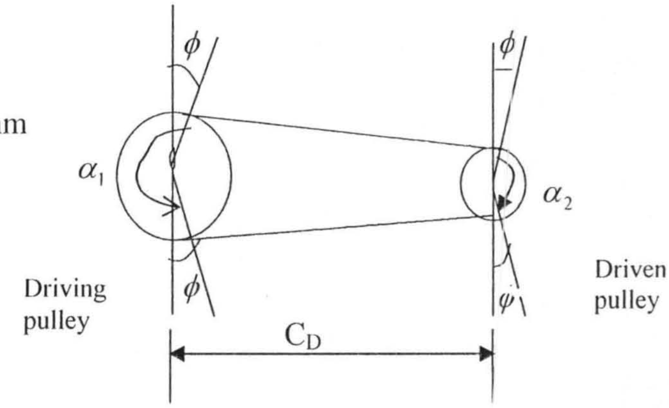


Fig 6: Belt pulley arrangement

The closest value to the calculated length of the belt form the table 1 is 823mm and this was selected.

Calculation of actual value of centre distance

$C = p + \sqrt{p^2 - q}$,

$P = L/4 - \pi/8(D_2 + D_1)$,

$= 823/4 - \pi/8(122) = 157.83mm$

$q = (D_2 + D_1)^2/8 = (18)^2/8 = 40.5mm$

$C = 157.83 + \sqrt{(157.83)^2 + 40.5}$

= <u>315.34mm</u>

3.2.7 Determination of Arc of Belt contact

$\Phi = \sin^{-1}[(\Delta_1 - \Delta_2)/2C]$ --(15)

$$\Phi = \sin^{-1}\left[\frac{(70-52)}{2x214}\right] = 2.4103^0$$

$\alpha_1 = 180 + 2\varphi$ --(16)

$= 180 + 2(2.4103) = 184.82^o = 3.23$ rad

$\alpha_2 = 180 - 2\varphi$ --(17)

= 180 - 2 (2.4103) = 175.18° = 3.06 rad

3.2.8 Determination of the Belt Cross-Sectional area.

Using the A type V-belt base on the following properties

- allowable power range of 0.75 to 5 KW
- Nominal top width w = 13mm
- Nominal thickness t = 8mm
- Pulley groove angle, $\theta = 40^0$
- Weight per meter length , p = 1.06N
- Leather belt density , $\rho = 970$ kg/m^3
- Coefficient of function, μ = 0.2-0.3 **(Hall, et al 1980; Sharman** and **Aggarwal, 1998)**

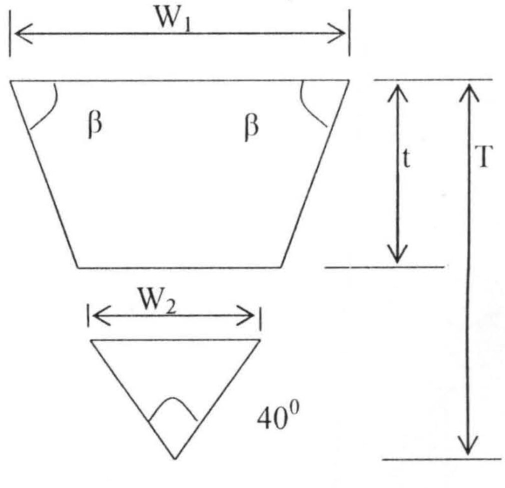


Fig 7 Belt dimension

$\theta = 180 - 2\beta$ ---(18)

but $\beta = \dfrac{180-40}{2} = 70^0$

$T = \dfrac{1}{2} W_1 \tan\beta$ ---(19)

$T = \dfrac{1}{2} x 13 x \tan 70 \;\; = \;\; 17.86$mm

from Fig. 7, similar triangle; $\dfrac{W_1}{W_2} = \dfrac{T}{t}$ --(20)

therefore, $W_2 = \dfrac{13x8}{17.82} \;\; = \;\; 5.823$ mm

Cross- sectional are of the belt

$$A_B = \frac{1}{2}(W_1 + W_2)x$$

$$= \frac{1}{2}(13 + 5.823)x\, 8$$

$75.29\ mm^2$

3.2.9 Determination of the Belt Tensions

$$\frac{T_1 - T_C}{T_2 - T_C} = e^{\mu\alpha / \sin \frac{1}{2}\theta} \text{ --- (22)}$$

(Gary, 1983; Hall et al 1980)

Where T_1 = Tension on the tight side of the belt, N

T_2 = Tension on the slack side of the belt N

T_C = Centrifugal force on the pulley N

α = The smallest of the two area of contact, rad

$T_c = MV^2$ --(23)

M = mass per metre length of the belt, kg/m

$$V = \frac{\pi\Delta_D N}{60} = \frac{3.142x0.052x1950}{60} = 5.31\text{m/s}$$

$$Tc = 0.1008 \text{ x } (5.31)^2$$

$$= 2.844\text{N}$$

The maximum allowable stress for leather belt is between 2 and 3.5 Mpa. Then taking the average 2.73 x N/m^2 as the tensile stress on the tight side.

$T_1 = 8 \text{ x } 13 \text{ x } 10^{-6}\ 2.73 \text{ x } 10^6 = \underline{283.92\text{N}}$

From the equation 22, $T_2 = \dfrac{T_1 - T_C}{e^{\mu\alpha / \sin 0.5\theta}} + T_C$

$$e\frac{0.3x3.06}{\sin 20} = e^{2.6841} = 14.64$$

$$T_2 = \frac{284 - 2.844}{14.64} + 2.844 = 22.05N$$

3.2.10 Determination of Design Power

$P = (T_1 - T_2)V$ ---(24)

(Garry, 1983) Where P = power, W

P = (284-22.05)5.31 = 1390.95W = 1.39KW

This is the maximum power that can be transmitted by the belt.

Torque on the driven shaft,

$Tn = (T_1 . T_2)Rn$ ---(25)

(Hall et all, 1980) Tn = (284-22)0.026 = 6.812Nm

similarly, torque = force x perpendicular distance from the axis of rotation

force = torque/perpendicular distance --(26)

= (6.812/0.11) = 61.93N

mass = force/acceleration due gravity

mass = (61.93/9.81) = 6.31kg

the mass of the shelling drum with impelles.

3.2.11 Determination of shear force and maximum bending moment

Taking moment about A,

R_B x 0.7 = 206.4(0.3) (0.35) + 306(0.6) = 21.674 + 183.6

$= \frac{205.27}{0.7} = 293.24N$

Sum of upward forces = sum of downward forces.

$R_A + R_B$ = 61.92 + 306 ---(27)

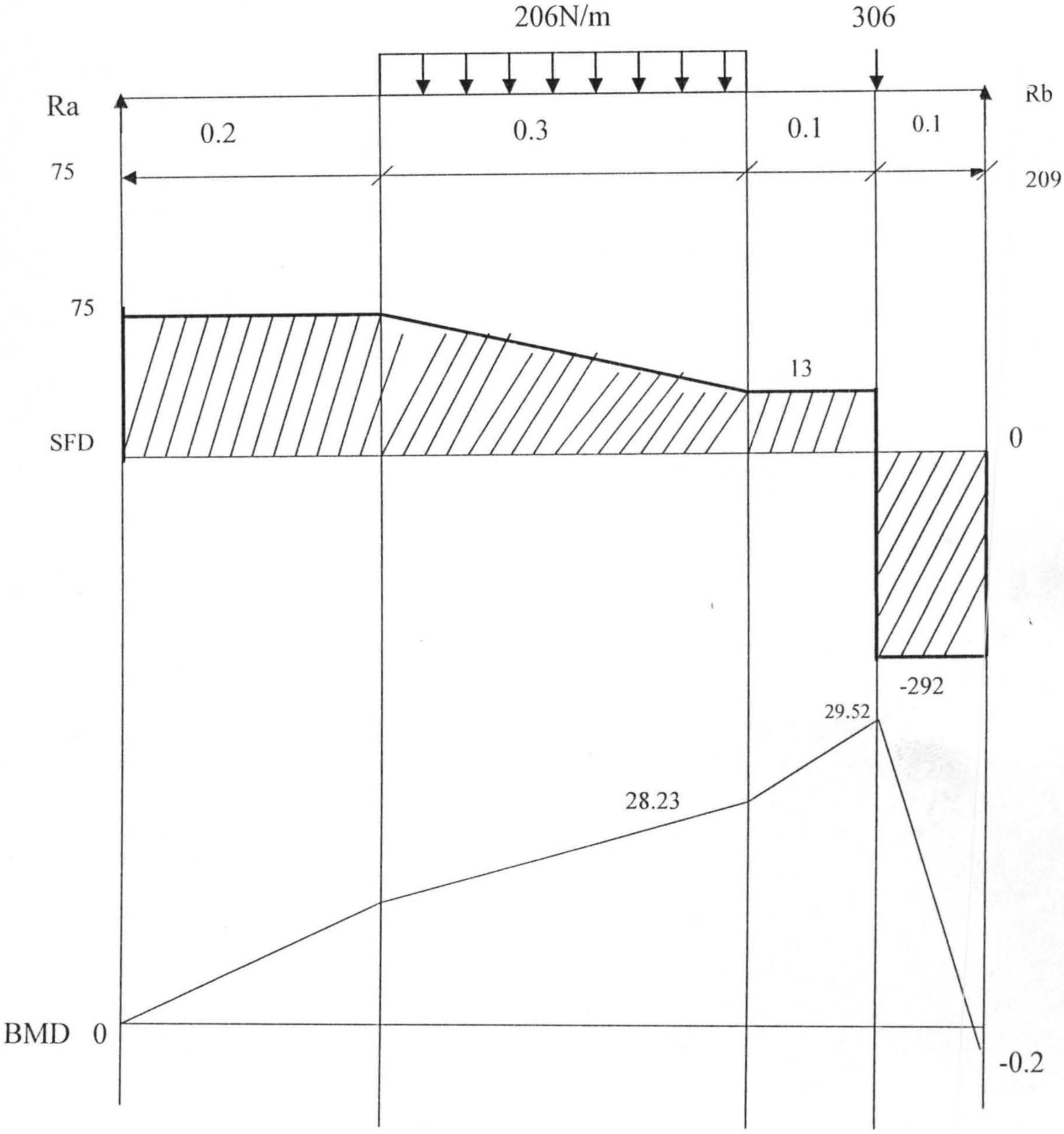
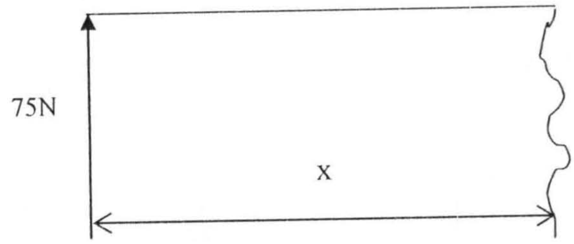


Fig 8: Shear force and bending moment diagram

$R_A = 367.92 - 293.24 = 74.68N$

When $0 \le X_1 \le 0.2$



$SF_1 = 75N$

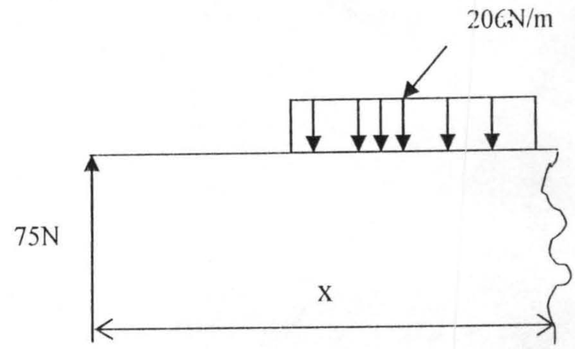
$BM_1 = 75X_1 = 75 \times 0 = 0$

$75 \times 0.2 = 15Nm$

When $0.2 \le X_2 \le 0.5$

$SF_2 = 75 - 206.4(x-0.2)$

$X = 0.2,$



$SF_2 = 75 - 206.4 = 75N$

$x = 0.5, SF_2 = 75 - 61.92 = 13.08N$

$$BM_2 = 75x_2 - 206\frac{(x_2 - 0.2)(x - 0.2)}{2}$$

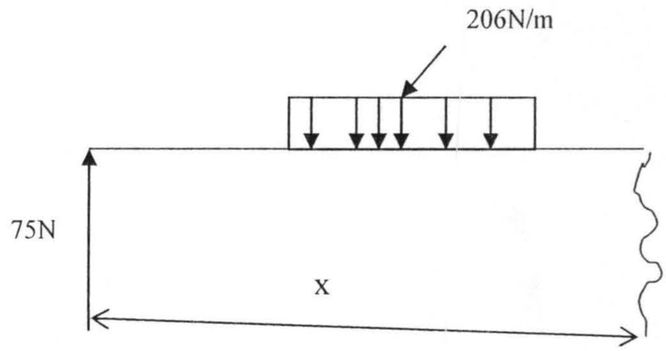
$X = 0.2$

$BM_2 = 75(0.2) - 206(0) = 15Nm$

$X = 0.5$

$$BM_2 = 75(0.5) - \frac{206(0.3)(0.3)}{2} = 37.5 - 9.27 = 28.23Nm$$

When $0.5 \le X_3 \le 0.6$



$BM_3 = 75x_3 - 61.92(x_3 - 0.35)$

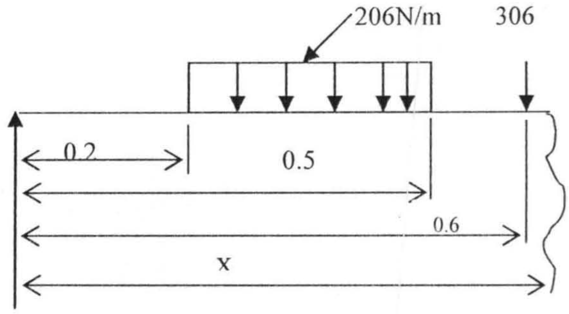
$X = 0.5$

$BM_3 = 75(0.5) - 61.92(0.15) = 28.212Nm$

$X = 0.6$

$BM_3 = 75(0.5) - 61.92(0.25) = 29.52Nm$

When 0.6 <x <0.7



Sf_4=75-61.92-306=-292.92N

$BM_4 = 75X_4 - 61.92(X_4 - 0.35) - 306(X_4 - 0.6)$

$BM_4 = 75(0.6) - 61.92(0.25) - 306(0) = 29.52$Nm

$BM_4 = 75(0.7) - 61.92(0.35) - 306(0.1) = -0.2$Nm

3.2.12 Determination of Shelling Shaft Diameter

$$d^2 = \frac{16}{\pi\tau}\sqrt{(K_b M_B)^2 + (k_t M_t)^2} \text{ ---(28)}$$

(Hall et all, 1980) where, d = shaft diameter

τ_s = Maximum allowable shear stress, 40 x 10^6 N/m^2

K_b = Combine shock and fatigue factor for bending, 2.0

K_t = Combine shock and fatigue factor twisting moment, 1.5

M_b = Maximum Bending moment, 29.52 Nm

M_t = Twisting moment (Torque), 6.872Nm

$$d^3 = \frac{16}{3.142x40x10^6}\sqrt{(2x29.5)^2 + (1.5x6.812)}$$

$$d^3 = \frac{16}{3.142x40x10^6}\sqrt{(3481 + 104.41)^{\frac{1}{2}}}$$

d = (7.66 x $10^{-6})^{1/3}$ = 0.01968m = 19.68mm = 20mm

To allow for proper sizing, a diameter of **25mm** for shaft is assumed

3.2.13 Bearing Design and Selection

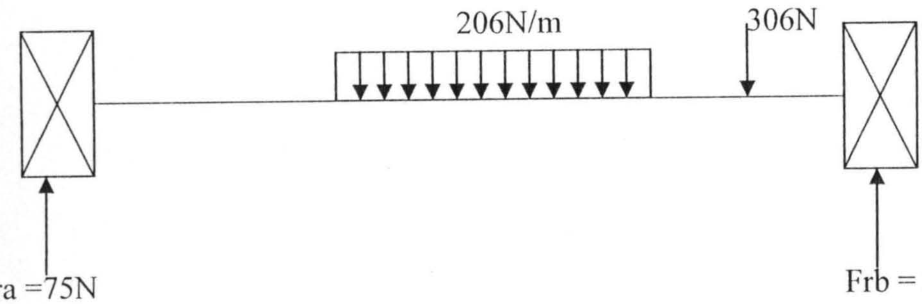


Fig. 9 Bearing Reaction

From fig above, load carried at point A = R_A = Fra = 75N

Load carried at point B = R_B = Frb = 293N

Finding the equivalent load, Po

Po = XoVha + YoFa --(29)

(Hall et all, 1980) Where, Xo = a radial factor

V = Rotation factor

Fr = the radial load, N

Fa = the thrust load, N

Yo = thrust factor

The rotation factor, V for a rotating inner ring = 1. The values of X and Y for single row bearing are 0.56 and 1 **(Hall et al, 1983)**. But in this type of loading, thrust load are not applied, hence, Fa = 0

At point A, Po = XVFr + YFa

= 0.56 x 1 x 75 + 1 x 0 = 42N

At point B, Po = 0.56 x 1 x 293 = 164.1 N

The maximum radial load of 293 will be used.

$$L = \left(\frac{C}{P}\right)^K x10^6 \text{ ---(30)}$$

(Hall et, al, 19801) where, L = rated life, revolutions

C = Basic load rating, 1b(N)

P = equivalent radial load, 1b (N)

K = Constant, 3 for ball bearings

To take care of shock/impact forces and tempt conditions that may be experienced.

Therefore, the design load, F, is calculated from the equivalent load, Po

F = P x Ka x Kt --(32)

(Sharma and Aggarwal, 1998). Where, Ka = application factors service factor = 2 (from table 2), Kt = Temperature factor = 1 (from table 3).

F = 164.1 x 2 x 1 = 328.2N

Required radial load rating, Cr = F*(Kc)*(Ks)---(33)

To care of life factors (Kc) and speed factor (Ks).

$$= \left(\frac{Ld}{Lc}\right)^{1/3}, Ks = \left(\frac{nd}{nc}\right)^{1/3}$$

Where K_L

$$Kl = \left(\frac{6000}{10,000}\right)^{1/3} = 0.8434$$

$$Ks = \left(\frac{1400}{500}\right)^{1/3} = 1.4095$$

Ld = desired life of bearing, hrs

Lc = catalogue life of bearing, hrs

nd = potential speed of bearing, rpm

nc = catalogue rotational speed, rpm

Cr = 328.2 x 0.8434 x 1.5741 = 435.72N

From table 4, with diameter of shaft = 25mm, bearing No. 205 with Radial load capacity of 2.225kN will be suitable and as such was selected. The bearing has the following dimension (from table 5)

Inter diameter = 25mm

Outside diameter = 52mm

Width of race = 15mm

Radial load C = 2.225kN

Life expectancy of this bearing

$$L = \left(\frac{C}{P}\right)^3 x10^6 \text{ --(36)}$$

L = $(C/P)^3$ x 10^6 = $(2225/164.1)^3$x10^6

= 249 x 10^7 revolutions

Designed life = 6000 x 60 x 1950

= 702 x 10^6 revolutions.

The design life for agricultural equipments is between 3000 and 6,000 hours **(Aloba, 1995; Sharma and Aggarwal, 1998)**

3.2.14 Determination of Melon Terminal Velocity

The terminal velocity and drag coefficient of individual materials may differ greatly which offers the possibility of separating the materials from each other in an air stream.

$$V_t = 1.74\left[\frac{g.dp(\rho_p - \rho_f)}{\rho_f}\right]^{1/2} \text{ --(37)}$$

(Mohsenin, 1976). From equation (1) $\Delta\rho$ = de = 0.0071m

g = 9.81 m/s

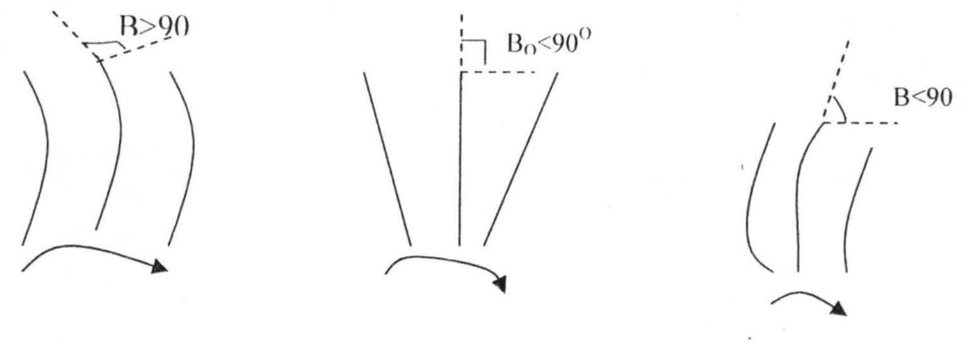
ρ_p = 1833 kg/m^3 ρ_f = 1.293 kg/m^3

$$V_t = 1.74\left[\frac{9.81x00071\,(1833 - 1.293)}{1.293_f}\right]^{\frac{1}{2}}$$

$$1.74(98.69)^{\frac{1}{2}}$$
$$= 17.29\,m/s$$

The drag coefficient at turbulent flow in the region where $10^3 < Nr < 2x10^3$, C = 0.44

The design of the blower includes deep study of different types of fans and in particular centrifugal force (fig.11). The forward curved blade fan was selected, The blade tip is angle, B > 90^0. The construction of the radial blade is comparatively simple, it has the ability to convey materials and deliver at high pressure. It has a low initial cost, maintenance and operating cost, low sound power, level and ability of delivery air at high pressure for separation of melon seed and shell (chaff).



Back ward curved blade radial blade forward curved blade

Fig. 10 Types of blades use in a centrifugal fans

3.2.15 Determination of Blade Diameter

The requirement of air discharge through a blower can be estimated on the basis of velocity of air required for separation, V, depth of air stream above the mouth of blower, D, and the width over which the air is required, W **(Stoeker, 1968)**.

$\vartheta_A = V\text{A}$ --(38)

A = D x W --(39)

Where;

ϑ_A = Actual air flow, m^3/s

V = Velocity of air, m/s

A = cross-sectional area, m^2

Let D = 100mm = 0.1m

W = 300mm = 0.3m

A = 0.1 x 0.3 = <u>$0.03m^2$</u>

$V = V_t = 17.29$m/s

$\vartheta_A = 17.29 \times 0.03\ m^2$

$= 0.519 m^3/s$

The theoretical discharge of the blower is 30% of the actual discharge (Osborne, (1977) as referenced by **Epapala, 1998)**.

$$\therefore\ \vartheta_A = \frac{\vartheta_A}{0.3} = \frac{0.519}{0.3} = 1.73 m^3/s$$

$\vartheta_A = \pi$ x d x W x V_{2r} --(40)

(Stoecker, 1968) Where:

V_{2r} = tangential components of absolute velocity

W = width of blades

d_2 = diameter of impeller/blades

Air velocity, V_{2r}, is 20% of peripheral velocity of the impeller tip **(Osborne, (1977)** as referenced by **(Epapala, 1988)**. But impeller velocity, $u_2 = \pi d_2 N$ --------------------(41)

Where: d_2 = impeller diameter

N = Speed of the impeller in rpm (speed of blower shaft)

therefore, V_{2r} in equation (40) above

$$\vartheta_A = \pi\ d_2 W \times 0.2\pi\ d_2 N \times k \text{ ---(42)}$$

K = number of blades = 4,

$$\text{Therefore,} = d_2^2 = \frac{Q_T x60}{0.2\pi^2 xWx\mu xK}$$

$$\frac{1.73x60}{0.2\pi^2 x0.33x1450x4} = \frac{103.8}{3435.51}$$

$d_2^2 = 00302$

d = 0.1769m = 176.9mm

180mm will be used.

Peripheral velocity of blower expressed in terms of impeller diameter and shaft speed,

$$V_3 = \frac{\pi\Delta_2 N}{60} = \frac{3.142x0.18x1450}{60} \text{ ---(43)}$$

= 13.67m/s

This velocity is enough to blow away any chaff and very light materials with terminal velocity below 13.67m/s and allow the melon seed with terminal velocity of 17.29m/s

According to **Aloba (1995)**, the impeller eye is constant and equal to $0.5d_2 = d_1$

= 0.5 x 0.18 = 0.09m.

3.2.16 Determination of Blower Housing Dimension

The configuration of the housing considerably affects the performance of a centrifugal blower and is as important as the blower wheel. The purpose of the centrifugal blower housing as shown in fig. 12 is to control the air flow from uptake to discharge.

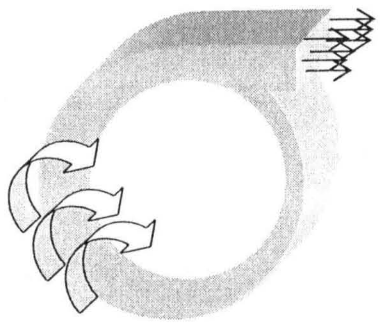


Fig. 11 Blower housing

From the fig. 13 below and according to **Sahay and Singh (1994)**

A = 1.7D --(44)

B = 1.5D -- (45)

C = 1.25 W + 0.1(D) ---(46)

Where:

D = diameter of the blade/impellers = d_2 = 180mm

W = Blade width = 300mm

A = 1.7(0.18) = 0.306m = 306mm

B = 1.5 (0.18) = 0.270m = 270mm

C = 1.25(0.3) + 0.1(0.18) = 0.393m = 393mm

B = diameter of the blower housing = 270mm

C = width of the blower housing = 395mm

It should be noted that the optimum dimension in based on blower blades mounted close to the inlet ring and minimal clearance between the blades and side of the housing **(Sahaya and Singh, 1994)**.

Casing inlet diameter.

$$d = \sqrt{\frac{4Q_A}{\pi Vo}} \text{---(47)}$$

Where Vo = Velocity at the inlet = 0.4 V_3

= 0.4 x 13.67 = 5.468 m/s

d = [(4*0.519)/(3.142*5.468)]

= 0.3476m = 348mm

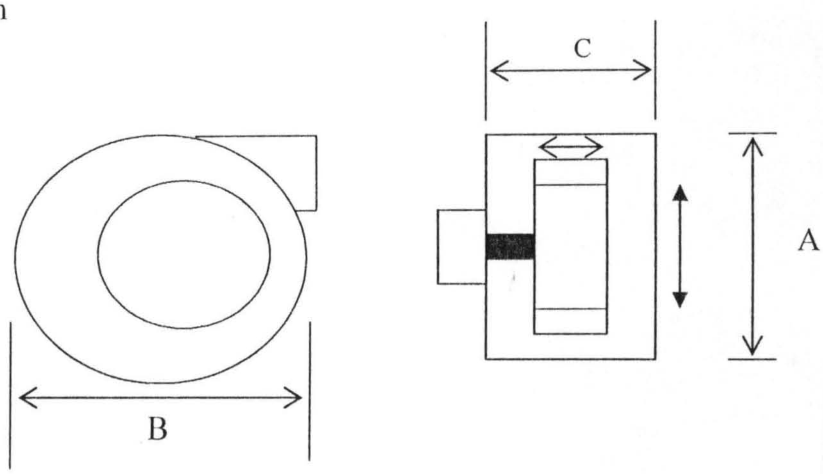


Fig. 12 Blower housing dimension

3.2.17 Determination Pressure Drop in the Rectangular Duct.

Pressure drop in a rectangular duct is given by the equation

$$\Delta p = \frac{fLV^2}{Deq2g} \text{---(48)}$$

(Stoecker,1968) where

F = friction factor, functions of both Reynolds number and roughness of the duct.

Δeq = equivalent diameter of the rectangular duct. Function of height (depth) and

width of duct, ft = $\frac{2ab}{a+b}$ ---(49)

L = length of the duct, ft

gc.= acceleration due to gravity, ft/s

a = d = 0.1, b = w = 0.3

$$\Delta eq = \frac{2ab}{a+b} = \frac{2x0.3x0.1}{0.3x0.1}$$

= 0.15m (0.492ft)

Relative roughness = $\frac{\text{Roughness}}{\text{Equivalent diameter}}$ ---(50)

$$= E/\Delta eq = \frac{0.0005ft}{0.492ft.}$$

Relative roughness = 0.001

Reynolds number, $N_R = \frac{\Delta V\rho}{\mu}$ ---(51)

Wherever Δ = Δeq = equivalent diameter, = 0.15m = 0.492ft

V = mean velocity = 17.29m/s = 56.63ft/s

F = density of fluid (air) = 1.293 kg/m3 = 0.080 ib/ft^3

μ. = absolute viscosity = 1.18 + 10^{-5} ib sec/ft^2

$$N_R = \frac{0.492x56.63x0.08}{1.18x10^5}$$

= 1.9x10^5

From graph 1, f = 0.021

Therefore $\Delta p = \dfrac{FLV^2}{\Delta eq^{2gc}}$

$$\Delta p = \frac{0.021 x 0.33 x (56.63)^2 x 0.08}{0.492 x 2 x 32.2}$$

$= \dfrac{1.7779}{31.6848}$ $= 2.68 N/m^2$

$= 0.056\ psf$

3.2.18 Velocity pressure

Pv, $psf = \dfrac{(Qcfs / outletmea)^2 p}{2g}$ ---(52)

Or Pv, in of water, $= \left(\dfrac{V.fpm}{4005}\right)^2$ ---(53)

(Stoecker, 1968). Using equation (53) above

$$Pv = \left(\frac{17.29x196.85}{4005}\right)^2$$

$= (0.8498)^2$

$= 0.7221$ in of water ($179.69 N/m^2$)

3.2.19 Determination of Blade Weight

Area of the blade = 100 x 300

$= 30{,}000mm^2 = 0.03m^2$

Blade construction form a gauge 16 mild steel sheet metal of thickness 1.6 mm, than

Volume of blade = area x thickness ---(54)

$= 0.03 \times 1.6 \times 10^{-3}$

$= 4.8 \times 10^{-5} m^3$

Density of mild steel = 7850 kg/m^3

Mass of blade = volume x density ---(55)

$= 4.8 \times 10^{-5} \times 7850 \quad = 0.3768kg$

Total mass of the blades = 0.3768 x 4 = 1.5072kg

Weight of the blades = 1.5072 x 9.81 = 14.79N.

3.2.20 Determination of the Blower Pulley Diameter

Speed of electric motor, N_m = 1450rpm

Electric motor pulley, diameter, D_m= 0.07m

Speed of the blower, N_b= 1400rpm (choosen)

Blower pulley diameter, D_b = ?

From equation (7)

$D_b = (N_{m*} D_m)/ N_b$ --(56)

$= (1450*0.07)/1400 = 0.073m$

3.2.21 Determination of the centre distance between blower and electric motor pulley

from equation (11,12,13)

$C_{max} = 3((D_1 + D_2) = 3(143) = 429mm$

$C_{min} = 0.55(D_1 + D_2) \times 3t = 0.5\,(143) + 3(8) = 95.5mm$

$C_{min} < C < C_{max}$

Using $C = 2.5\,(D_2 + D_1) \quad = \quad 2.5\,(70 + 73) = 357.5mm$

Therefore $C_{min} < C < C_{max}$. The condition is satisfied

3.2.22 Length of the Belt between Blower and Electric Motor

From equation 11,

$L = 2(357.5) + 3.142[(70 + 73)/2] + [(73+70)^2/4(357.5)$

$= 715 + 224.65 + .0063$

$= 940.65mm$

From table (1) the nearest length of belt, mm is 950mm, this was selected. Now the actual centre distance can be calculated.

$C = p + \sqrt{p^2 - q}$,

$P = L/4 - \pi/8(D_2 + D_1)$,

$= 950/4 - \pi/8(143) = 181.34mm$

$q = (D_2 + D_1)^2/8 = (3)^2/8 = 1.125mm$

$C = 181.34 + \sqrt{(181.34)^2 + 1.125}$

$= \underline{362.68mm}$

3.2.23 Determination of Arc of Belt Contact.

$$\phi = sm^{-1}\left[\frac{\Delta_b - \Delta_m}{2C}\right] \text{---(57)}$$

$$\phi = sm^{-1}\left[\frac{73-70}{2(250)}\right] = 0.006^o$$

$$\alpha_1 = 180 + 2\phi = 180 + 2(0.006) = 180.012^0 \cong 180^0 = 3.142rad.$$

$$\alpha_2 = 180 + 2\phi = 180 + 2(0.006) = 179.988 \cong 180^0 = 3.142rad.$$

3.2.24 Determination of Belt Tensions

Adopting A–type V - belt with crossectional area, $75.29mm^2$ and mass of belt, m = 0.1009 kg/m

From equation (22)

$$T_3 = \frac{T_1 - T_C}{e^{\mu\alpha/\sin\frac{1}{2}\theta}} + T_c$$

T_3 = Tension on the slack side

But Tc = MV^2

$$= 0.1008\left[\frac{\pi\Delta_b n}{60}\right]^2 = 0.1008\left(\frac{3.142x0.073x1400}{60}\right)^2$$

= 2.887N

The maximum allowable stress of a leather belt is between 2 and 3.5 Mpa. Then, taking the average, 2.73 x 10^{6} N/m^2 as the tensile stress on the tight side, T_1

T_1 = 8 x 13 x 10^{-6} x 2.73 x 10^6 = 284N

$$e^{\mu\alpha/\sin\frac{1}{2}\theta} = e^{0.3x3.142/\sin 20} = e^{2.756} = 15.74$$

$$\therefore T_3 = \frac{284 - 2.887}{15.74} + 2.887$$
$$= 20.75N$$

The total force acting on the shaft as a result of the belt tension =

254.00 + 20.75 = 304.75N

3.2.25 Determination of shear force and maximum bending moment

The shaft can be illustrated as a simply supported beam carrying a uniformly distributed load of fan blade and belt tension as shown below in fig.14

Sum of upward forces = sum of downward force

$R_c + R_d$ = 305 + 15 = 320N --(58)

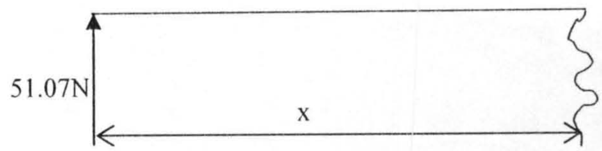
Taking moment about C,

R_d x 0.7 = 305(0.6) + 15(0.35)

$R_d = 268.93N$

Therefore, $R_c = 320 - R_d = 320 - 268.93 = \underline{51.07N}$

When $0 < x < 0.2$



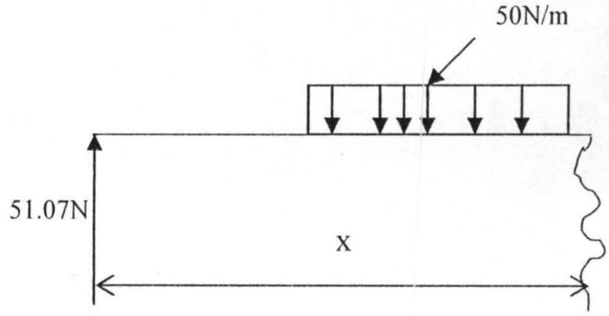
$SF_1 = 51.07N$

$BM_1 = 51.07x$

$x = 0, \quad BM_1 = 0$

$x = 0.2, BM_1 = 51.07(0.2) = 10.21Nm$

When $0.2 < x < 0.5$



$SF_2 = Rc - w(x - 0.2)$

$x = 0.2, \; SF_2 = 51.07 - 50(0.2 - 0.2) = \underline{51.07N}$

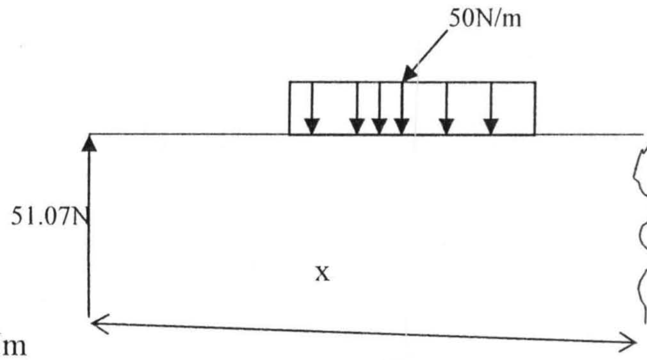
$x = 0.5, SF_2 = 51.07 - 50(0.5 - 0.2) = \underline{36.07N}$

$$BM_2 = R_C(x) - \frac{w(x-0.2)(x-0.2)}{2}$$

$$x = 0.2, \quad BM_2 = 51.07(0.2) - \frac{50(0.2-0.2)(0.2-0.2)}{2}$$
$$= 10.21Nm$$

$$x = 0.5, \quad BM_2 = 51.07(0.5) - \frac{50(0.3)(0.3)}{2}$$
$$= 23.29Nm$$

When $0.5 < x < 0.6$



$SF_3 = Rc - W(x - 0.2)$

$x = 0.5, = 51.07 - 50(0.5 - 0.2) = 36.07N$

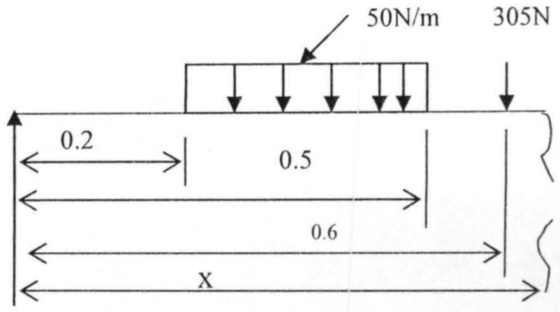
$x = 0.6, SF_3 = 51.7 - 50(0.6 - 0.2) = 31.07N$

$BM_3 = Rc(x) - W(0.3)(x - 0.35)$

$x = 0.5, BM_3 = 51.07(0.5) - 15\,(0.5 - 0.35) = 23.29Nm$

$x = 0.6, BM_3 = 51.07(0.6) - 15\,(0.6 - 0.35) = 26.89Nm$

When $0.6 < x < 0.7$



$SF_4 = Rc - w(0.3) - w_p$

$SF_4 = 51.07 - 50(0.3) - 305 = -268.93N$

$BM_4 = Rc(x) - w(0.3)(x - 0.35) - W_p(x - 0.6)$

$x = 0.6,\ BM_4 = 51.07(0.6) - 15(0.25) - 305(0.0) = 26.89Nm$

$x = 0.7,\ BM_4 = 51.07(0.7) - 15(0.35) - 305(0.1) = -0.001Nm$

3.2.26 Determination of Blower Shaft Diameter

From equation (28)

$$d_f^3 = \frac{16}{\pi \tau_s}\sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$

Where:

df = blower shaft diameter, m

τ_s = maximum allowable shear stress, $40 \times 10^6\ N/m^2$

M_b = maximum bending moment, $BM_3 = 26.89N/m$

M_t = Twisting moment (torque)

K_b = combine shock and fatigue factor for bending = 1.5

K_t = combine shock and fatigue factor for twisting = 1.0

Torsional moment for this drive or Torque on the blower pulley, M_t

$= (T_1 - T_2) R_b$, where $R_b = 0.073/2 = 0.0365m$

$= (305 - 15)\ 0.0365 = (290)\ 0.0365 = 10.59Nm$

$$d_f^3 = \frac{16}{\pi x 40 x 10^6}\sqrt{(1.5x26.89)^2 + (1x10.59)^2}$$

$$d_f^3 = \frac{16}{12568x10^6}\sqrt{(162691)+(11215)}$$

$$d_f^3 = \frac{16}{12565x10^6}(41.702)$$

$= 5.309 \times 10^{-6}$

d = 0.0174m = 17.44mm 20mm diameter shaft will be adopted.

3.2.27 Blower belt power

P = ($T_1 - T_3$) V ---(58)

Where P = Power, W

V = Velocity or speed of the belt

$$\frac{\pi\Delta_b N}{60} = \frac{3.142x0.073x1400}{60}$$
$$= 5.35m/s$$

P = (284 – 20.75) 5.35 = (263.25)5.35

=1408.39W = 1.4kW

3.2.28 Blower Bearing design and selection

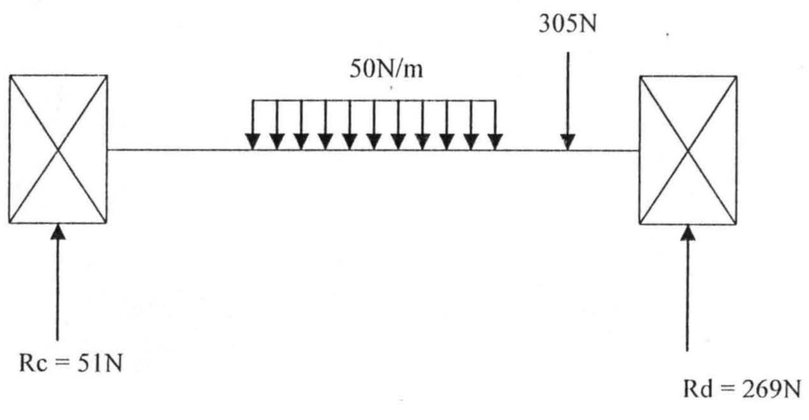


Fig. 13 Blowing bearing reaction.

From fig 16 above, Load carried at point c = Rc = 51N = Frc

Load carried at point d = Rd = 269 N = Fra

Finding the equivalent load, Po

Po = XVFr + YFa.

Where X = Radial factor = 0.56

V = Rotational factor = 1 (for a rotating inner race)

Fr = radial load, = (the larger of the two loads)

Fa = thrust load = 0N

Y = Thrust factor = 0.5

Since there is no any thrust load, Fa = 0

P = X x V x Frc

= 0.56 x 1 x 51 = 28.56 N

P = X x V x Frd

= 0.56 x 1 x 269 = 150.64N

To take into account impact forces and temperature conditions which will be experienced. Therefore, the design load, F is calculated from the equivalent load. P

F = P x Ka x Kt

Where Ka = application factors service factor, table 3

Kt = temperature factor, table 4

F = 150.64 x 2 x 1, Ka = 2, Kt = 1

Required radial load rating, Cr = F*(Kc)* (Ks)

To take care of life factors and speed factor.

$$= \left(\frac{Ld}{Lc}\right)^{1/3}, Ks = \left(\frac{nd}{nc}\right)^{1/3}$$

Where K_L

$$Kl = \left(\frac{6000}{10,000}\right)^{1/3} = 0.8434$$

$$Ks = \left(\frac{1400}{500}\right)^{1/3} = 1.4095$$

Ld = desired life of bearing, hrs

Lc = catalogue life of bearing, hrs

nd = rotational speed of bearing, rpm

nc = catalogue rotational speed, rpm

Cr = 301.28 x 0.8434 x 1.4096

= 358.18N

From table 4 with diameter of shaft = 20mm, bearing 204 with radial load capacity of 1.780 will be suitable and as such selected.

3.3 Material Selection

The material mainly used for the fabrication of the Sheller is made up of mild steel sheet and angle iron. This is as a result of easy workability, durability, easily available, cheap and strength properties of the material (mild Steel). Appropriate gauges and grade of the material were selected for the fabrication.

The belt and bearings selected were such that can be able to withstand the expected maximum load, stress and power of the transmission. The dimensions and nature of the material were such that can last for a longer period of work without failure. The prime mover (Electric motor) selected is such that can provide the required wattage for the maximum load of the Sheller.

3.4 Machine Description

The machine (Fig. 14) was constructed using the available but suitable materials, namely:

1. angle iron (mild steel) – 40mm x 40mm
2. metal sheet – mild steel – gauge 16
3. shaft (rod) – mild steel
4. pulleys – cast iron
5. belt – leather belt

The basic features of the machine are:

- The feed hopper
- Shelling mechanism and housing
- Blower and its housing unit.
- Drive components – shaft, pulleys, belt and bearing
- Prime mover (electric motor)

The hopper was constructed using the mild steel sheet with a capacity to accommodate 25kg of the melon seed at a time. It is directly welded above the shelling units. The shelling chamber, is centrally located on the frame, consist of shelling mechanism and the housing, all of which were constructed from mild steel material. The gap between the shelling and housing is about 3mm.

The rotating drum is connected to the electric motor through the drive components. These components include shaft, pulleys of various diameter and A type V-belt. The rims of the pulleys are V- grooved as well as the belt merged sectioned. The shafts were machined to the required diameter of 25mm and 20mm while the appropriate bearings were selected after determining the radial load capacity. The bearing numbers are 205 and 204.

The blower consists of the shaft (20mm) and 4 blades housed in the blower housing made of mild steel sheet. The blower was supported on the mainframe through the ball bearings at the shaft ends. The main frame gives support to the other components and ensures stability of the Sheller. The frame has dimensions of 70 x 70 x 80 mm. The factor that determines the selection of the above dimension is the dimension of all other components coupled on the frame as well as the human physiological consideration.

Electric motors with horse power rating of 1.5 kW (2 hp) at a rated speed of 1450 rpm was used to drive the components. Alternatively a petrol/gas engine in the same class of power rating can be used.

3.5 Test Performance

3.5.1 Determination of moisture content for shelling

The moisture content of a material is often used as a parameter for storage. Moisture content determination can be direct or indirect methods. In direct method, moisture (water) is driven off from the material and the loss in weight of the material or the amount of vapour evolved is used to determine the moisture content.

The Oven method was used in this study. Weighed samples of the market melon seed were placed in an oven at 105^0c for 1 – 2 hours. The loss in weight compared to the original (market) weight of the material was than used to calculate the moisture content (wet basis) of the market sample.

Similarly, weighed samples of pre-soaked melon seeds at 30, 45 and 60minutes were placed in an Oven 105^0c for 1- 2hours. The difference in weight compared to the initial weight was noted and used to calculate the moisture content (wet basis) of material. The results of the above determination are as shown below on table 6.

$$\% M.C = \frac{M_1 - M_2}{M_1} \times 100$$

M_1 = Initial weight of the material before drying

M_2 = Final weight of the material after drying

These materials at different moisture content were used in carrying out the test performance of the Melon Sheller.

3.5.2 Test Procedure

The performance test of the machine was carried out to evaluate the efficiency of the machine based on Shelling efficiency, Separation efficiency, Breakage percentage, Losses percentage, as well as the Grain Recovery Range.

One (0.5) kg of dry melon seeds at market moisture content was weighed and introduced into the hopper of the machine. The melon was shelled and cotyledon separated from shell (chaff). Time taken for shelling was noted. The output from the clean seed outlet and chaff outlet were collected and analyzed. The procedure was repeated three times (replicate).

The same quantity of pre-soaked melon seeds at 30, 45 and 60 minutes were taken and the above procedure repeated. The results of the test performance are as shown on table 8, 9, 10 & 11 and used to determine shelling efficiency, percentage breakage, percentage losses and separation efficiency.

a. Shelling efficiency = $\frac{\text{Weight of shelled melon seeds}}{\text{Sum of weight of shelled, unshelled \& broken of melon seeds.}} \times 100$

b. Percentage breakage = $\frac{\text{Weight of broken seeds}}{\text{Sum of weight of shelled, unshelled \& broken of melon seeds.}} \times 100$

c. Percentage losses =

$$\frac{\text{Total weight of seeds - (wt. of shelled +wt of unshelled + wt of broken seeds +wt of chaff}}{\text{Total weight of seeds introduced}}$$

d. Separation efficiency = $\frac{\text{Weight of Chaff (Shell) blown out}}{\text{Wt of chaff not blown out + Wt of chaff blown out}} \times 100$

e. Grain Recovery Range (GRR) : This is expressed as the difference between 100 percent and percentage total loses **(Chukwu, 1992).**

GRR = 100 - % total losses

3.6 Cost Analysis

This includes the cost of materials and labour. The materials used and thier cost as at the time of fabrication of the Sheller are stated below.

Table 6: Material List and Cost

S/NO	Item Description	Quantity	Unit Cost	Total Cost
1	Angle iron (50mm x 50)mm (thick/black)	2 length	2,500	5,000:00
2	Mild steel sheet gauge 16	2 length	4,000	8,000:00
3	Bearings 6205 (complete housing) 6204	1 pair 1 pair	4,500 500	4,000:00 500:00
4	V – belt A 55 A 44	1 no 1 no	550 550	500:00 500:00
5	30mm shaft (2000mm length)	1	2,000	2000:00
6	Flat bar (25mm)	3 lengths	500	1500:00
7	Pulleys	3 no		1400:00
8	Bolts and nuts (assorted)	40pis		600:00
9	Electrode (olekon)	$1^{1/2}$	1,500	2,250:00
10	Filler rod	2 length	300	600:00
12	Paint	1 gallon	1000	1000:00
13	Cellulose	1 gallon	900	980:00
14	Electric motor (2HP)	1	16000	16,000:00
	SUB TOTAL			₦45,250:00

Labour cost = 25% of material cost = ₦ 11,312.50

Overhead cost = 60% of labour cost = ₦ 6787.5

Grand total = ₦ 63,350.00

CHAPTER FOUR

4.0 Results and Discussions

4.1 Results

Table 7: Moisture Content Determination

Samples	Initial Weight, M_1(g)	Final Weight, M_2 (g)	Moisture Content (%)
A_1	50.10	49.56	1.0778
A_2	50.10	49.59	1.0180
A_3	50.10	49.55	1.0978
Average	**50.10**	**49.567**	**1.065**
B_1	25.00	22.22	11.12
B_2	25.00	22.01	11.96
B_3	25.00	21.52	13.92
Average	**25.00**	**21.917**	**12.333**
C_1	25.00	21.36	14.56
C_2	25.00	21.77	12.92
C_3	25.00	21.38	10.48
Average	**25.00**	**21.837**	**12.653**
D_1	25.00	21.49	14.04
D_2	25.00	21.83	12.68
D_3	25.00	21.87	12.52
Average	**25.00**	**21.73**	**13.08**

Sample A = Direct from the market and not soaked in water.

Sample B = Soaked in water for 30 minutes

Sample C = Soaked in water for 45 minutes

Sample D = Soaked in water for 60 minutes

Table 8: Performance data of the sheller at 1.2% moisture content

Replicate	Wt of seed introduced (g)	Wt of seeds shelled (g)	Wt of seeds not shelled (g)	Wt of broken seeds (g)	Wt of Chaff not blown (g)	Material blown out (chaff) g	Time of shelling (s)
	A	B	C	D	E	F	T
1	500	60	180	101	15	103	12
2	500	58	150	150	20	108	13
3	500	55	190	118	23	110	13
Average	**500**	**57.65**	**173.33**	**123**	**19.33**	**107**	**12.67**

Shelling Efficiency = [B/(B+C+D)]x100 = (57.67/373.33)x100=15.45%

Percentage breakage = [B/(B+C+D)] x100 = (123/373.33) x100=32.95%

Percentage Losses = [{A – (B+C+D+E+F)}/A]x100 ={(500-480.33)/500}x100=3.93%

Cleaning Efficiency = [F/{E+F}]x100 =[107/126.33] x 100=84.7%

GRR = 100 - % total losses = 100-3.39%= 96.07%

Mass flow rate = A/T =500/12.67=39.46g/s (142.07kg/hr)

Table 9: Performance data of the sheller at 12.33% moisture content

Replicate	Wt of seed introduced (g)	Wt of seeds shelled (g)	Wt of seeds not shelled (g)	Wt of broken seeds (g)	Wt of Chaff not blown (g)	Material blown out (chaff) g	Time of shelling (s)
	A	B	C	D	E	F	T
1	500	235.00	10.40	12.23	184.56	45.11	20
2	500	232.50	28.82	12.09	159.78	49.23	18
3	500	238.10	17.01	12.45	147.69	58.10	22
Average	**500**	**235.20**	**18.74**	**12.26**	**164.01**	**50.81**	**20**

Shelling Efficiency = (235.20/266.2)x100 = 88.35 %

Percentage breakage = (12.26/266.2)x100 = 4.61%

Percentage Losses = [{500 – (481.02)}/500]x100 = 3.8%

Cleaning Efficiency = [50.81/214.82]x100 = 23.65%

GRR = 100 – 3.8% = 96.2%

Mass flow rate =(500/20) = 25g/s (90 kg/hr)

Table10: Performance data of the sheller at 12.65% moisture content

Replicate	Wt of seed introduced (g)	Wt of seeds shelled (g)	Wt of seeds not shelled (g)	Wt of broken seeds (g)	Wt of Chaff not blown (g)	Material blown out (chaff) g	Time of shelling (s)
	A	B	C	D	E	F	T
1	500	236.02	20.25	14.31	180.12	40.31	23
2	500	250.01	18.32	16.89	164.28	41.50	21
3	500	250.61	21.50	18.32	163.46	38.11	24
Average	**500**	**245.55**	**20.02**	**16.51**	**169.29**	**39.97**	**22**

Shelling Efficiency = (245.55/282.08)x100 = 87.05%

Percentage breakage = (16.51/282.08)x100 = 5.85%

Percentage Losses = [{500 – 491.34}/500]x100 = 1.73%

Cleaning Efficiency = [39.97/209.26]x100 = 19.10%

GRR = 100 –1.73 % = 98.27%

Mass flow rate = 500/22 =22.73g/s (81.81kg/hr)

Table 11: Performance data of the sheller at 13.08% moisture content

Replicate	Wt of seed introduced (g)	Wt of seeds shelled (g)	Wt of seeds not shelled (g)	Wt of broken seeds (g)	Wt of Chaff not blown (g)	Material blown out (chaff) g	Time of shelling (s)
	A	B	C	D	E	F	T
1	500	263.09	38.39	10.46	135.34	36.18	26
2	500	291.16	22.35	10.74	122.25	48.00	24
3	500	240.67	56.99	28.97	128.87	35.00	24
Average	**500**	**264.97**	**39.24**	**16.72**	**128.82**	**39.73**	**24.67**

Shelling Efficiency = (264.97/320.94)x100 = 82.56%

Percentage breakage = (16.72/320.94)x100 = 5.21%

Percentage Losses = [{500 – 489.49}/500]x100 = 2.10%

Cleaning Efficiency = [39.73/168.55]x100 = 23.57%

GRR = 100 – 2.10 % = 97.90%

Mass flow rate = 500/24.67 = 20.27g/s (72.96kg/hr)

4.2 Discussions

The analysis of the results obtained from table 7 indicate that melon seeds direct from the market and oven dried at about 105^0c for 90 minutes has a moisture content below 2 %. While when soaked for 30, 45 and 60 minutes in water increases the moisture content of the seeds to 12.33, 12.65 and 13.08% respectively. It was these samples at the various moisture content that were used to determine the various parameters of shelling. The performance data of the sheller at 1.06%, 12.33%, 12.65% and 13.08% are as shown on table 8, 9, 10 and 11 respectively. The average percentages of the efficiencies are plotted against moisture content on graph 1.

From the graph, the shelling efficiency increases from 15% at a moisture content below 2% to about 88% at a moisture content of 12.33% and begin to have a gradual decrease with increase in the moisture content to 13.08%. This could be as a result of the seeds been more slippery as the moisture content of the seeds increases beyond 12.33%. And this can be related to increase in the amount of the unshelled seeds as the moisture content increases.

The cleaning efficiency of about 85% was achieved when the moisture content of the seeds was below 2% and drastically reduced to 23% and 19% at a moisture content of 12.33% and 12.65% respectively. This could be as a result of increase in particle weight with the increase in the moisture content. The cleaning efficiency suddenly begins to rise even though with the increase in moisture content to 13.08%. This is as a result of less melon seed being shelled at that moisture content and less chaff to be blown out.

From the graph, the breakage percentage was very high (33%) at moisture content below 2% and reduces to about 4% at moisture content of 12.33%. At 12.65% moisture content, the percentage breakage increases slightly to 6% and then falls back to 5% at 13.08%. The initial high percentage breakage is clearly as a result of a very low moisture content of the seeds and decrease downward as the moisture content was gradually being increased. The sudden increase at 12.65% could be as a result of some few seeds retained within the sheller who by then has reduced moisture content.

Percentage losses of the sheller at moisture content below 12.33% remain at 4% and further reduced to 2% at a higher moisture content above 12.65%. This can be explained as at a higher moisture content the melon seeds are either shelled or not shelled at all, hence breakages and losses. The grain recovery range (GRR) of the machine at all the moisture content tested does not fall below 96% indicating a good throughput. The mass flow rate at 2% moisture content was 142kg/hr and reduces to 90 kg/hr, 81kg/hr and 73kg/hr at moisture content of 12.33%, 12.65% and 13.08%.

From the above, the machine shelled and separated melon seeds at a moisture content of 12.33%. That is seeds soaked for about 30minutes will produce a better shelling and chaff seperation.

CHAPTER FIVE

5.0 Conclusion and Recommendation

5.1 Conclusion

A Melon Sheller with blowing mechanism has been designed, fabricated and tested. The machine showed that it is a good substitute for the traditional methods, manually operated shellers and modern mechanical melon shellers available. The design also showed that it is suitable for usage even at the rural areas through alternative sources of power.

The Sheller was able to achieve a shelling efficiency of 88% and a separation/cleaning efficiency of 30%. However with little practice and proper adjustment the machine efficiency can be increase.

5.2 Recommendation

The melon Sheller is recommended to be use properly and according to the operational procedure. The vibration effect can be checked either by bolting it on the ground or damper should be use below the stands.

The separation efficiency can be improved upon by changing the size of the blower and the channel.

An instant moisture determination apparatus should be used in ascertaining the moisture content of the melon seeds before shelling.

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APPENDIX A

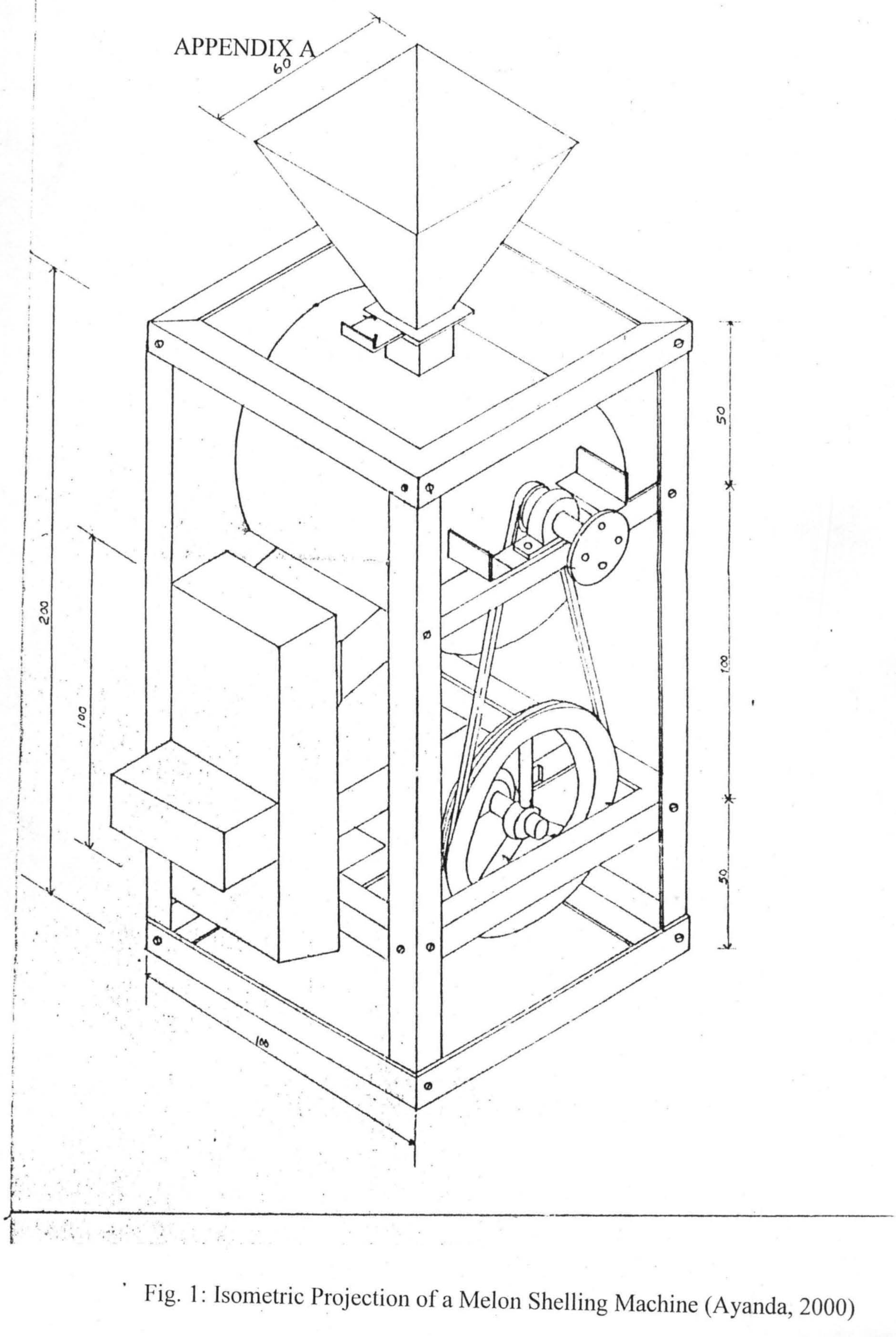


Fig. 1: Isometric Projection of a Melon Shelling Machine (Ayanda, 2000)

APPENDIX B

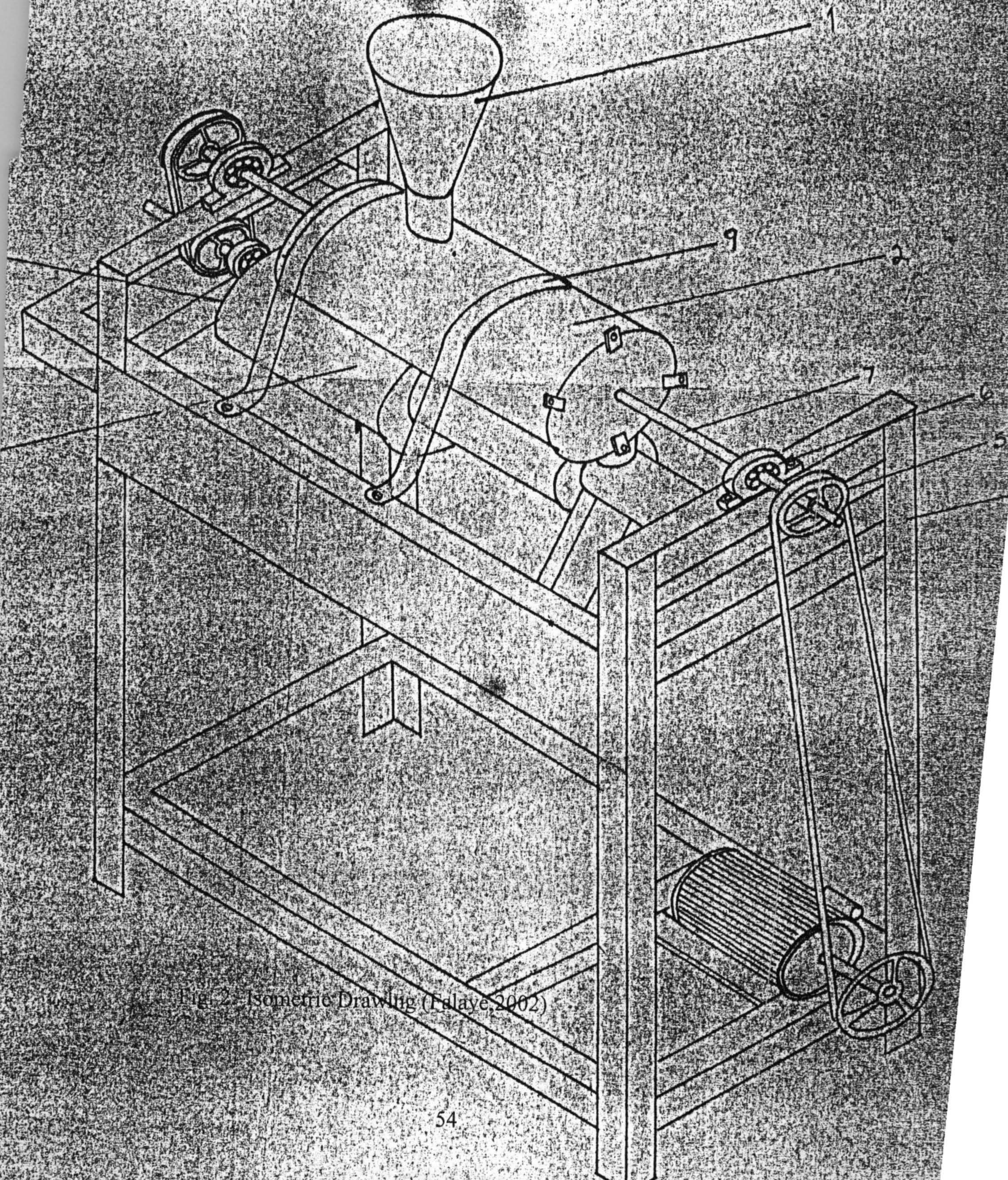


Fig. 2: Isometric Drawing (Falaye, 2002)

APPENDIX C

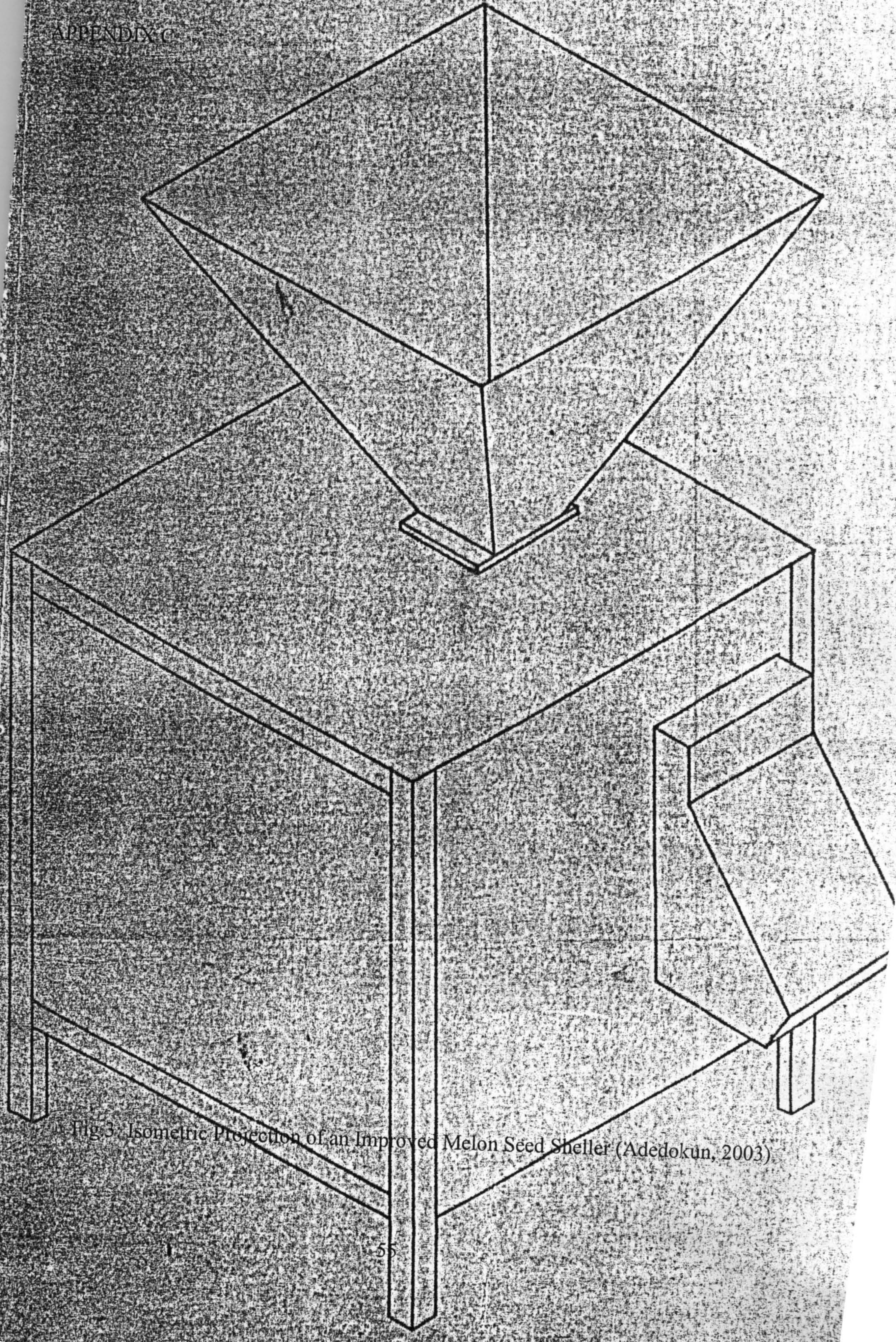


Fig.3: Isometric Projection of an Improved Melon Seed Sheller (Adedokun, 2003)

APPENDIX D

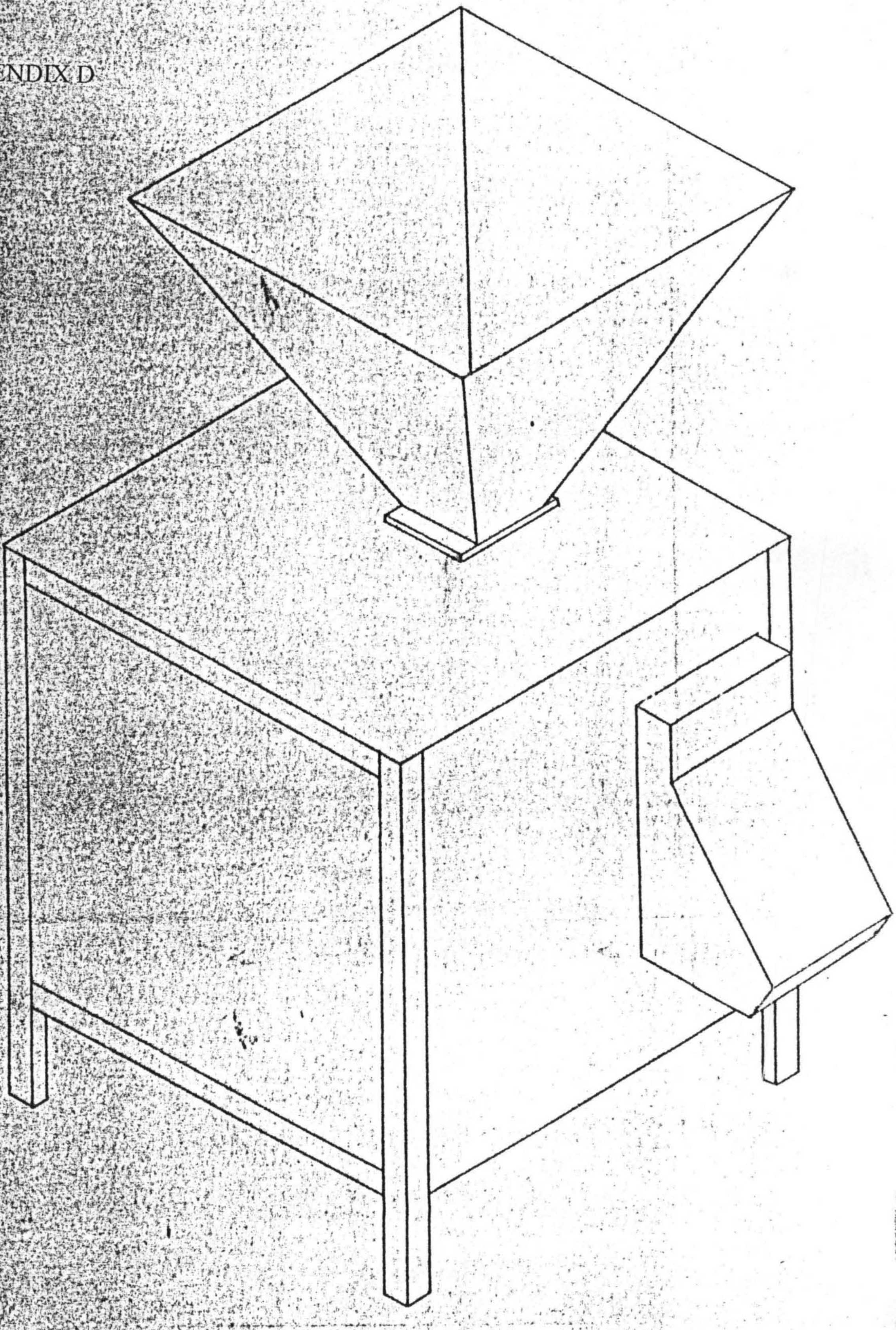
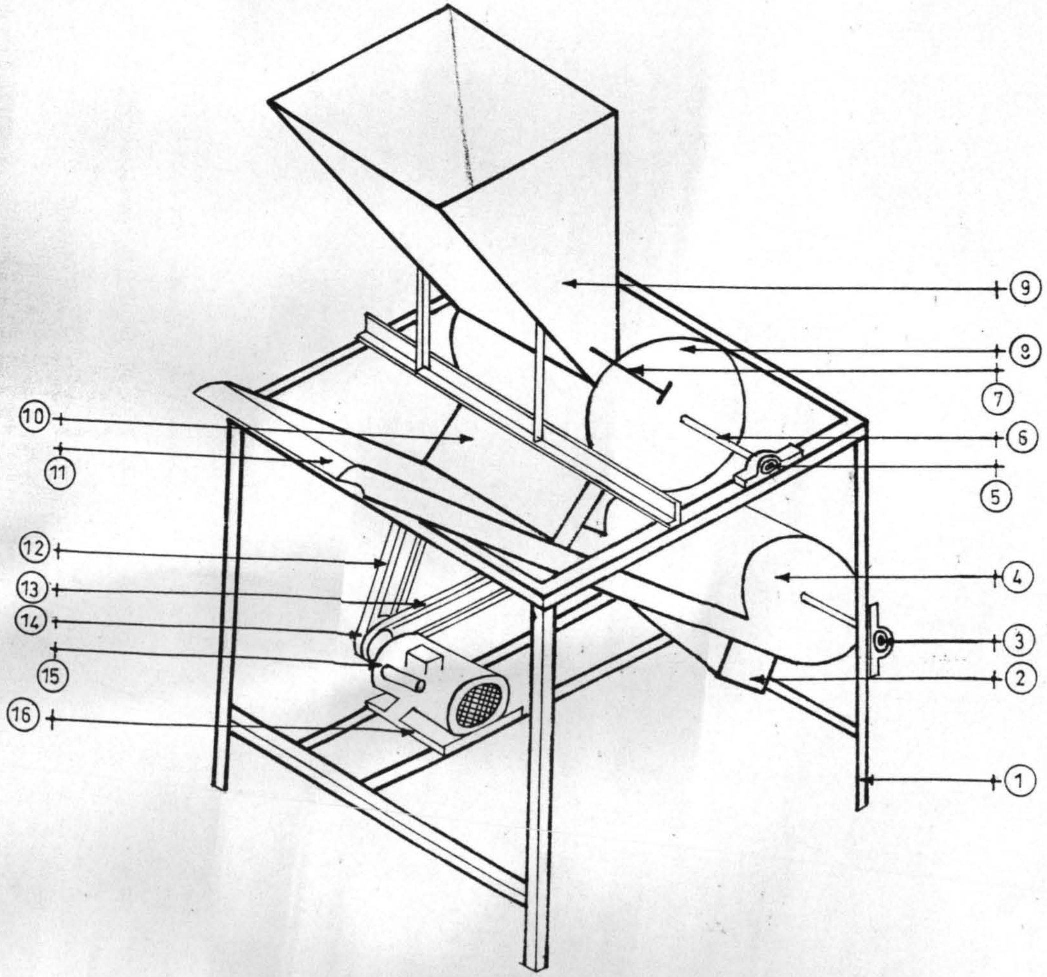


Fig. 4: Isometric View of Melon Seed Desheller (Oyewo, 2004)



S NO	DESCRIPTION	QTY	MATERI
16	ELECTRIC MOTOR BASE ·	1	MILD STEEL
15	ELECTRIC MOTOR ·	---	------
14	ELECTRIC MOTOR PULLEY ·	1	
13	ELECTRIC MOTOR - BLOWER BELT ·	1	M S
12	ELECTRIC MOTOR - DRUM BELT ·	1	LEATHER
11	CHAFF / SHELL OUTLET ·	1	LEATHER
10	CHUTE ·	1	M S
9	SEED HOPPER ·	1	M S
8	SHELLING CHAMBER ·	1	M S
7	SEED FLOW REGULATOR ·	1	M S
6	SHELLING DRUM SHAFT ·	1	M S
5	SHELLING SHAFT BEARING ·	2	M S
4	BLOWER HOUSING UNIT ·	1	M S
3	BLOWER SHAFT BEARING ·	2	M S
2	CLEAN SEED OUTLET ·	1	M S
1	MAIN FRAME / STAND ·		M S

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DEPARTMENT OF AGRICULTURAL ENGINEERING ·

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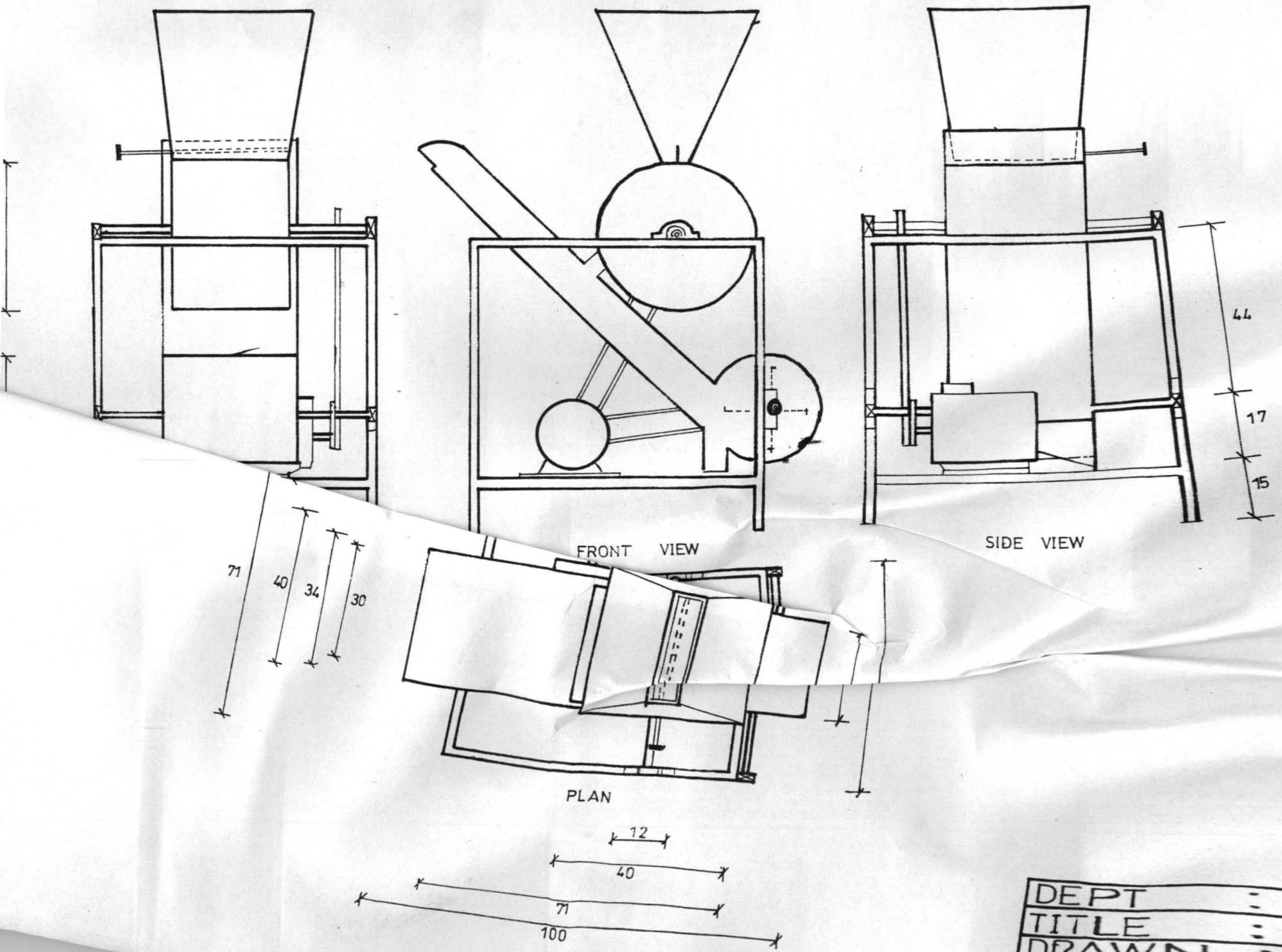
REG NO	PGD / AGRIC ENGR 2003 / 179 ·
APPROVED BY	DR · D AAGIDZI ·
DATE	MARCH, 2005 · SCALE:



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