DESIGN, FABRICATION AND PERFORMANCE EVALUATION OF A RICE DEHULLING MACHINE

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PGD/AGRIC.ENG./2004/186

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MINNA, NIGER STATE.

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BY

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Project submitted to the Department of Agricultural Engineering, Federal University of Technology, Minna in partial fulfillment of the requirements for the award of Post Graduate Diploma (P.G.D.) in Agricultural Engineering of the Federal University of Technology, Minna

DECEMBER, 2006.

DECLARATION

This is to declare that this project was carried out by me and all the published and unpublished materials of others have been duly acknowledged in the text and duly referred.

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CERTIFICATION

This is to certify that the project work undertaken by Kehinde Bello has been read and found to have met the standard required for the award of Post Graduate Diploma Degree in Agric. Engineering Federal University of Technology, Minna.

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ABSTRACT

In an attempt to improve the quality of rice through a better processing techniques, this project focuses on the design, fabrication and performance test of a simple knife-blade type rice milling machine use for quick and efficient dehulling of rice paddy to meet the increasing demand for edible rice by the expanding population. It is powered by diesel or petrol engine or by electric motor depending on the availability.Parboiled rice at 32% moisture content was dried to18% moisture content and then milled in the huller to obtain the average milling rate (372 kg/hr),average total milling recovery (50.9%),average coefficient of husking (82.85%), milling efficiency (98.01%), cleaning efficiency (99.32%),milling index 0.510 (or 51.0%) input capacity 490kg/hr output capacity 267kg/hr.

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I would like to acknowledge with gratitude to all who have contributed to the successful production of this project work.

First and foremost, my most grateful thanks goes to the Almighty God for granting me the knowledge, courage, wisdom, good health and understanding for the successful completion of this project as well as the programme itself.

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To all I say thanks, may God Almighty bless you (Amen).

DEDICATION

I dedicate this Project to God Almighty, My Creator for granting me success in the Project work and in the programme as a whole.

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NOMENCLATURE

h.p	Horsepower	
d_1	Drive Pulley diameter	m
d_2	Driven Pulley diameter	m
n_1	Speed of the electric motor	rpm
n_2	Speed of the milling shaft	rpm
ω_1	Angular velocity of the electric motor	rad/s
ω_2	Angular velocity of the driven shaft	rad/s
T_m	Mean torque	Nm
T_2	Transmitted torque	Nm
π	3.142	
g	Acceleration due to gravity	m/s^2
P	Power	kW
F_c	Inertia force on the belt	N
W_1	Weight per unit length of the belt	kg/m
R_1	Radius of drive pulley	m
R_2	Radius of driven pulley	m
α	Angle of twist	rad
θ	Angle of wrap	rad
b	Groove angle of v-belt	rad
f	Co-efficient of friction	
F_1	Maximum belt tension	N

F_2	Minimum belt tension	N
F_B	Bending force on the sheaves	N
F_n	Net force on the sheaves	N
D	Minimum shaft diameter	m
S_{ut}	Minimum tensile strength	MN/m2
C	Centre distance between the pulleys	m
s.f	Shear force	N
S_c	Endurance limit	MN/m2
n	Design factor of safety	
F_R	Catalog radia rating	kN
L_R	Catalog rated life	h
N_R	Catalog rated speed	rpm
F_D	Equivalent radial load	kN
F_2	Required design life	h
R_P	Rated speed	rpm
V	Rotation factor	
x	Radial factor	
Y	Thrust factor	
F_R	Applied radial load	kN
m.c	Moisture content	%

CHAPTER ONE

1.0 INTRODUCTION

Rice (Oryza Sativa L) is an important cereal crop which belongs to the gramineae family. Rice is a leading cereal crop in many countries. It is grown on all the continents. The species oryza sativa was introduced into African countries long ago from Asia. It is the most widely grown species. However, there is also another species oryza glaberrima, which originated in Africa (Michael and Brigitte,1999). According to Michael and Brigitte (1999) upland varieties includes Mofaberekan, IRATI 3, OS6 and lowland varieties include lm16 and Gambioka.

Rice milling is the removal of the outer cover (hull) and possibly the seed-coat (bran). Paddy husking and hulling operations are freely interchanged to mean the removal of the outer seed coat with the grain kernel retaining its original shape. The scouring operation removes the outer brown layer known as the bran. In flour milling, the bran is removed from the grain to produce flour without any emphasis on its shape.

The husk is removed either traditionally by hand-pounding or by hulling using power driven machines. Typical hand pounding equipment include a pestle of about two meters in length and mortars of various sizes. Pounding is carried out by up to three people, usually women and children working simultaneously with the same motar. Hulls and brans are winnowed away from the rice periodically, and additional pounding and winnowing occur depending on the desired degree of milling. Milling recovery i.e percentage of paddy converted to milled rice is quite high in hand-pounding and is about 68% in a study, (Robert and Larry 1981). Mechanized milling systems were developed to replace the traditional hand-pounding method as a result of the drudgery involved in the process. Different types of machines have been produced for husking and scouring operations. These are: - The Huller, Cono-mill machine and the rubber roll machine.

The advantage of the huller mill over other types of mills is its simplicity in design, ease of operation, low maintenance and ability to combine hulling and scouring operations together. The milling recovery is low (62 to 68% compared to 66 – 68% of cono-mill and 71 – 74% of rubber roll mill. (Rober and Larry, 1981). The emery stone and rubber roll in cono-mill and rubber roll mills respectively needs to be replaced regularly and they are often not available.

Also due to rapid urbanization and migration of farm labour to cities a big vacuum has been created in the supply and demand ratio of farm labour. This paucity of labour force has been forcing farmers to go for mechanization Sheruddin et al.(1991).

Based on the above reasons, it is therefore necessary to design and fabricate a simple and efficient machine which can be capable of improving output to (50 – 80) kg/hrThe machine is capable of removing the hull from the paddy to give edible rice.

1.2 Objectives of the Study

The objectives of this project are to design and fabricate from locally available materials, a rice dehulling machine that is affordable by both urban and the rural farmers. It is also to be of low-cost without compromising functionality and durability. The objective above is directed towards the following aims:

1.3 Aims of the Project

1. To encourage the peasant farmers to embark upon increased production of rice

2. To improve the production efficiency, time usage and output, while cost and drudgery are reduced.

1.4 Justification of the Research

i. The machine will serve both the urban and rural farmers as an alternative to the traditional method of dehulling which is labour intensive and time consuming.

ii. It will also reduce grain damage, ~~see~~ losses, as well as improve the quality of harvested rice.

iii. It will encourage the peasant farmers to embark on large-scale production of rice.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Concept of Unit Operations

The concept of unit operation promotes appreciation of a given process in an orderly manner regarding the numerous processes and activities involved in food processing, food engineering and technology. Any of these numerous processes is a unit operation Chukwu (2001)

The finished product of one unit operation may serve as the raw material for another unit operation in a unit process. The transformation of such raw material into finished products via a total food process involves a series of unit operations performed in a logical manner. For example, the processing of rice paddy into polished rice involves the following major unit operations:

1. Cleaning: removal of stones chaff and other foreign bodies from rice paddy.
2. Steeping: soaking in water during which both the husk and starch granules absorb water and swell.
3. Steaming: heating of the rice using steam until the starch present in the grain is gelatinized.
4. Drying: Steamed grain is dried to 12-14% moisture content (wet basis) to impart hardness to the grain to enable it stand the rigour of milling.
5. Milling: Removal of the husk and polishing of the grain using a pestle and mortar or a rice milling machine – Wudiri (1995)

Control over the processes is exercised by controlling the flowing of energy and material into the system. The quality of the final product can be affected at any of these steps if proper care is not taken. However, milling is very important since grains can hardly be put into any practical use without first milling them. Besides, the total head yield (whole grain kernels milled) is largely dependent by the quantity of milling.

About 26.1 million tones (6.3%) are produced in the developed countries FAO (1999) the usefulness of rice is indeed universal because it is the staple food for almost half of the world's population. Man benefits not only from its starchy grain for food but also from other parts of the plant and the by-products of its processing.

The grain with the hull, bran and germ removed by milling is used in dry cereals. The dry matter of milled rice contain 88% starch (amylase and amylorectin), 6 to 8% protein, 0.5% fat and 0.5% sugar. Because of its high digestibility (98%) and high nutritive value, white rice has become indispensable for use in baby and breakfast foods; and indeed for the sick. Rice is also used for the production of starch, alcoholic beverages and soft drinks. Rice flour may be used as a blending material in baking white bread and in biscuits.

Rice hulls and polish that include bran, aleurone layer and the germ are used in the pharmaceutical industries for the production of phytin and vitamin B (thiamine, ribqelkarin, niacin). Rice bran and polish are fed to farm animals. It is also used for the production of high quality rice oil used in medicine and in corrosive resistant coatings. Chemical processing of rice chaff gives furfural, which is a basic raw material for the manufacturing of plastics, Sheruddin et al.(1991).

Rice straw is an important raw material for the manufacture of high quality paper; other products include cardboard, ropes, packing material, handbags, rugs, hats and sandals, sacks and baskets, brooms etc.

Growing rice facilitates the improvement of saline and alkaline soils which after two or three years in rice, can successfully be used for growing other commercial crops to the benefit of the rice grower.

In spite of the enumerated importance of rice to human diet, its harvesting in Nigeria had been and remains a serious problem to the farmers. Michael and Brigitte (1999). The techniques for harvesting are still traditional based on using mainly sickle. The total labour requirements for traditional manual harvesting with sickle is 80 – 160 man h/ha of which 60 – 100 man-h are used in cutting and laying the crop. The harvesting period is very short and crop losses increase rapidly with delay in harvesting. Delayed harvesting of mature crops also exposes it to many hazards like rains, windstorm and fire. Gajendra et al.(1998).

2.3 The Traditional Methods of Milling:

The traditional method of rice milling involves the use of mortar and pestle made of wood and worked with either hand or foot. In the type worked by hand the pestles are about 5.83 – 6.4 metres long and heavy Grisit (2001)

Usually two or three pestles are worked by the same number of people on paddy contained in one mortar to apply a normal force onto the grains in the mortar. The friction force generated due to relative grain moment helps in the dehusking operations.

When worked by foot, the pestle is on a fulcrum. The pestle is about 1.83 to 2.4 metres in length Grisit (2001) and is fixed on the underside of the beam of wood. More than half way from the pestle to give added weight to the pounding of the paddy. The workers press the beam down with the foot, thus raising the pestle. On releasing the foot, the pestle falls on the paddy in the mortar. The operation is repeated sometimes after which the paddy is removed from the Mortar and winnowed. The portion remaining consists of rice and paddy. The operation of hulling is repeated several times until practically all the husk is removed and rice remains. Any paddy that has escaped milling is removed by hand mortars are of various sizes and about 4.54kg to 22.68 kg of paddy can be milled in an hour (Grisit, 2001).

2.4 Milling as a Unit Operation

The term milling covers a wide range of processes which include the method of processing cereal grains in flour. In the context of this project, emphasis will be laid on the milling of rice and the milling procedures used for this purpose. For this reason, it is necessary to differentiate between milling and grinding. Milling includes all operations which lead to defined end products and grinding covers those processes which brings about particle size reduction. The objective of rice milling is the removal of hulls, bran layer germ with a minimum of endosperm breakage.

The problem associated with this form of milling is that apart from being energy sapping and very slow, the applied normal force often breaks rather than mill the grain. The quantity of rice that could be milled per unit time is also very limited.

2.5 The Modern Method of Milling:

The modern method of milling involves the use of machines to mill rice paddy. These machines are usually powered by electric motors or an internal combustion engine (diesel or petrol engine). The operation of the milling machines can be divided according to the following three basic principles.

1. **Compression and Shear:** This compresses, splits and strips off the husk from grain concave type dehusking machines and rubber roll dehusker are designed on the basis of this principle.

2. **Abrasion and Friction:** This is based on the friction between the grain and an abrasive surface. Hollanders are example of this.

3. **Impact and friction:** Husk can be stripped off grain by the action of impact and friction force. Centrifugal type sheller comes under this group.

2.6 De-Husking:

De-husking is the removal of only rice from paddy. The purpose of a modern dehusking machine is to remove husk from paddy without damage to the bran layer and rice kernel. There are two major types of dehusking machines: The impact type paddy dehusker and rubber roll dehusker.

2.6.1 Impact Type Paddy Dehusker

The working principle of the impact or centrifugal type of dehusker is based on the utilization of impact and frictional force for dehusking of paddy. In the impact type dehusker, paddy is thrown against a rubber wall by a rotating disc. The impact on the rubber wall due to the centrifugal force of the rotating disc causes cracking of hulls with a minimum damage to the kernel .

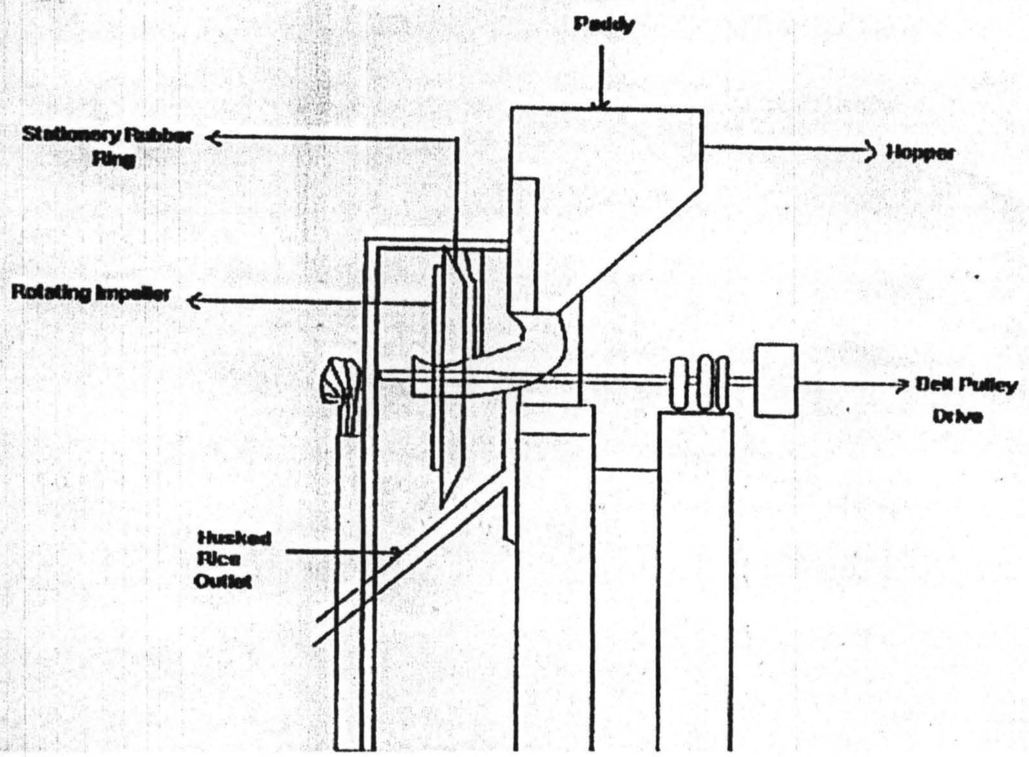


Fig. 1 Impact Type Husker Source (Bandy and Roy, 1980)

A common type of centrifugal dehusker consists of a rotating disc of diameter 28.5cm within a stationary rum of synthetic rubber 30cm in diameter centered at the same axle. The dehusking capacity of a machine with a disc diameter of 30cm is about 300 kg/hr. The power requirement of this type of dehusker is low (746w/500kg paddy/hr)

2.6.2 Rubber Roll Dehusker (Dehusking Machine)

Paddy deformation caused by shear and compression of the two rotating rubber surface in a rubber roll dehusker splits and separates the husk from the grains. The paddy is passed through the clearance between two rubber rollers rotating in opposite direction at different speeds.

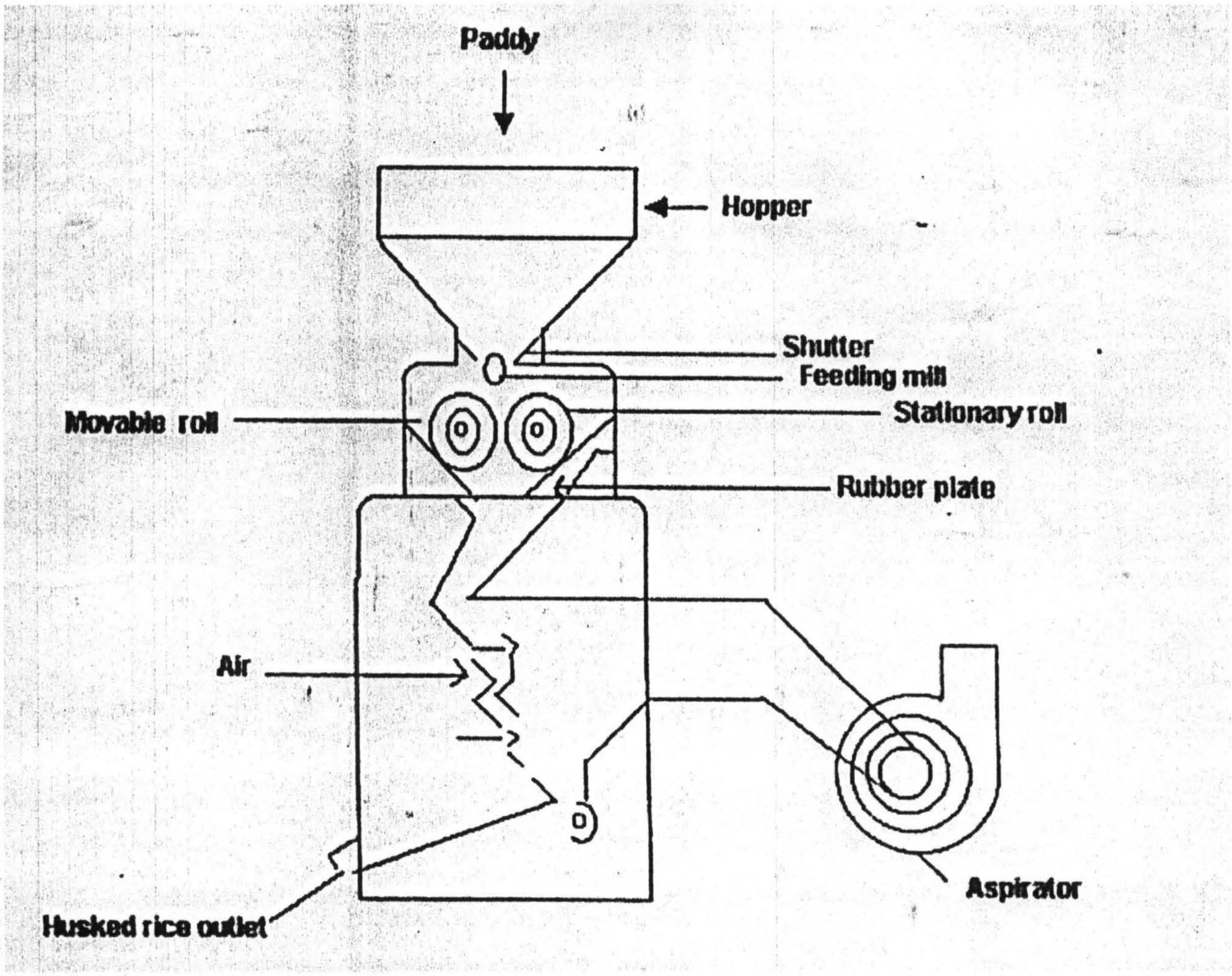


Fig. 2 Robber Roll Husker Source (Bandy and Roy, 1980)

The clearance between them is smaller than the mean thickness of the paddy.

One of the husk is subjected to shearing forces whereas the other part is in contact with the slower roll is under compression, and is thus subjected to breaking force. Dehusking is done by the action of these forces.

2.7 Types of Rice Milling Machines

2.7.1 Huller Mill

The earlier mechanized rice mill consists of huller usually called Engel-berg

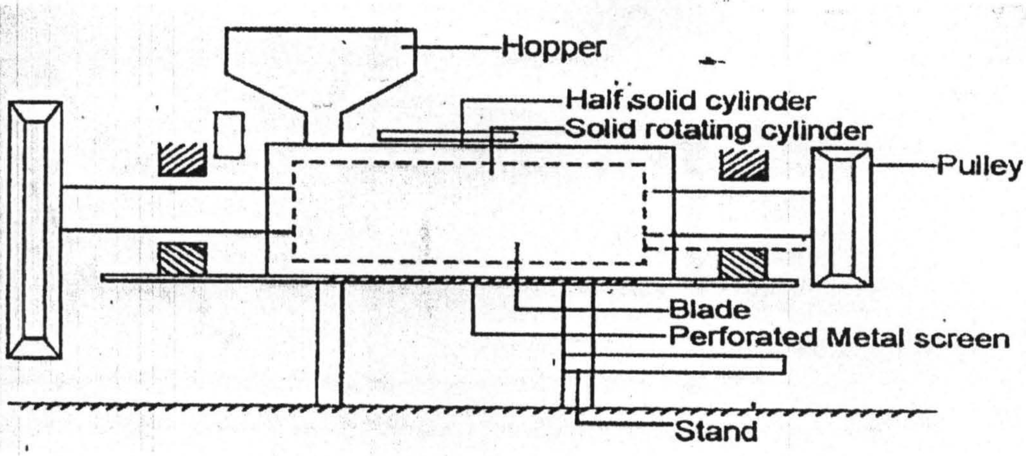


Fig. 3 Huller Mill (Source Bandy and Roy, 1980)

It consists of an iron-ribbed cylinder mounted on a rotating shaft on bearing and fitted in a concentric cylindrical housing. The inner ribbed cylinder has helical ribs up to one-fourth of its length and four to six numbers of straight ribes for rest of the length. These cylindrical casing can be divided into two halves. The bottom half of the cylinder is replaceable and made of slotted sheet so that the bran removed during the milling may pass through the slots by the pressure generated in the cylinder. The ribbed cylinder is rotated at a speed of 800 to 900 rpm by an electric or diesel motor using a flat belt and pulley drive. Feed rate to the huller is controlled by a slide gate at the bottom of the feed hopper.

Huller is a relatively small unit with a through put capacity of 250 – 500 kg/hr. In small village mills, milling may be done in one or two passes through the huller. In larger mills, three to five hullers are operated in series

to accomplish dehusking and polishing. In the first pass paddy is partially dehusked with 65 percent to 80 percent shelling depending upon the polishing of the knife. The mixture of paddy dehusked rice and husk is fed to the huller No. 2 and No. 3 operating with lower clearance of knife edge. It is in these hullers that complete dehusking and removal of bran (polishing) are accomplished.

Although the huller mills are simple to operate and less expensive, they have serious disadvantages:

1. Very low outturn o rice e.g. 63 percent on an overage
2. Little or no control on the degree of polishing
3. Rice bran gets mixed with husks, resulting in loss of a valuable by-product of the industries.

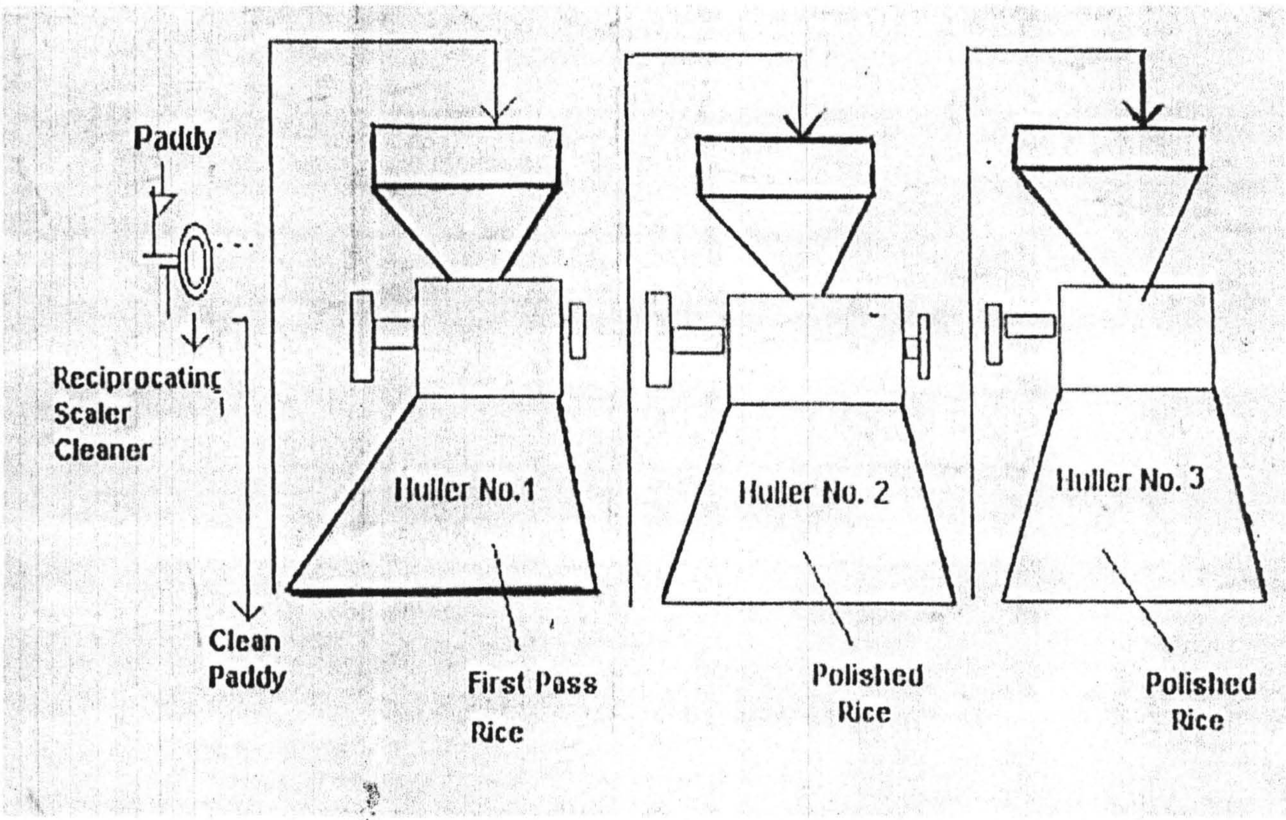


Fig. 4 Multipurpose Huller Mill Source (Bandy and Roy, 1980)

2.7.2 Sheller Mills:

These mills are improvements over the huller mills in the sense that dehusking, polishing, separation and grading are performed by separate machines. An example of a sheller is the under-runner disc sheller which consist of two horizontal iron discs coated with emery on side facing each other. The hopper disc remains stationary while the lower is rotated. Paddy is fed through the central feed hopper and centrifugal action causes radial movement of the paddy outward between the discs. Contact of the grain with the two discs removes the hull from the rice kernels. The degree of pressure and thus husk removal is controlled by the adjustment of the vertical clearance between the two discs.

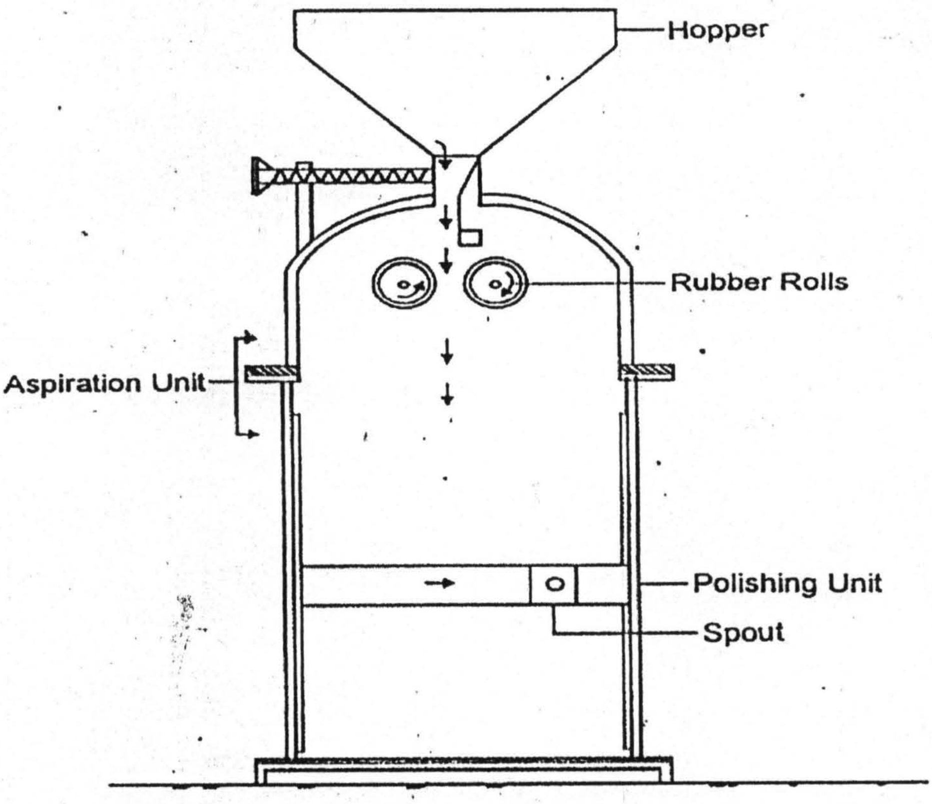


Fig 5 Sheller Mill Source (Bandy and Roy, 1980)

Among all traditional rice mills total and head yields are highest in sheller mills.

Disadvantages:

1. Head rice and total yields are less than the modern rice mills
2. Some scratches may be found on the rice kernel, which are undesirable for long storage.

2.7.3 Modern Rice Mill:

The important features of a modern rice mill are:

a. These mills are equipped with rubber roll sheller instead of the conventional emery under-runner sheller

b. Most of the mills have arrangements for recovery of broken grain and germs from the bran, which substantially increase its milling efficiency.

c. Provision of an efficient paddy cleaner in these mills removes most of the impurities, thus helping further in reducing breakage during milling.

d. Better performance due to general provision of the equipment'

The major operations performed by modern rice mills are as follows: (1) Paddy Storage (2) Efficient Paddy Cleaning (3) Husking (4) Separation of Paddy (5) Whitening or Polishing (6) Bran Separation (7) Grading

A modern rice mill designed by Satake Engineering Company of Japan with Collaborator Bonny Engineering Company of India is shown below:

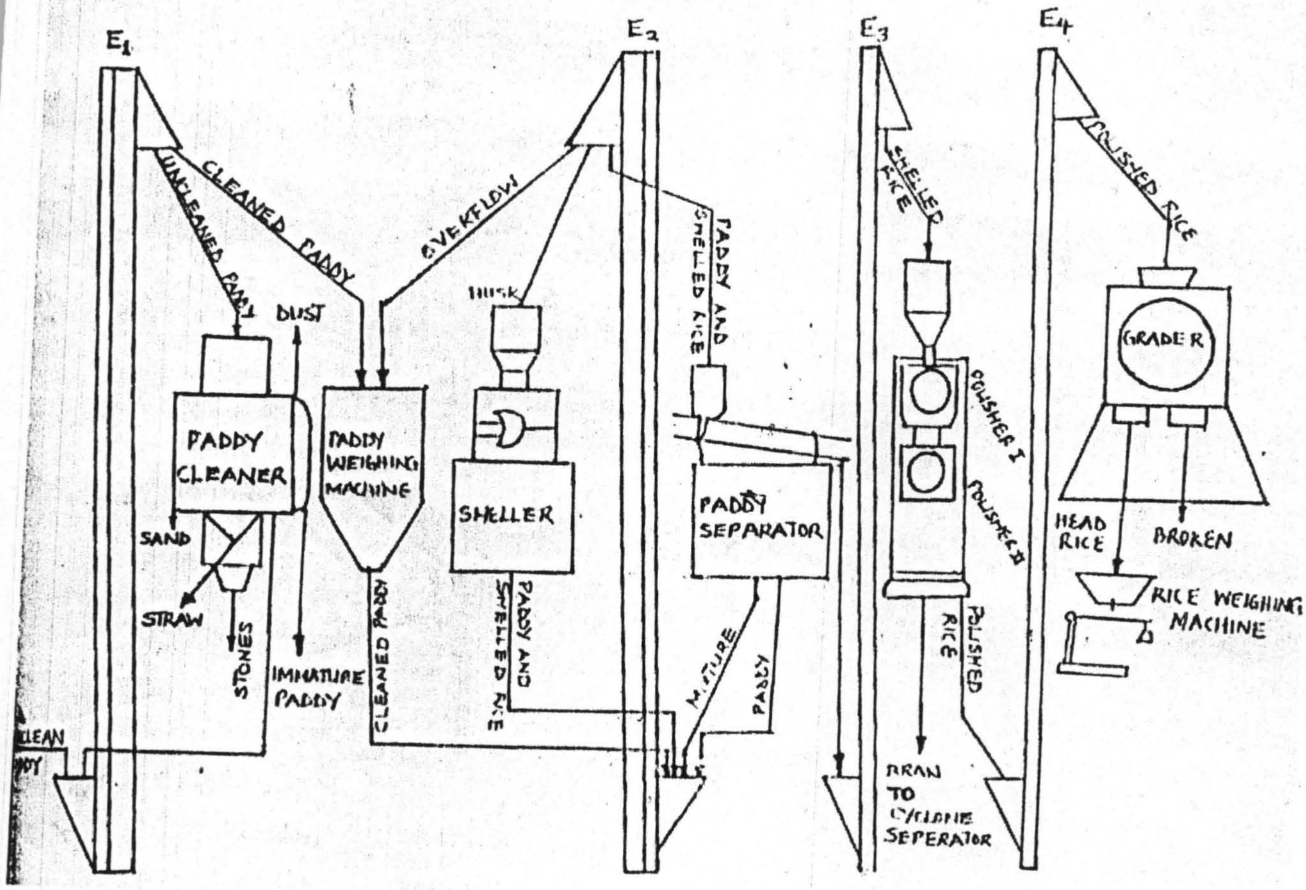


Fig 6 Modern Rice Mill Source (Bandy and Roy, 1980)

Table 1 gives the operational data of various equipment of a modern mill.

The relative advantage of milling by the different method mentioned above are summarized below in Table 1.

Table 1: Operational Data of Equipment for a Rice Mill
All dimensions in mm

Rubber-Roll Sheller	2000 – 3000	Speed: 1185 rpm Rubber Roll: 260 mm Length: 220mm dia Dimension (1070 x 851 x 1850)	7.5
Paddy Separator	1500 – 2000	Nor of compartment 24 Dimensions: 2040 x 1750 x 1480	2.2
Pearhing Cone	1230 – 1450 Double Milling	Diameter of Cone: 800 Speed: 320 rpm Air required: $12m^3$/min Dimension: 1400x1230x1825	7.5

Source: Bandy and Roy (1980)

Equipment	***Capacity (kg)***	***Specification***	***Motor Power (kw)***
Paddy Cleaner	1000	Sieve width 400 Dimension (990 X 2330)	2.3

Table 2: Relative Advantages in Milling by Different Methods

Particular	Hand Pounding	Hullers	Sheller & Huller	Modern Mills
Yield of Processed Rice	60-75%	61 – 65%	62 – 63%	67 – 71%
By Products	Broken + Bran+Husk 25 – 40%	Broken+Bran+ Husk 35%	Broken 4-6% Bran 5 – 7% Total Recovery 72 – 75%	Broken 3% Bran 5% Germ 2% Total Recovery 77%

Source: Chattergie & Maiti (2001)

2.7.4 Loss of Rice during Milling:

The quantity of grain breakage which occurs using a milling machine is much less than the number of grain breakage using motor and wooden pestle. At the initial stage of milling using machines, the loss per grain is usually lower but as the milling continues, the loss per grain is higher when compared to the loss of grains using mortar and pestle. This is because at the initial stage of milling using machine, the broken grain have sharp edges but as a broken part of a grain moves onward by rolling through the milling chamber, it continues to become smoother Chukwu (2001)

Thus the major loss occurred immediately after the breakage and the degree of such loss is a function of the time spent by the broken parts inside the milling chamber

Chukwu also observed that in the case of "Ikwe" Milling where the degree of milling was restricted to lower level, the broken parts have time and chance for smoothening and rounding actions. The result was thus lesser loss from individual grains though the percentage of breakage was higher.

2.7.5 Quantitative Rice Loss Due to Breakage:

Table 3 shows the quantity of endosperm loss from each grain if broken. It has been estimated that individual grain, if broken during milling may loss from 11.93 to as high as 26.11% of its head rice weight – Chukwu (2001). This loss from individual grain accumulated to a total average milled rice loss of 3.61kg of rough rice feed for milling

2.8 Milling Quantity of Rice

The milling quantity of rice is based on its head rice yield (whole-grain kernels milled) since head rice is usually the milled product with greatest monetary value. The yield of total milled kernel (head rice and all sizes of broken kernels) is important too. This yield is influenced by the proportion of hulls and the amount of broken kernels which are unavoidably inducted in the bran fraction during milling process. The following are some of the properties that describe the milling quantity of rice.

The checking of rice: This refers to cracks on rice grains. It is mainly attributed primarily to the low elasticity and poor mechanical strength of the grain and depends basically on drying. During drying, when the outer portion of the kernel is exposed to increases in temperature they expand since the central portions are inelastic internal pulling apart results in cracks. This could be avoided or minimized by drying the kernel at low air temperature leading to gradual removal of moisture from the kernel.

One of the chief causes of breakage of rice kernel during milling is the development of cracks. The percentage of checked grains varies greatly from 5 – 10 to sometimes 60 to 70. A one per cent increase in checking reduces the yield of head rice by 0.2 – 0.5 percent Konokhova (1995)

Vitreousness: It is quality of rice that described its degree of brittleness, it is an important measure of the milling qualities of rice. Usually, it varies between 95 and 98 percent. The more vitreous the grain, the less breakage during milling and the more flaky and non-sticky the rice when cooked. The longitudinal location of the mealy spot along the edge of kernel is preferable for milling as it gives good vitreous head rice.

Huskiness: This refers to the amount of husk a kernel has. The higher the percentage of hulls removed, the lower the milling yield. Because huskiness is associated with the structural and mechanical characteristics of the grain, slight change of about one percent in huskiness, which includes the bran and the polish changes the total yield of milled rice by about 1.5 – 2 percent.

The Grain Type: The smaller the length-width ratio, the higher the milling yield of head rice. The long-grain are highly esteemed because of their high cooking quality, although the yiesd of head rice of long grain rice is appreciably low.

In summary, the milling quality of rice depends on variety, grain type, cultivation practices and post-harvest methods of processing.

CHAPTER THREE

3.0 MATERIAL AND METHOD

3.1 Belt Drive Mechanism

It was noted by Shigley and Mischke (1989) that the tighter the belt, the more power that can be transmitted but the more damaging is the tension both to the belt and to the supporting shafts and bearings. It was further observed that v-belt can transmit more power. It was noted further that v-belts are slightly less efficient than flat belts i.e 70-96% and about 98% respectively but a number of v-belts can be used on a single sheave: thus making a multiple choice.

It was concluded that the pulley axes must be separated by a certain minimum distance, depending on the type of belt and size to operate properly. Zimmerman (1977) explained that in belt drive design it is essential to have not only the equation of the power transmitted but also a relationship linking belt tensions to the belt size strength, and speed and to the drive geometry and to the frictional co-efficient. It was further explained that most of the quantities in the design equation will have to be procured from manufacturer's literature or from hand book.

For a well-designed belt drive, where belt tensions are adequate the output speed will not be much less than one percent under the speed predicted by pulley speeds equation.

It was concluded that to maintain initial tension, the motor should be mounted on an adjustable base. Then from time to time, the motor can be moved farther away from the driven pulley to re-establish good initial tentions

It was also observed that, minimum pulley diameters are limited by the elongation of the belt's outer fibers as the belt bends around the pulleys. Small pulleys increase this elongation and it greatly reduces the belt life. It was noted further that, if a large speed ratio or a small distance between shafts are used, the angle of contact between the belt and pulley will be less than 180°.

Artus (1977) said that the total tension required by a v-belt is independent of the brand type or number of belts. He explained that two belt drives that are identical require the same total tension but the drive with fewer belts requires greater tension per belt.

3.3 Pulley Diameter

To compute the speed of the output pulley, the effective diameters must be used (Zimmerman, 1977)

It was also noted that except for timing belts, other belts experience slip and creep, and so the angular velocity ratio between the driving and driven shafts is neither constant nor exactly equal to the ratio of the pulley diameters.

3.4 Belt Wear

It was noted by Zimmerman, (1977) that belt wear is not by abrasion but by failure and it is very much like fatigue failure in metals. He explained that as the belt goes around the pulley, a varying stress is applied to it, a stress that becomes rather severe if the belt is wrapped around a very small pulley. Therefore, belt manufacturers recommend minimum pulley sizes for their various belt thickness.

3.5 Design of Shaft

Components mounted or integrated with shafts cause various stresses in the shaft. These stresses could be axial (tensile or compressive), bending stresses, shear stresses (torsion). These stresses can also be either static, cyclic (variable) or shock loaded.

The design analysis is to obtain shaft diameter that will ensure failure – free operation of the shaft under these loading conditions. Here, bending and torsional stresses are most active.

$T_y = T_3 \text{ Sin } 300 + T_4 \text{ Sin } 300$

$= 104.31 \text{ Sin } 300 + 37.28 \text{ Sin } 300$

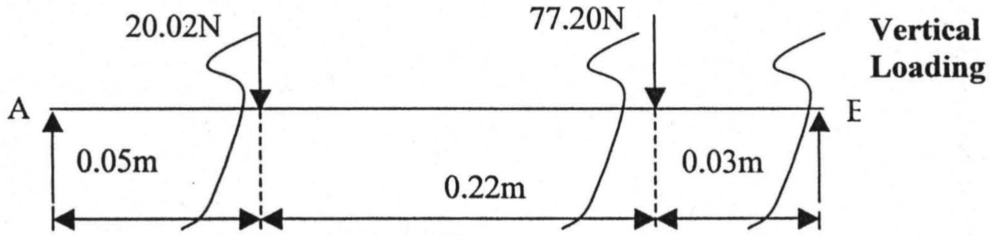
$= 70.80N$

$T_x = T_3 \text{ Cos } 300 + 37.28 \text{ Cos } 300$

$= 104.51 \text{ Cos } 300 + 37.28 \text{ Cos } 300$

$= 122.62N$

Shaft Loading in the Vertical Direction



Tx = 122.62N

Ty = 70.80N

$30.8\ (0.8) = RV_1 + RV_2 + 70.8$

$-46.16 = RV_1 = RV_2$

Taking moments about RV_2

$RV_1 = (0.95) - 30.8\ (0.8)\ (0.475) - 70.8\ (0.05) = 0$ (1)

$RV_1 = 16.05N$

From (1)

$Rv_1 = -62.21N$

Showing that RV_2 is acting in opposite direction

Taking moment about A.

$BM_A = 16.05\ (0.075) = 1.204Nm$

Taking moment about B,

$BM_b = 70.8\ (0.125) - 62.21\ (0.075) = 4.184Nm$

For maximum bending moment at C

$RV_1 - W(x - 0.075) = 0$

$16.05 - 30.8x + 2.81 = 0$

$x = 0.596$

bending moment at $x = 0.596m$

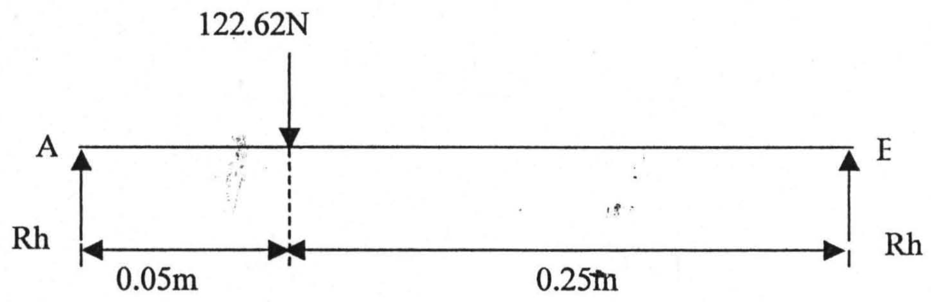
$BM_c = RV_1(x) - w/2\ (x - 0.075)^2$

$= 16.05\ (0.596) - 30.8/2\ (0.596 - 0.075)^2$

$= 5.39Nm = B_{max}\ V \times 1.5 = 8.085Nm$

Maximum bending moment in the vertical direction is 8.085

Shaft Loading in the Horizontal Direction



$RH_1 + RH_2 = 122.62N$ (2)

Taking moment about RH_1

$-RH_2 (0.950) + 122.62 (1.0) = 0, RH_2 = 129.07N$

Substituting into equation (2)

$RH_1 = -6.45N$

Indicating that RH_1 acts in the opposite direction, maximum bending moment occurs at point B.

$$BM_b = 122.62 (0.05) = 6.13Nm = B_{max} h$$

Resultant Bending Moment

Maximum bending moment $= \sqrt{(B_{max}h_2 + B_{max} V_2)}$

$$= \sqrt{(5.392 + 6.132)} = 8.163Nm$$

3.5.1 Diameter

Allen (1992) said, shaft design consists primarily of the determination of correct strength and rigidity when the shaft is transmitting power under various operating and loading conditions. He explained that, bending and torsional moments are the main factors influencing shaft design.

It was noted further that, design of shafts of ductile materials based on strength is controlled by the maximum shear theory while shaft of brittle materials is designed on the basis of maximum normal stress theory. Maximum distortion failure theory is less conservative than the maximum shear failure theory. However, both theories cause the shaft diameters not to be too far apart from each other, especially where the applied torque is much smaller in magnitude than the applied bending moment. The equations resulting from these two theories are rational but include only stresses due to fluctuating loads and not shock loads. (Shigley and Mischke, 1989)

Aaron (1982)said when gears, pulley, flywheels, friction sheels, cams and ratchets are mounted on shafting in various combinations and locations, to determine the shaft diameter, it will be necessary to calculate the bending moment and torque distribution along the full length of the shaft. He noted further that with this information, the designer can specify the required diameters for different parts of the shaft.

3.5.2 Diameter of Shaft

The material selected for the shaft is smooth mild steel rod

Design bending moment = $B_{max} \times 2$

$= 8.163 \times 2 = 16.33Nm$

Design Torque = $2 \times T_{max}$

$= 2 \times 3.183 = 6.366Nm$

the material has a maximum shear stress

= 40 × 106 N/m2

$d^3 = 16/ (\Pi \times T_{max}) (Fbm)^2 + (KLT)^2$

$d = [16/(\Pi \times T_{max} \sqrt{((1.5 \times 16.33)^2 + (1.5 \times 6.366)2)^{1/3}}$

d = 0.022cm

= 22mm

3.5.3 Cylinder Shaft Design

Optimum cylinder peripheral velocity for threshing paddy on impact force is 9.42m/s (Ahuja 1989). Cylinder of diameter 300mm rotating at a speed of 560rpm satisfies this threshing speed.

Volume = Circumference × length×thickness

$= 2\Pi\ (155) \times 600 \times 1.0$

$= 7.79 \times 105mm3$

since density of steel is 7800kg/m3

mass = $7800 \times 7.79 \times 105 = 6.077$kg/m3

3.5.4 Elements of the Shaft

The shaft has some elements on it, which contributes in the threshing action of the machine. The elements include cylinder and cylinder end plates, steel spikes. On the steel cylinder support, the weight of each is calculated

3.5.5 Cylinder

Housing mild steel sheet

Diameter = 300mm

Thickness = 1mm

Length = 600mm

Volume = Circumference × length × thickness

$= 2\Pi\ (155) \times 600 \times 1.0$

$= 7.79 \times 105mm^3$

since density of steel is 7800kg/m^3

mass = $7800 \times 7.79 \times 105 = 6.077$kg/m^3

3.5.6 Cylinder End Plates

Diameter = 300mm

Thickness = 1mm

Volume = Πr^2 (thickness) = $\Pi(300)^2/2 \times 1.0mm = 7.5 \times 104mm^3$

But a bore of diameter 30mm was opened at the center of each plate. This hole is where the shaft passes before being welded to the plates.

Therefore, the volume of each of these plates is the welded to the plates.

Therefore, the each of these plates is the volume less the hole.

i.e.

volume of hole = $\Pi r^2 = \Pi(30)^2/2\times1.0 = 706.858mm^3$

therefore volume of each cylinder end plate

= volume of plate – volume of hole

= $7.5 \times 104 - 706.858 = 7.4 \times 110mm^3$

mass of the cylinder plates

= 2(volume×density)

= $2(7.4 \times 104 \times 7800)$

= 1.15kg

Loading on Cylinder Shaft

$Ty_1 = T_1 \text{ Sin } 30 + T_2 \text{ Sin}30 + T_3 \text{ Sin } 30 + T_4 \text{ Sin } 30$

$= 212 \text{ Sin } 30 + 88 \text{ Sin } 30 + 104.31 \text{ Sin } 30 + 37.28 \text{ Sin } 30$

$= 106 + 44 + 52\ 155 + 18.64 = 18.64 = 220.80N$

$TX_1 = T_1 \text{ Cos } 30 + T_2 \text{ Cos } 30 + T_3 \text{ Cos } 30 + T_4 \text{ Cos } 30$

$= 212 \cos 30 + 88 \text{ Cos } 30 + 104.31 \text{ Cos } 30 + 37.28 \text{ Cos } 30$

= 382.43N

$Ty_2 = T_5 \text{ Sin } 90 + T_6 \text{ Sin } 90$

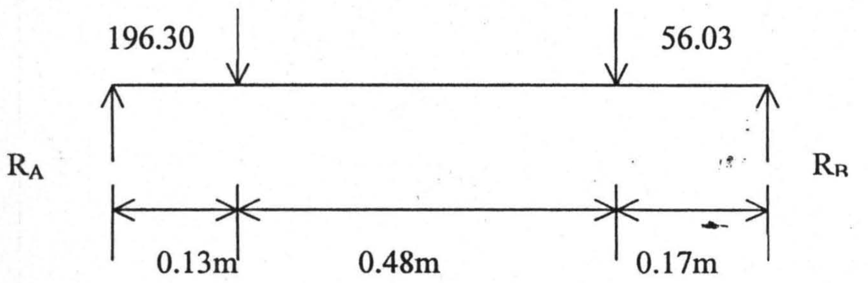
$= 43.35 \text{ Sin } 90 + 18.09$

$= 43.35 + 18.09$

= 61. 44N

$Tx_2 = 0$

Cylinder Shaft Loading in Vertical Direction



Vertical loading

220.80 + 131.0 (0.8) + 61.44 = $R_a + R_b$ = 387.04 (3)

Taking moment about R_a

Ty_2 (1.000) – R_6 (0.900) + (0.800) (0.450) – Ty_1 (0.100) = 0

61.44 (1.0) – r_6 (0.900) + 131 (0.800) (0.450) – Ty_1(0.100) = 0

61.44 – R_b (0.9) + 47.16 – 22.80 = 0

R_b = 96.13N

Substituting into equation (3)

R_a = 290.91N

Taking moment about A,

BM = -220.80 (0.1) = -22.08Mn

Taking moment about B,

$BM = -220.80\ (0.15) - 290.91\ (0.05) = -18.575NM$

Taking moment about D,

$BH = 61.44\ (0.15) - 96.13\ (0.05) = 4.4Nm$

Taking moment about E

$BM = 61.44 \times 0.1 = 6.144Nm$

Bending moment at C,

$R_a - Ty_1 - W(X - 0.15) = 0$

$X = 0.685m$

For bending moment at $x = 0.0685m$

$BMC = Ty_1 \times R_a(X - 0.1) - W/2\ (X - 0.15)^2$

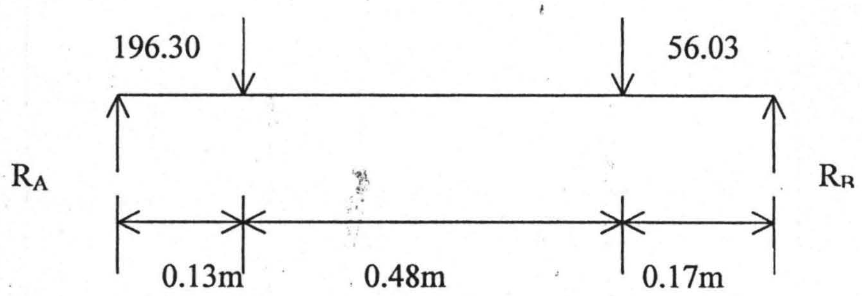
$= -220.8\ (0..665) + 290.91\ (0.685 - 0.1) - 131/2$

$(0.665 - 0.15)^2 = - 151.248 + 170.182 - 18.78$

$= 0.186Nm$

Maximum bending moment in the vertical direction is 22.08Nm

Cylinder Shaft Loading in Horizontal Direction



Horizontal loading

$R_a + R_b = 382.43.71 = 386.14N$ (4)

Taking moment about R_a

$3.21\ (1.045) - R_b\ (0.9) - 382.43\ (0.1) = 0$

$R_b = -\ 38.185N$

Showing that R_b acts in the opposite direction

Substituting into eqn. (4)

$R_a = 424.33N$

Taking moment about A

$Bm = 382.43\ (0.1) = 38.24Nm = B_{max}h$

$Bm = 3.71 \times 0.145 = 0.538Nm$

Maximum bending moment occurs at point A

Resultant Bending Moment

Maximum bending moment = $\sqrt{(B^2{}_{max}\ h + B^2{}_{max}\ V} =$

$= \sqrt{(38.24)^2 + (22.08)^2}$

$=44.16Nm = B_{max}$

Torsional Load

Torque, T = Power/Angular

$= 575 \times 60/(211 \times 530) = 10.36Nm$

Twisting moment = $10.36Nm = T_{max} = 10.36 \times 1.5$

$= 15.54Nm$

3.5.7 Diameter of Shaft

Light – shock factor for bending, $K_b = 1.5$

Light – shock factor for torsion, $k_c = 1.5$

Smooth round steel bar was used for the shaft

Design bending moment = $B_{max} \times 2 = 44.16 \times 2 = 88.32Nm$

Design (torque = $(T_{max}) \times 2 = 10.36 \times 2 = 20.72$Nm

The material has a maximum shear stress as $T_{max} = 40 \times 106$ N/m2

From $d^3 = 16/Ø \times 40 \times 106\ (k6m)^2 + (K + T)^2$

$d = (16 /Ø \times 40 \times 106\ (1.5 \times 88.32)^2 + (1.5 \times 20.70)^2)^{1/3}$

d = 0.0259m = 26mm

from standard shaft, 25mm is selected

3.5.8 Design for Torsional Rigidity

Ø = TL/GJ (5)

But Øall = 0.88/300 × : = 0.08/300 × 1145 = 0.30530 = 0.005rad

Substituting into (5)

Ø = 10.36 × 1.145/81 × 109 × J

J = 10.36×1.145/81 × 109 = $d^4 \Pi/32$

Using Ø = Øall

$d^4 = 32 \times 10.36 \times 1.145/\Pi \times 80 \times 109 \times 0.005$

= 0.0234m = 23mm

From standard shaft, 25mm is selected

3.5.9 Shaft Bearing

Loading carried at point A has a resultant

Fra = $\sqrt{(R^2 av + R^2 ah)}$

Fra = $\sqrt{(290.912 + 424.332)}$ = 514.48N

At point B

Frb = $\sqrt{(Rb^2 \times 96.132)}$ = 103.44N

Finding the equivalent load Pe, one use

$Pe = XVFr \times Yfa$

Pe = Equivalent radial load

Fr = Applied radial load

V = Rotational factor

X = A radial factor

Y = a thrust factor

The rotational factor V is to correct for various rotating ring conditions. For a rotating ring V = 1 – This is the situation on this design. The X and Y factor depend upon the eometry of the bearing including the number of balls and ball diameter. For this design, thrust load are not applied hence, Fa = 0 and Y = 0, X = 1.

At Point A

$Pe = 1 \times 1 \times 1 \times 514.48 = 514.48N$ (52.44kgf)

At point B

$Pe\ 1 \times 1 \times 103.44 = 103.44N$ (10.54kgf)

Number of revolution per (N) minute of shaft in bearing = 560rpm

Let the bearing have a reliability of 97%

Since the system operates for 48 hours per week (having six working days), 50 weeks per year, and for a probable life of 15 years. Life in hours = 48 × 50 × 15 = 36,000 hours

Using Kleibull expression

$R = e- (L)1.17/6.64L10$ (6)

Where:

R = Reliability (97%)

L = bearing life in hours (36,000 hrs)

L10 = rated life = Life of bearing for 97% survival at 1 million revolutions

From equation (6)

InR = -(L)1.17/6.84L10

L10hr = 36,000/-(lnR) 1.17 (6.84)

= 36,000/- ln(0.97) × 6.84 = 104,043.13 hrs

L10 hr = 104,043.13 hours

L10 revs = 104.043.13 × 560 × 60 = L10hr × N × 60

= 3.308571527 × 109 revs

= 3309 million revolutions

= 3.309 × 106 revolutions

Since Fra > frb

Fra > frb

Fra is used in this design

The dynamic load capacity is given by

C =(L10 rev/L10)1/k × Fra + Ks

Where:

Fra = Load or bearing

Ks = service factor = 1.5 for rotary machine

K = exponent = 3 for small bearins

C = (3309×106 rev/106 rev)1/3 × 514.48 × 1.5

= 11499.85N (1172.26kgF)

Basic dynamic capacity = 1021.13N

FS bearing p207 was selected from the series.

D = 42mm

B = 14mm

A = 25mm

3.6 Frame Design

Fc/Pc + Fbc/Pbc < 1 (7)

Where:

Fc = actual direct axial stress

Fbc = actual direct bending stress

Pbc = allowable bending stress

Pc = allowable axial stress

But Fc = F/A (8)

Where: F = axial load

A = cross sectional area of the section

Fbc = M/Z (9)

Whr: M = Moment

Z = sectional modulus

From Fbc = M/Z

Assume frame to be rectangular

Y = 850mm

X = 1700mm

$M_{xx} = 121.64 \times 0.3 = 36.49$Nm

$M_{yy} = 121.64 \times 0.225 = 27.37$Nm

Z_{xx} = db2/6 (10)

Z_{yy} = db2/6 (11)

Where:

B = width, d = depth

Z_{xx} = 0.85 × 1.702/6 = 0.409m3

Z_{yy} = 1.70 × 0.852/6 = 0.205m3

Therefore Fbc = 36.49 = 892.18N/m2

Pc/Pc + Fbc/Pbc < 1

And since the sum above is less than 2, it implies that the frame is safe to carry the design loads.

3.6.1 Shaft Geometry

Shigley and Mischke (1989) observed that, there is no rigid formula to determine the shaft geometry for any given design situation. The best approach is to study the existing designs to learn how similar problems have been solved and then combining the best of these to solve your own problem.

It was recommended that, the geometry of a shaft should generally be a stepped cylinder. A uniform diameter shaft would require no finishing cuts and appear to be inexpensive but it would be difficult to locate bearings, gears, pulleys and other members on it in a positive manner. He concluded that these elements must always be accurately positioned and provision made to accept thrust loads. However, if there is no existing design to use as a start, then the determination of the shaft geometry may have many solutions.

3.6.2 Keyways

Aaron (1982) said keyways and slots are a source of stress raisers. Care must be exercised in their selection and location in order to minimize the resulting stress concentration. He confirmed that they relieved the surface stress of the machined areas, causing the shaft to wrap.

Shigley and Mischke (1989) explained that the length of the keyways is based on the hub length and the torsional load to be transferred and the stress concentration factors depend for their values upon the fillet radius at the botton and end of the keyway.

Accoridng to Peterson (1974) it is 2.14 for bending and 2.62 for torsion.

3.6.3 Deflection

Aaron (1982) explained that, the information on shaft deflection is used to establish the minimum permissible clearance between the pulley, gear and housing (enclosure) for shaft assembly. It noted further that, it helps in determining the minimum bearing clearance for sleeve bearings as well as self-align bearings required.

He went on to say that a shaft having too large a lateral deflection can cause excessive bearing wear or failure. He concluded that a large lateral deflection is also responsible for lowering the critical speed, which may cause the shaft to vibrate if its revolutions per minute are at or near this speed.

Shigley and Mischke (1989) said, it is not enough to design a shaft that is not overly stressed, a shaft so designed may still be unsatisfactory because it lacks rigidity. He went on to further say that, insufficient rigidity or stiffness can result in poor performance of various shaft-mounted elements such as gears, clutches, bearing and flywheels. Therefore, he continued, angular deflection at bearings must be kept within the limits prescribed for bearings. Linear deflection should not be too large. He concluded that, lack of shaft stiffness will result in both linear and torsional vibration, the effects of which can show up in many ways.

3.6.4 Selection of Bearings:

The bearings are selected based on the shaft diameter and catalog radial rating.

The catalog radial rating is calculated as follows:

$$FR = Fp \quad LDND^{\underline{1}} \qquad (12)$$

Where

LR	=	catalog radial life
NR	=	catalog radial speed
FD	=	equivalent radial load
LD	=	required design life
ND	=	radial speed
A	=	constant = 3 (for ball bearings)

While the equivalent load for ball bearings is the maximum of the two values below:

$$FD = VFr \qquad (13)$$
$$FD = XVFr + YFa \qquad (14)$$

Where

Fr	=	applied radial load
Fa	=	applied thrust load
V	=	rotation factor – for ratating outer ring = 1.2
X	=	radial factor

Y = thrust factor

Source: Shigley and Mischke (1989)

3.7 Design Analysis

3.7.1 Mean Torque

In belt drive design, we have to first and foremost calculate the mean torque. Mean torque can be calculated using the equation

$$Tm = \frac{P}{W_1} \quad (15)$$

Where

P = the rated power of the motor i.e 5h.p (3.73kW)

ω_1 = angular velocity of the electric motor 1450 rev/min (15184 rads/s)

3.7.2 Output Pulley Speed

The speed of the driven pulley n_2 can be calculated using the following Relationship.

$$n_2 = \frac{n_1 \times d_1}{d_2} \quad (16)$$

Where n_1 = the speed of the electric motor

d_1 = the pitch diameter of drive pulley

d_2 = the pitch diameter of driven pulley

Both d_1 and d_2 were selected on the basis of available space and cost.

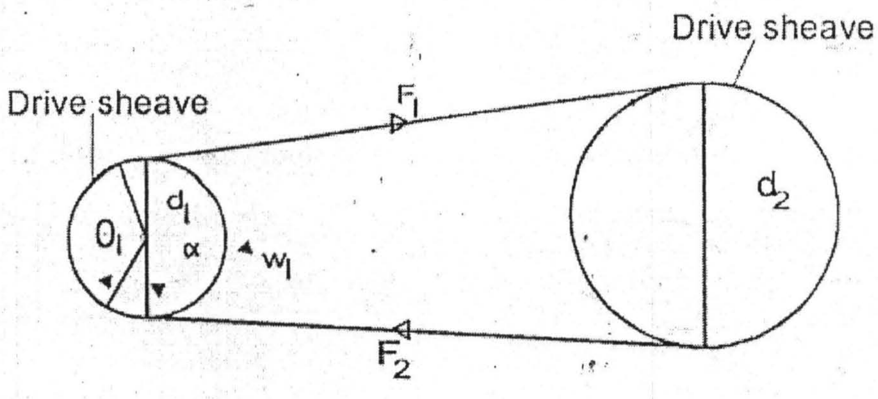


Fig. 7 A schematic diagram of a belt drive

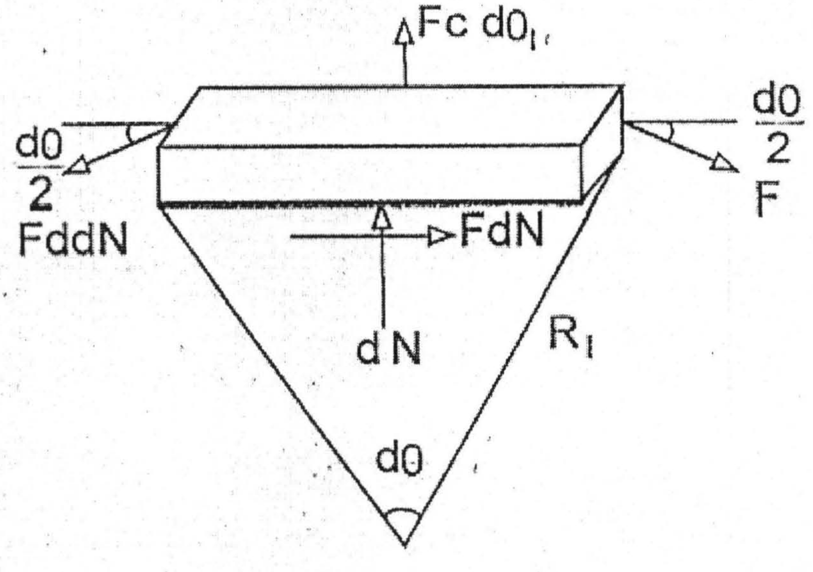


Fig.8 A schematic diagram of forces acting on an Elementary section of a flat belt on verge of slipping

If the radius R_1, is measured to the belt center and the mass of the belt per unit length is m the length of the elementary section of belt is $Rd\theta$

thus:

The mass of the belt is given as

$$m \quad = \quad \omega_1 R_1, d\theta \ (kg) \tag{17}$$

For angular velocity w1 the normal acceleration is

$$a = \quad \omega_1^2 R_1 \ (m/s^2) \tag{18}$$

3.7.3 The Centrifugal Force On The Belt

$$F_c = m \quad \omega_1^2 R_1, (N) \qquad (19)$$

Where

m = Mass per cent length for a typical v-belt = 0.28kg/m

R = radius of the sheave

3.7.4 Angle of Wrap

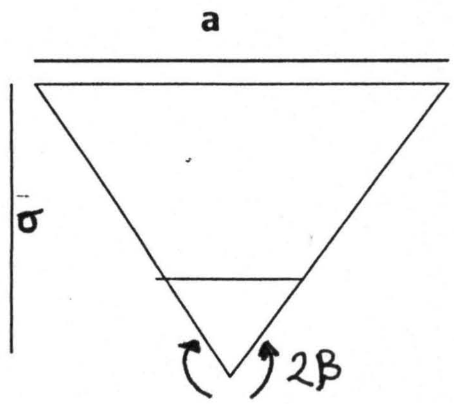


Fig. 9 A schematic diagram of a standard v-belt cross Section

For unequal pulley radii, angle of twist (α) in fig 3.1 can be expressed as follows:

$$\text{Sin}\alpha = \frac{R_2 - R_1}{C} \qquad (20)$$

R_1 = drive pulley radius
R_2 = driven pulley radius

C = centre distance between the pulleys

The angle of contact on the small pulley is given as follows:-

$$\theta_1 = \Pi - 2\alpha \tag{21}$$

where

Π = 3.142

α = angle of twist

3.7.5 V-Belt Tension Relationships

The expression of v-belt tension relationship is

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\frac{f\theta_1}{\sin\beta}} \tag{22}$$

Where

F_1 = tension on the tight side

F_2 = tension on the slack side

F = co-efficient of friction for the belt i.e 0.25 for

Rubberized canvass belt. Source: Zimmerman (1977)

1_c = centrifugal force on the belt

0_1 = angle of contact on the small pulley

β = v-belt-section angle. This is given as 20^0

Source: Shigley and Mischke (1989)

3.7.6 Transmitted Torque

Transmitted torque can be calculated using the following relationship

$$T_2 = (F_1 - F_2)R_2 \tag{23}$$

where

F_1 = tension on the tight side

F_2 = tension on the slack side

R_2 = driven pulley radius

F_1 is calculated from equations 3.8 as thus

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\frac{f\theta_1}{\sin\beta}}$$

Let the right-right side be equal to γ

then;

$$F_1 = F_c + \gamma\,(F_2 - F_c) \tag{24}$$

The mean torque can also be calculated as follows:

$$T_1 = (F_1 - F_2)R_1 \tag{25}$$

Where

F_1 = tension on the tight side

F_2 = tension on the slack side

R_1 = driven pulley radius

From equation 3.11

$$F_2 = F_1 - \frac{T_1}{R_1} \tag{26}$$

And eliminating F2 in equation 3.10 gives

$$F_1 = F_c + \frac{\gamma}{\gamma - 1}\,\frac{T_1}{R_1} \tag{27}$$

3.7.7 Calculation of Minimum Shaft Diameter

The minimum shaft diameter is calculated by combining the distortion energy theory with the modified Goodman line of failure for metal fatique.

Thus, for a shaft with steady tension and reversed bening

$$D3 \quad 32n \quad \frac{KF\,M_a}{S_e} + \frac{3T_m}{2\,S_{ut}} \qquad (28)$$

Where	d	=	Minimum shaft diameter
	Ma	=	Mean applied bending moment
	Tm	=	Mean applied torque
	Sut	=	Minimum Ultimate tensile strength
	N	=	design factor of safety
	Kf	=	Fatique stress concentration factor
		=	Constant (3.142)

For ASTM (The American Society for Testing Materials)

No. 60 for glay cast iron

Sut	=	62.5 Kpsi	=	431 Mn/m2
Se	=	24.5 kpsi	=	169 MN/m2
Kf	=	1.50		

Source: Shigley and Mischke (1989)

Fig 3.4 – A schematic diagram of the forces on the sheave.

The tight side tension F1 is greater than the slack side tension F2 and thus there is a net driving force on the sheave equal to

$$F_N = F_1 - F_2 \qquad (29)$$

The net driving force can also be calculated from the torque transmitted.

Fig. 3.5 A schematic drawing of milling shaft assembly

$$F_N = \frac{T X D}{2} \qquad (30)$$

Where T = torque transmitted (NM)

D = diameter of the sheave (m)

For V-belt drives, it is assumed that the ratio of the tight side tension to slack side tension is given as

$$\frac{F_1}{F_2} = 5 \qquad (31)$$

And the relationship between the bending force F_B and the net driving force F_N for V-belt is expressed as follows:

$$F_b = 2.0F_N \qquad (32)$$

It is customary to consider the bending force F_b to act as a single force in the direction along the line of centers of the two sheaves

3.7.8 Selection of Bearings

The bearings are selected based on the shaft diameter and catalog radial rating.

The catalog radial rating is calculated as follows:-

$$FR = FD \; \frac{LDND}{LRNR} \; \frac{1}{q} \qquad (33)$$

Where

LR = Catalog radia life

NR = Catalog radia speed

FD = Equivalent radial load

LD = required design life

ND = Radial speed

Q = Constant = 3 (For ball bearings)

While the equivalent load for ball bearing is the maximum of the two values below

$$FD = VFr \quad (34)$$

$$FD = XVFr + YFq \quad (35)$$

Where Fr = applied radial load

Fq = applied thrust load

V = rotation factor for outerring = 1.2

X = radial factor

Y = Thrust factor

Source: Shigley and Mischke (1989)

3.8 Description of Machine Main Units

. The rice huller is a machine made of steel drum on shaft rotating inside a housing with a screen underneath. It consists of three basic units, the milling unit, the power unit and the support (stand).

3.8.1 The Milling Unit

This unit consists of an iron-ribbed cylinder having helical ribs up to 1/3 to ½ of the length and straight rib in the remaining portion. The cylinder is rigidly fixed to a shaft that passes through it. The shaft is supported at the end by the use of roller bearings. One end of the shaft carried a pulley which transmit power from the power transmission unit to the milling head.

The milling head (milling cylinder) is covered by the machine housing which opens to the surface by the use of an hopper through which rice is poured to the milling unit. The ıelical ribs of the milling cylinder is directly under the hopper. As paddy comes from the hopper, it falls on the helical ribs, which convey it to the milling end.

A straight edge or knife is inserted into the milling chamber to control the husking and polishing operation by adjusting the clearance between the rotating cylinder and milling knife. This enables the machine to mill various rice varieties and conditions with minimum breakages. Feed rate to the machine is controlled by a slide gate at the bottom of feed hopper. Below the milling cylinder is a sieve that separates the milled rice from husk and bran. See Working Drawing.

3.8.2 The Power Transmission Unit

The power transmission unit is made up of an electric motor, 2. pullies (one on the electric motor and the other on shaft that passes through the cylinder) The shaft is support at both end by ball bearings and belts.

The power input is from the pulley on the motor through the belts to the pulley on the shaft on the corrugated cylinder that does the de-husking.

3.8.3 The Support

The rigid structure offers support to the whole machine. It is made from a (40 X 40) mm angle iron of 5mm thickness. The height of the support has been chosen to be 800mm taking into consideration the anthrometics data of the target end users.

3.8.4 Bolts and Nuts

Total number of bolts and nuts used on the machine is 24 (21 M8 X 30m and 3 M10 X 25mm). This is because the machine is made to be dismantleable for easy transportation. They are made of cast iron.

.8.5 Milling Knife

The milling knife was made of mild steel and it help to mill he paddy rice efficiently when adjusted. It made the machine to be versatile in that when adjusted, the machine can also mill maize and any type of grain. It regulates the severity of the dehusking process and kept breakage to minimum. See Working Drawing.

3.8.6 Body Frame

The 2mm thick angle iron (40 X 40) where the solid cylinder was mounted were cut to size, welded with 1.5mm thick mild steel plate welded on it for more rigidity. See Working Drawing

3.8.7 Milling Shaft

The shaft was made of mild steel. It has two 8mm thick rod fabricated has augers along its length on its outside diameter. The augers serve three (3) purposes:

(a) To help in removing the shell or husk from the material in question

(b) To help to convey the materials from the point of feeding to discharge point

(c) Serves as a fan to blow the shell or husk away from the material through the perforated cylinder below the shaft.

On both ends of the shaft there are bearings to balance the rotary motion of the shaft, and on one end of the shaft is the pulley with two groves through which the machine receive its power via a V-belt. See Working Drawing

3.8.8 HOPPER

The hopper was mounted on the upper half hollow cylinder that contained the milling shaft. The hopper was made of 0.9mm thick galvanized sheet to reduce weight and to prevent rust. It was formed into a tapped shafe to private gravity loading to the center of the shaft.

A 90 x 160 mm mild steel plate slot freely in a groove at the bottom of the hopper to control the feeding rate. See Working Drawing

3.8.9 Hollow Cylinder

The upper half hollow was made of mild steel iron pipe, cut into half along its length. The lower half cylinder was made of brass and it is perforated to screen out the rice blan and mall particles. See Working Drawing

3.9 Bearings

The 30mm internal diameter bearings were selected but bushed based on the minimum milling shaft diameter. They are sealed on both surfaces to prevent rice blan solid particles from penetrating into the rotating surfaces. They are made of carbon steel with nipples for lubrication. The bearing size is P207

3.9.1 Pulleys

A pulley (130mm and 25mm outside and inside diameters respectively was used on the milling shaft while another pulley of 60mm and 25mm outside and inside diameter respectively was used on the electric motor. They are made of cast iron. See Working Drawing

3.9.2 Belt

V-belt was chosen because of its flexibility and cheap cost. It can also transmit more power for a maximum initial tension than the flat belt.

3.9.3 Electric Motor

The 5 HP electric motor was selected because of the low maintenance cost, smoothness, less noise in operation than engines and smoke free.

3.9.4 Bolts and Nuts

Total number of bolts and nuts used on the machine is 24 (21 M8 X 30mm and 3 M10 X 25mm). This is because the machine is made to be dismantleble for easy transportation. They are made of cast iron.

CHAPTER FOUR

4.0 MATERIALS SELECTION, DESCRIPTION AND COST ESTIMATES

4.1 Material Selection

The machine was design with parts of considerable strength than can resist the shearing and abrasive forces produced during operation. The overall consideration was to have a portable and dismantleable machine for easy transportation at a reasonable cost but strong enough to withstand resistive loads and varieties.

The material selection is the ability of the designer to choose the right type of material in construction of engineering structure and component.

The following factors were considered in the selection of materials for this work:

(a) The ability of the materials to withstand severe condition

(b) The properties of the materials

(c) Easy workability of materials

(d) Cost of materials, transportation, handling and processing during the period of construction

4.1.1 Body Frame

The 5mm thick plates where the solid rotating cylinder was mounted, were cut to size, wielded and together with 10mm diameter iron rods along its length to form a rigid body.

4.1.2 Milling Shaft

The shaft was made of mild steel. It have two 5mm thick augers fabricated along its length on its outside diameter

4.1.3 Hopper

The hopper was mounted on the upper shaft hollow cylinder that contained the milling shaft. The hopper was made of 2.5mm thick steel plate, formed into a tapered shape to private gravity loading to the center of the shaft. A 4X10mm mild steel plate slots freely in a groove at the bottom of the hopper to control the feeding rate.

4.1.4 Hollow Cylinder

The upper half hollow was made of galvanized iron pipe, cut into half along its length. The lower half cylinder was made of brass and it is perforate to screen out rice bran and small particles.

4.1.5 Bearings

The 30mm internal diameter bearings were selected based on the minimum milling shaft diameter. They are sealed on their outer surfaces to prevent rice bran solid particles from penetrating into the rotating surfaces. They are made of carbon steel.

4.1.6 Pulleys

Four V-shaped pulleys of 231, 121 and 6mm diameter were used as drive pulleys for the electric motor and the compressor respectively. The 231mm diameter pulley drives the milling shaft, while the 121 mm diameter pulley drives the compressor. They are made of cast iron

4.1.7 Belt

V-belt was chosen because of its flexibility and cheap cost. It can also transmit more power for a maximum initial tension than the flat belt.

4.1.8 Electric Motor

The 5 hp Electric Motor was selected because of the low maintenance cost, smoothness and less noise in operation than engines.

4.2 Materials and Cost Estimates

Table 3 Material Selection and Costing

S/No.	Component	Material	Dimension (mm)	Qty	Unit Cost	Total
1.	Shaft	Mild Steel	dia = 301	1	3,500.00	3,500
			Lenghth = 96			
2.	Upper half cylinder	Zinc	dia = 140	1	860	860
			lenghth = 450			
3.	Lower half cylinder	brass	dia = 140	2	350	700
			length = 225			
4.	Body frame	steel	thickness = 5	1	4,500	4,500
			length = 300			
			width = 200			
5.	Bearing	carbon steel	dia = 304	1	650	650
6.	Bolt	steel	dia = 246	12	300	420
			dia = 206			420
			length = 2000			
			breadth = 1000			
7.	Upper hopper		thickness = 2.5	1	500	500
			length = 450			

			Width = 150			
8.	Fan belt	Rubberized	A 54	2	250	500
9.	Paint			1	500	500
	Electrode			1/2 pkt		350
				TOTAL N 14,180		

Number of hours used in fabricating and welding of the components = 92 hours. The welder receives N42 per hour

The total amount collected by the welder = N3,864.00

The apprentice welder receives N10 per hour

The total amount collected by the apprentice = N920.00

Amount collected as service charge N3,864

+ 920

4,784.00

The total cost of materials and service charge (overhead cost) =N22,764.00

CHAPTER FIVE

5.0 PERFORMANCE EVALUATION AND EXPERIMENTAL RESULTS

5.1 Performance Evaluation

Technical evaluation is a scientific method of ascertaining the technical condition of the various components of a system with a view to establishing how the components contribute to the overall efficiency of the system. For an objective evaluation of machine such as threshers, performance tests are to be carried out. Type tests carried out on a thresher to prove the conformity with the requirements of relevant standards (or design specifications of the threshers). Type tests carried out include general tests, test at no load and test at load.

5.1.1 General Test

i. Checking of specifications

ii. Checking of material

iii. Visual observation and provision for adjustments

5.1.2 Test at no load

This is running th threshers at no load for at least half an hour at the specified revolutions of the threshing unit an electric motor or appropriate power nad recording the readings of the energy meter at intervals of five minutes (NCAM, 1990). The difference between two consecutive readings gives power consumption for five minutes. This is used in calculating the power consumption at no load for one hour. During and after completing power consumption, the following observations are made and recorded.

i. Presence of any marked oscillation during operation

ii. Presence of undeue knocking or rattling sound

iii. Other observations (if any).

5.2.3 Test at load

Test at load of two types

a. Short run test and

b. Long run test

Short run test enables the tester to get the following data.

i. Total losses

ii. Milling efficiency

iii. Cleaning efficiency

iv. Power consumption

v. Input capacity

vi. Output capacity

Te final sample obtained is analyzed for cracked and broken grains, refractions unmilled grains and clean grains. Analysis for cracked and broken grains is made only from the samples taken at specified grain outlets. Grain losses threshing and cleaning efficiencies are also determined.

5.2.4 Determination of Total Losses

a. Percentage unmilled grain

= (Quantity of unmilled grain from straws in kg /total grain received at grain outlet in kg) * 100

= 5.33/267.9 * 100 = 1.99%

b. Percentage of cracked and broken grain

= (Cracked and broken grain from grain outlet in kg/Total grain received at grain outlet in kg) * 100

From the sample taken, no broken or cracked grain seen. Therefore nothing was recorded.

= 0/267.9 * 100 = 0%

c. Percentage of blown grain

= (Quantity of clean grain obtained at straw outlet in k/Total grain input in kg) * 100

there was no clean grain obtained at the straw outlet, hence there was nothing recorded.

= 0/267.9 * 100 = 0%

d. Percentage of sieve loss

= (Clean grain at sieve overflow + sieve underflow + stuck grain in kg/Total grain input in kg) * 100

the major component of the sieve loss is the sieve underflow. The loose grain under the sieve was found by spreading a mat under the machine to collect and check the losses. The grain obtained was weighed. The sieve overflow and stuck grain were also weighed.

Clean grain obtained at sieve overflow = 2.0kg

Clean grain obtained at sieve underflow = 3.27kg

Stick grain = 2.2kg

Total sieve loss = 7.47kg

Percent sieve loss = 7.47/267.9 * 100 = 2.788%

Total losses = Sum of losses obtained at (a), (b), (c) and (d) above.

= 1.99 + 0 + 0 + 2.79 = 4.78%

5.2.5 Determination of Efficiencies

Milling Efficiency: This is the ration of total weight of grains milled to the total weight of grains fed into the miller machine for milling expressed as a percentage. It is also the difference between 100% and the percentage of unmilled grain.

Milling Efficiency (ME) = 100 – percent of unmilled grain

= 100 – 1.99% = 98.01%

Cleaning Efficiency: The ratio of the weight of clean grains that pass through the cleaning unit to the total weight of grains at the outlet of the grain retainer expressed as a percentage.

Cleaning Efficiency (CE) =

(Clean grain received at grain outlet in kg/Total grain received at grain outlet in kg) * 100

= 266.0/267.9 * 100 = 99.32%

Determination of Output Capacity

To determine the output capacity, the weight of threshed grain received grain received at specified grain outlet is taken and recorded.

Long Run Test

Long run test entails operating the machine for at least twenty to fifty hours. This enables the tester to determine the major breakdowns, defects developed an repairs to be made. In this study, long run test was not carried out due to lack of facilities.

Routine Test

Routine tests are carried out on a machine to check the requirements, which are likely to vary during production or use. These ae grouped into essential and optional tests. The essential routine tests are visual observations and provisions for adjustments and tests at no load. While the optional tests are checking of specifications and materials. The pretest observations carried out include the determination of grain – straw ratio, moisture content, grain length and breadth and length of ears rice crop.

Input Capacity and Output Capacity

In order to evaluate the capacity of the rice thresher cleaner, the input and output streams were carefully timed with a stop watch and the rate of output calculated on the basis of the results as presented in test data sheet Tables 8 and 9. Based on the definitions given in appendix B, the following can be calculated.

Grain Recovery Range (GRR) = 100 – percent total losses

= 100 – 4.78 = 95.22%

Capacity Utilization (CU) = output capacity/input capacity * 100%

= 267.9/490 * 100% = 54.67%

Milling Index (MI) = GRR * CU * TE, decimal

= 0.9522 * 0.5467 * 0.9801 = 0.510 (or 51.0%)

Milling Intensity (MIN) = Power consumed by milling machine/Output capacity of milling machine

= 7.9kw/267.9kg

= 0.029kw/kg

The amount of rice to be milled (400kg) was measured and fed into the hopper to the solid rotating shaft, the discharge outlet was closed and the batch was milled for a specific time.

5.2.6 Weighing of the Product and By-Product

The product discharged from the rice outlet was collected and separated into milled and un-milled rice, and the brokens. Each of these was then weighed. The by-product (husk and bran) was collected at the bottom of the perforated lower half brass cylinder and weighed. The experiment was repeated for another batch of rice.

5.2.7 Experimental Results

a. First Experiment

Date 9th November,2006

1.	Initial moisture content	12.41% (w.b)
2.	Ambient air temperature	35.6°C
3.	Grain layer thickness	9.5cm
4.	Drying temperature	100 oC
5.	Exposure time per passage	2min
6.	Number of passage	4
7.	Total quantity dried	865.42g
8.	Average weight of a dried paddy	0.026g
9.	Final moisture content (m.c.)	8.77%
10.	Number of times milled	1
11.	Hydrothermal treatment	none
12.	Milling time	0.5hr
13.	Amount of the husk and mealy waste	20.872g
14.	Amount of the broken rice	23.996g

15. Amount of the milled rice 32.272g

16. Amount of the unhulled rice 37.529g

17. Amount of a grain of paddy before milling 0.0285g

18. Total amount of the grain before hulling 191.529g

From the above data, the milling rate, total milling recovery and co-efficient of husking are calculated as follows:-

$$\text{Milling rate} = \frac{\text{Total amount of the grain milled}}{\text{Milling time}}$$

$$= \frac{0.192}{0.5}$$

$$= 3.84\text{kg/hr}$$

$$\text{Total milling recovery} = \frac{\text{Amount of milled rice}}{\text{Total amount of rice before dehulling}} \times 100$$

$$= \frac{32.272}{191.529} \times 100$$

$$= 16.850\%$$

$$\text{Co-efficient of husking } (E_{hulling}) = \frac{n_1 - n_2}{n_1} \times 100$$

Where n_1 = amount of grain before hulling

n_2 = amount of unhulled grain after hulling

Therefore

$$E_{hulling} = \frac{191.529 - 37.529}{191.529}$$

$$= 80.41\%$$

b. Second Experiment

The paddy rice was parboiled and then subjected to the same testing conditions and went under two passages in the mill.

Results

1.	Amount of the husk and mealy waste	=	32.389g
2.	Amount of the broken rice	=	8.68g
3.	Amount of the milled rice	=	64.27g
4.	Amount of the unhulled rice	=	27.246g
5.	Amount of a grain of paddy before milling	=	0.0342g
6.	Total amount of the grain before dehulling	=	185.567g

$$\text{Milling rate} = \frac{183\text{kg}}{0.05}$$

$$= 4.62\text{kg/hr}$$

$$\text{Total milling recovery} = \frac{64.27 \times 100}{185.567}$$

$$= 85.3\%$$

$$\text{Co-efficient of husking } (E_{hulling}) = \frac{185.567 - 27.246 \times 100}{185.567}$$

$$= 85.3\%$$

$$\text{Moisture content (w.b)} = \frac{0.032 - 0.026}{0.032} \times 100$$

$$= 18.75\%$$

Table of Results

I.	Variety of rice handled	Faro 51
II.	Moisture content of rice handled:	18% (average) wet basis
III.	Power requirement:	5hp (3.7kw) electric motor
IV	Losses:	
a)	Unmilled grain:	1.99%
b)	Cracked and broken grains	23.9kg
c)	Sieve loss	2.79%
d)	Blown rain	0%
VI.	Milling efficiency	98.01%
VII.	Cleaning efficiency	99.32%
IX.	Input capacity	490kg/hr
X.	Output capacity	267.9kg/hr
XI.	Grain recovery range (GRR)	95.22%
XII.	Capacity Utilization (CU)	54.57%
XIII.	Milling index (M.I.)	51.0%
XIV.	Milling intensity (M.I)	0.029%

XV. Observation affecting performance:

a). Moisture content of rice crop

b). Length of rice crop exceeding 93cm

c). Number of workers required is three

d). Machine requires continuous feeding

PARAMETER	SYMBOL	UNIT	VALUE
Mean Torque	Tm	Nm	24.57
Output pulley Speed	n2		378.261
Centrifugal	Fc	N	5.81
Angle of Twist		rad	0.171
Angle of contact	1	rad	2.80
Tension on the light side of the bye	F1	N	946.323
Tension on the slack side of the belt	F2	N	127.323
Minimum shaft diameter	d	M	30

The result presented in the table represents the average performance evaluation of the rice milling machine.

CHAPTER SIX

6.0 RESULTS CONCLUSION AND RECOMMENDATION

6.1 RESULTS

Parboiled rice at 32% moisture content was dried at 18% moisture content and then milled in the huller to obtain the average milling rate (372 kg/hr),average total milling recovery (50.9%),average coefficient of husking (82.85%), milling efficiency (98.01%), cleaning efficiency (99.32%), capacity utilization (54.67%), milling index 0.510 (or 51.0%) milling intensity (0.029kw/kg) input capacity 490kg/hr output capacity 267kg/hr. Grain recovery range(GRR) 95.22% and Capacity Utilization(CU) 54.57%.

6.2 Conclusion

The objectives of carrying out this Project work have been fulfilled. The machine has been tested, the result of the preliminary test was very encouraging as shown on table 5.0, the machine compactness and simplicity makes it easy to understand and operate, efficient in terms of milling recovery and effectiveness of milling.

It cost N22, 400 to produce the machine as compared to N35, 000 cost of original one in the market as at September, 2006.

When compared to the existing ones it has the following advantages:

(a) Easy to move from one place to another due to the fact that the components were made to be dismountable.

(b) Its versatibility due to the adjustability of the milling knife which makes it to be able to mill any other grain by adjusting the clearance between the milling shaft and the milling knife through an adjuster.

The knowledge of rice milling has increased considerably as a result of extensive research on methods and applications to tackle the problem encountered.

No design can be considered as ideal therefore, this design can be subjected to further analysis which will result in elimination of some parts and modification of others, and this will make the machine simpler in design and operation and will also reduce construction cost.

The machine has been designed to be operated with a 5hp electric motor

6.4 Recommendations

Having tested the machine, results were obtained; some observations were also made and thus pave way for arriving at a reasonable conclusion.

From the performance test, results, observations and conclusion the following recommendations were made:

iv. The machine should be subjected to an intense milling operation so as to allow any short coming or fault to manifest for further improvements

v. Constant greasing of the bearings as they are subjected to wear

vi. Proper belt tension should be maintained at all times

vii. The electric motor should be protected against moisture to avoid shock

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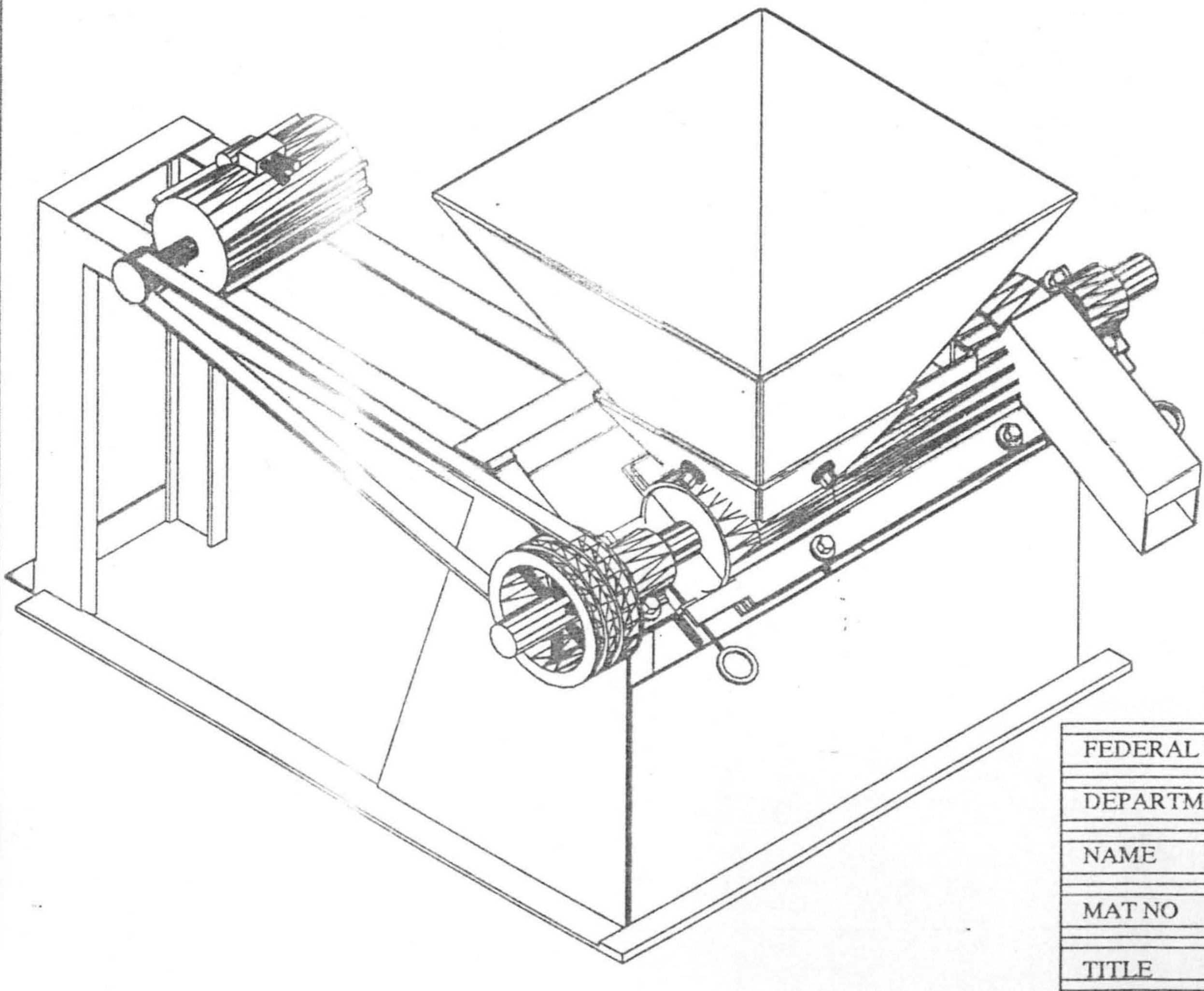
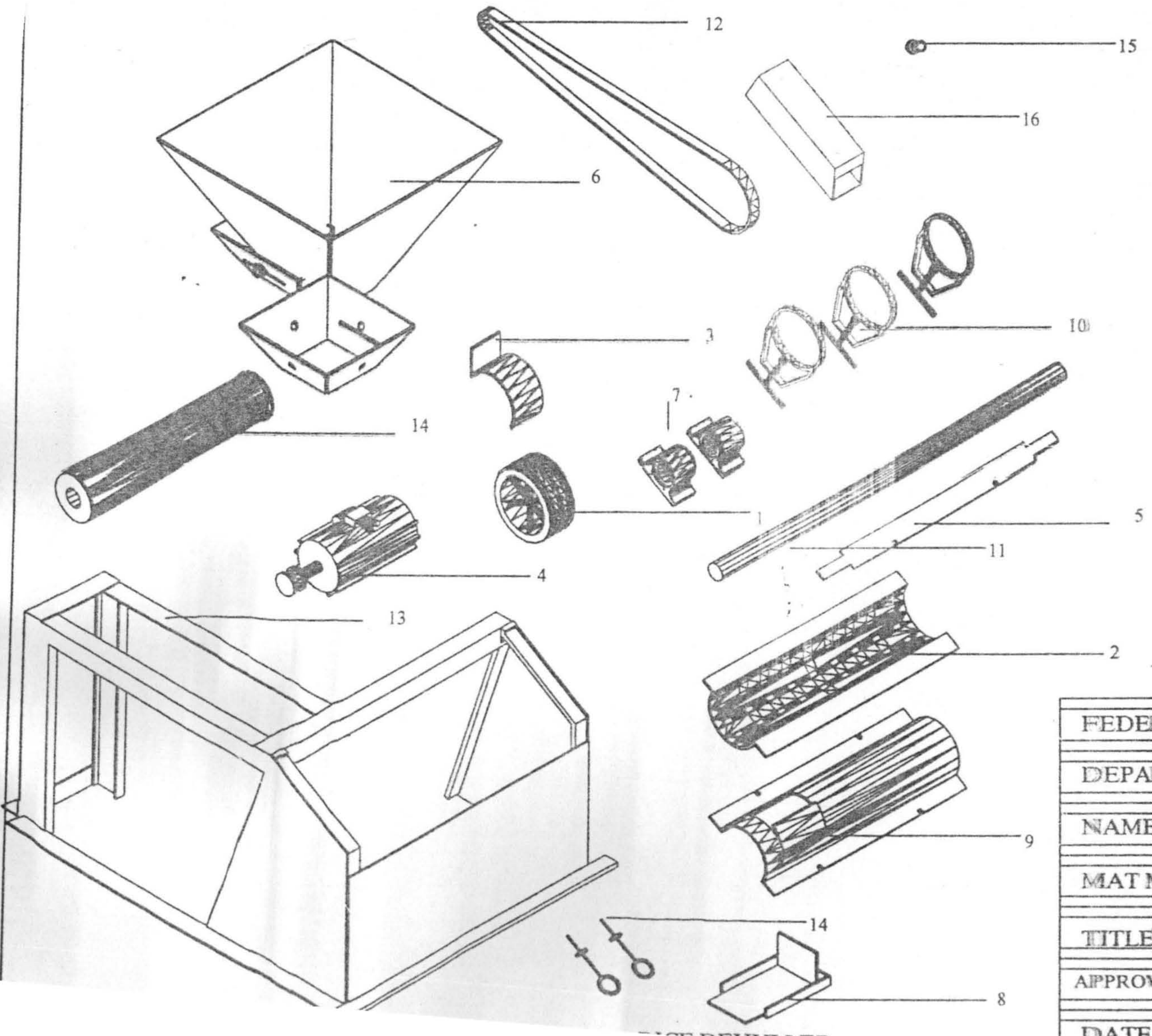


ISOMETRIC DRAWING OF A RICE DEHULLER

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA		
DEPARTMENT OF AGRICULTURAL ENGINEERING		
NAME	KEHINDE BELLO	
MAT NO	P G D / AGRIC ENGR / 2004/2005/186	
TITLE	ISOMETRIC DRAWING	DIM ALL IN MM
APPROVED BY	ENGR. S.M. DAUDA	
DATE	SEPTEMBER 2006	



S/N	DESCRIPTION	QTY	MATERIALS USED
16	DISCHARGE	1	MILD STEEL
15	BOLT AND NUT	16	MILD STEEL
14	MILLING SHAFT	1	MILD STEEL
13	FRAME	1	MILD STEEL
12	PULLEY BELT	1	RUBBER
11	SHAFT	1	MILD STEELROD
10	CONCAVE ADJUSTER	1	MILD STEEL
9	UPPER HALF CYL	1	MILD STEEL
8	INTAKE FEED CONTR	1	MILD STEEL
7	BEARINGS	2	MILD STEEL
6	HOPPER	1	MILD STEEL
5	MILING KNIFE	1	MILD STEEL
4	ELECTRIC MOTOR	1	MILD STEEL
3	DISCHARGE FEED CO.	1	MILD STEEL
2	LOWER HALF CYL.	1	MILD STEEL
1	PULLEY	1	MILD STEEL

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NAME	KEHINDE BELLO	
MAT NO	PGD /AGRIC. ENGR /2004 / 2005 / 186	
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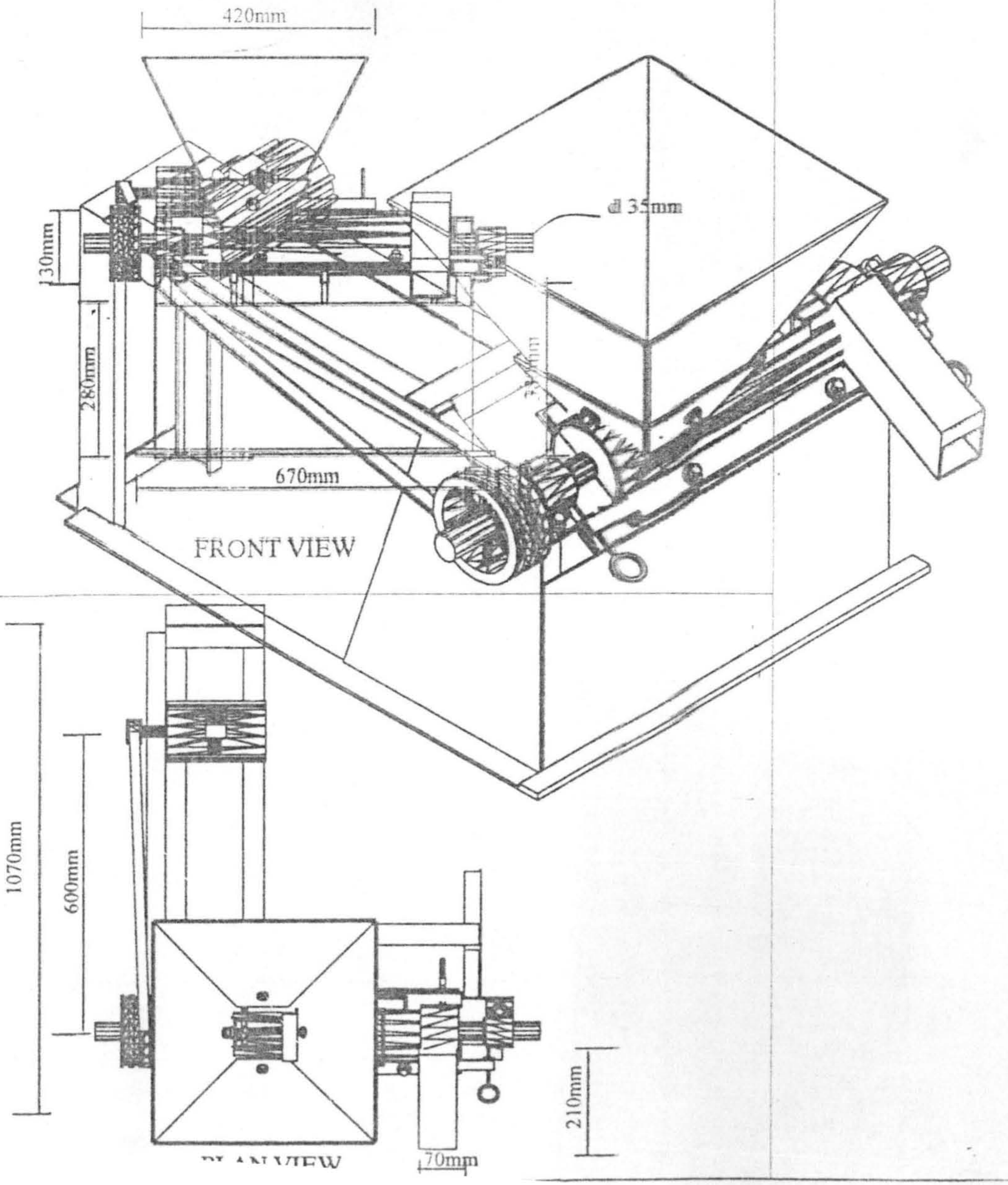
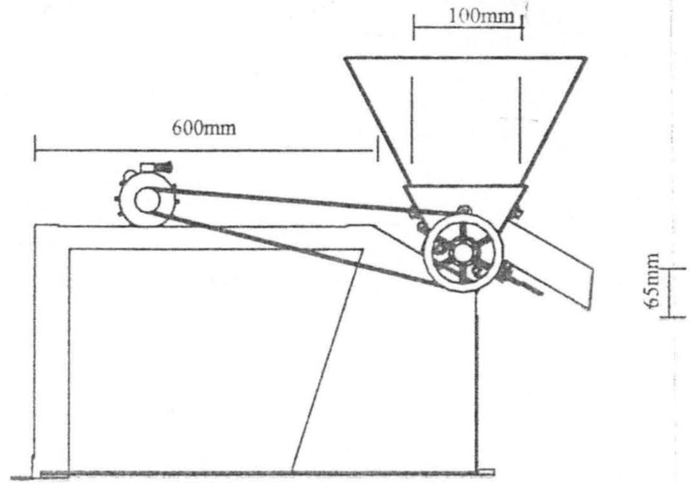
APPROVED BY	ENGR. S. M. DAUDA	
DATE	SEPTEMBER 2006	





SIDE VIEW

ORTHOGRAPHIC DRAWING OF A RICE DEHULLER

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA		
DEPARTMENT OF AGRICULTURAL ENGINEERING		
NAME	KEHINDE BELLO	
MAT NO	P G D / AGRIC ENGR / 2004 / 2005 / 186	
TITLE	ORTHOGRAPHIC DRAWING	DIM ALL IN MM
APPROVED BY	ENGR. S. M. DAUDA	
DATE	SEPTEMBER 2006	