DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF A MELON FRUIT SLICER

BY

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DEDICATION

This project work is dedicated to God Almighty Allah for helping me to this stage of life.

CERTIFICATION

This is to certify that this project work was carried out by Gana Yusuf in the Department of Agricultural Engineering, Federal University of Technology, Minna.

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ABSTRACT

The work reported here presents the design, construction and performance evaluation of a melon fruit slicer.

This prototype machine can slice about 1800 fruits/hour when operated manually at 30 revolution/minute and about 2500 fruits/hour when motorized at 50 revolution/minute, as against a hand slicing rate of 90 fruits/hour. Decomposition of the mesocarp and endocarp of the seed bearing slice of the fruit took 3 days as against 7 days for the traditional methods of processing.

The performance test were carried out with the slicer using three sets of melon fruits, each set consist of five fruits and different times were recorded due to shapes, stiffness and low moisture content of the fruits and also the sharpness of the blade, the speed of the machine contribute to the differences.

This report also give details of the construction and mode of operation of the slicer.

TABLE OF CONTENTS

CHAPTER FIVE

List of Tables

List of Figures

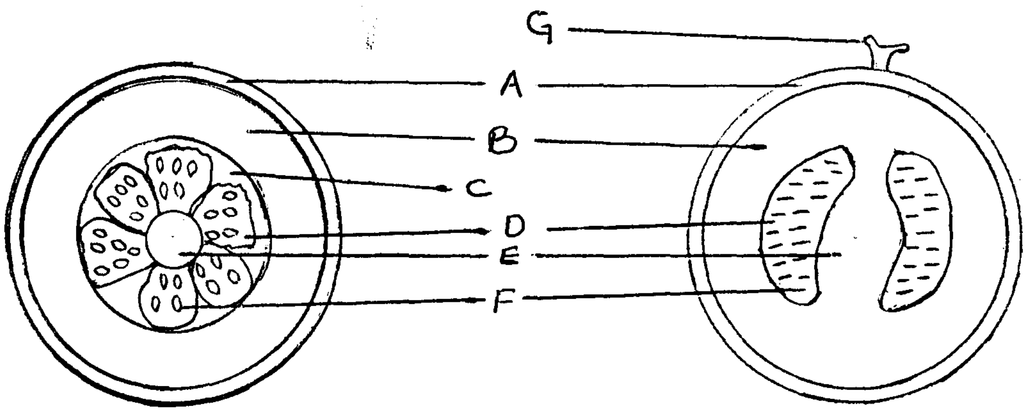
CHAPTER ONE

1.0 INTRODUCTION

The melon fruit physically resembles the water melon in many respects. The Nigerian name is "egusi", this is mentioned here because of the apparent confusion regarding the correct name of the food seeds generally agreed to be of the citrullus speces (Odigboh,1979). It is a fleshy fruit which is generally green in colour, though some varieties have their green colour streaked with white. The external surface of the fruit is relatively hard and smooth. The majority of the fruits are nearly spherical in shape but some are ellipsoids having slightly elongated head-tail axial dimensions. (Nwosu,1988). Unlike water melon, the fresh of the fruit is better and therefore not edible. The melon fruit is grown for the seeds which are very nutritious, rich in protein and very important in the Nigerian diet. The seeds contain about 53% oil by weight and 32.6% crude protein and unsaturated fatty acids. Its amino-acid content compares with those of soyabean and whole poultry egg. The melon fruit yield 1 – 15 t/ha and mature in 12 – 15 weeks after planting (Oyolu,1977).

Generally, the production and processing of melon is very labour intensive. Although, as technology continues to grow, a mechanized melon fruit slicing machine is necessary to remove the tediousness in manual slicing of the fruits. The manual peeling or slicing is particularly tedious because it consumes large amount of energy and also time consuming. The purpose of slicing or peeling is to expose the seed bearing core to microorganisms to achieve complete decomposition of the mesocarp and endocarp within a short period of time. The slicing machine consist of reciprocating blade which bisects a fruit at each stroke and can be operated manually or by an electric motor. It bisect the melon fruit so as to expose the seed bearing mesocarp and endocarp to microorganism for decomposition. The prototype machine can slice about 1800 fruits/hour when operated manually at 30 revolution/minute and about 2500 fruits/hour when motorized at 50 revolution/minute, as against a hand slicing rate of 90 fruits/hour. Decomposition of the mesocarp and endocarp of the seed bearing slice of the fruit took 3 days as against 7 days for the traditional methods of processing.

A photograph of the common variety (Colocynths citrullus) of fruit shows that it is nearly spherical in shape. The transverse and longitudinal bisections of the fruit are shown below with parts labeled.



TRANSVERSE SECTION

A - Epicarp

C - Septum

E - Central septum

G - Stock.

LONGITUDINAL SECTION

B - Mesocarp

D - Endocarp

F - Seed

Fig.1.1 - Transverse and longitudinal sections of melon fruits.

The epicarp (A) is a thick tough outer coat strongly attached to the much softer fleshy mesocarp (B) to form what is jointly referred to as the rind. The epicarp does not decompose easily and cracking is necessary to initiate decomposition. The endocarp (D) is segmented and separated from each other by the septum (C). Within the segments are the seed (E) which lies on their flat sides in planes nearly perpendicular to the head-tail axis, with their heads directed towards the central septum and distinctly separated from each other by the flesh component of the endocarp. The longitudinal section is obtained by cutting the fruit along the head-tail axis. The edges of the seeds are displayed and look like thick lines perpendicular to the head-tail axis. The seeds are symmetrically arranged all around the central septum and concentrated more within the central portion of the fruit than at the ends.

1.1.0 PROJECT OBJECTIVES

1. The main aim of this project is to reduce the large amount of energy consumed or used during the harvesting of the melon fruits manually.
2. Also to make the decomposition faster due to the wide area being exposed to microorganisms compared to the cracked ones.
3. It also gives a complete bisection of the melon fruits for each stroke.

CHAPTER TWO

2.0 LITERATURE REVIEW

Due to tedious and series of work involved in the harvesting of melon which discourage the mass production of melon fruits to compare with it's high economic values as mentioned in chapter one, a lot of research work is going on by the engineers and scientists to reduce or eliminate this tediousness in order to encourage mass production of melon to meet up with high demand. (Makanjuola, 1976).

Such series of work includes picking of the fruits together (fruits gathering), slicing or cracking, collection of decayed septum and endocarp mixed with seeds, washing of the mixture to separates the seeds, drying of the seeds on the sun, shelling of the melon seeds to removes the skin, grinding the seeds into paste and finally separation of oil from the paste to remain residue as cake in which both oil and cake become food for consumption. (Makanjuola,1976).

From the above listed series of works involved in the harvesting of melon fruit, slicing or cracking is one of the most tedious work because of large amount of energy involved. The next less tedious but time consuming is shelling of the melon seeds. Although, substantial work on the shelling on the melon seeds has been reported in the literature (Odigboh,1979; Makanjuola, 1976; Olude 1978;

Modupe, 1984), nothing has been reported on the extraction of the seeds from the melon fruit. This project discusses the physical characteristics of the melon fruit and the design, construction and testing of a melon fruit slicing machine intended to facilitate the extraction of the seeds.

The traditional method of extracting melon seed from the fruit involves manual cracking of the fruits with woodern clubs or cutting off the head or tail portion of the fruits with knife or cutlass, all done in order to create access for microorganisms to enter and cause the decomposition of the fleshy mesocarp and endocarp. The fruit so treated is left for about seven days to decompose. Then the seeds are removed by washing in water. This traditional method requires a lot of time and labour. The task is unattractive especially because of the repulsive ordour from the decomposing biomass. Consequently, the quantity of fruits a farmer can process is limited (Onyemelukwe,1991). The decomposition period can be shortened if an extensive cut surface area is created for entry of microorganism. This preliminary effort of melon coring machine did not yield any practical result as the machine designed was not built because of it complexity (Nwosu,1988). Although this coring mechanic would have be the better way of extracting melon seeds from the fruit with higher efficiency but this involves the separation of the fruits into various diameters to use various ring cutter. The separation of fruits discourage the mass production because it consumes a lot of time compared to the melon fruits slicing machine which slices irrespective to any diameter and also decays faster and facilitates the extraction of seeds from fruits. (Onyemelukwe, 1991).

2.1.0 PHYSICAL PROPERTIES OF MELON FRUITS

Relevant physical properties of the fruits grouped into three diameter ranges 9-11, 11-13 and 13-15 cm were determined using 40 fruits in each diameter range making a total of 120 fruits. The physical properties determined were: the characteristic dimensions, weight, volume and density, which can be seen on the table below.

The sphericity of the variety studied was found to be about 1.03 on the average showing that the shape of a fruit closely approximates to that of a sphere. Therefore, a fruit can roll on any of its sides. The density of about 0.87 g/cm^3 shows that the fruit can float in water, these characteristics can be used in handling the fruits.

Physical characteristics of the fruit in three sizes with an average moisture content of 96.8% wet basis. Small size 9-11cm diameter range: medium size 11-13cm diameter range: and larger size 13-15cm diameter range. (Mohsenin, 1970).

Table 2.1: **PHYSICAL PROPERTIES OF MELON FRUITS**

Parameters	Mean values Small size	Medium size	Large side
Major diameter(a)cm	9.60	11.70	14.80
Intermediate diameter(b)cm	10.01	12.60	14.91
Minor diameter ©	9.85	12.48	15.65
Geometric mean diameter cm	9.82	12.25	15.12
Sphericity	1.02	1.05	1.02
Unit volume cm^3	560.60	1085.29	2095.45
Unit weight g	500.46	918.19	1817.20
Unit density g/cm^3	0.88	0.86	0.88

2.1.1 MELON (COLOCYNTHIS CITRULLUS) AND ITS ECONOMIC VALUES

A melon fruit is a fleshy fruit which is generally green in colour, though some varieties have their green colour streaked with white. The external surface of the fruit is relatively hard and smooth. The majority of the fruits are nearly spherical in shape but some are ellipsoids having slightly elongated head-tail axial dimension. Unlike water melon the flesh of the melon fruit is bitter and therefore not edible.

Melon fruit is grown for the seeds which are very nutritious, rich in protein and very important in the Nigerian diet. The seeds contains about 53% oil by weight and 32.6% crude protein and also unsaturated fatty acid. Its amino acid content compares well with those of soyabeans and whole poultry egg. The seed is a major soup ingredient in Nigeria and about 77mt are produced annually.

The Nigerian name for melon (Egusi) yield 1-15 t/ha and mature in 12-15 weeks after planting. (Oyolu, 1977).

2.1.2 METHODS OF HARVESTING MELON FRUITS

(A) Manual cracking of the fruits with wooden clubs, is very tedious because it involves the use of large amount of energy before some fruits are cracked. Also due to small area expose to microorganism it takes a longer time for the fruits to decompose and this make the melon farming uninteresting to most of the farmers.

(B) Manual cutting off the head-tail portion or total peeling of the fruit with a knife. Although, with this method the decomposition of the fruits is faster due to large are been expose mean while it is laborious and time consuming.

(C) Manual bisection of melon fruit with the aid of cutlass. This method also makes the decomposition faster and saves time but unlike the melon slicing machine the method is very tedious because it involves the use of certain amount of energy which results into muscular pains and thus makes it uninteresting to some farmers.

(D) Manual and motorized melon slicing machine. The machine slices with the aid of a reciprocating blade which can be operated manual using crank shaft turning handle or an electric motor. This method decomposes faster, save time and it uses less amount of energy compared to the above listed once, most especially when using electric motor to operate the machine. (Onyemelukwe, 1991).

CHAPTER THREE

3.0 MACHINE COMPONENTS AND DESIGN CALCULATIONS

3.1.0 MACHINE COMPONENTS

Different materials were selected for various components of the machine to serve different functions. Such components include the feeding hopper, the crankshaft, connecting bar and extension rod, metal blade, open and close plate, bush and rolling bearing houses etc.

3.1.1 THE FEEDING HOPPER

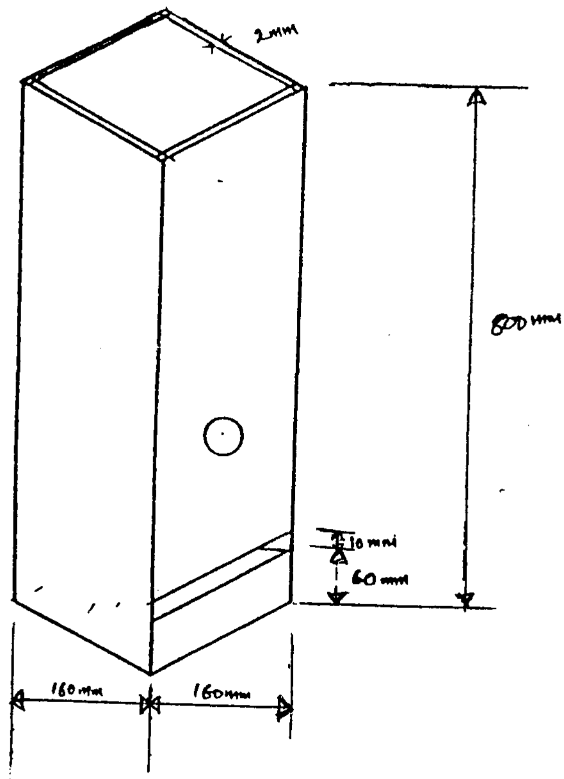


Fig.3.1 - Feeding hopper

The selected height of the hopper is 800mm (0.8m) to accommodate about five melon fruits at a time and has both length and breath equal to 160mm. It serves the purpose by which the melon fruits are been arranged vertically for horizontal blade to cut

The selected height of the hopper is 800mm (0.8m) to accommodate about five melon fruits at a time and has both length and breath equal to 160mm. It serves the purpose by which the melon fruits are been arranged vertically for horizontal blade to cut one after the other. It is a mild steel plate of density 7850kg/m^3 and thickness of 2mm. It has both ends open with the cutting chamber 60mm from the base of the hopper, while 220mm from the base is the location of blade observing hole.

Volume (V) of the hopper = Area (A) X height (h)

Where Area (A) = 0.16x0.16

= 0.0256m^2

height (h) = 0.8m

Hence volume (V) = 0.0256x0.8

= <u>0.02048m^3</u>

From the relationship: density (ρ) = $\frac{\text{mass (m)}}{\text{Volume(v)}}$

Where density (ρ) = 7850kg.m^3 (Gitin 1986).

Volume (v) = 0.02048m^3

Hence mass (m) = density (ρ) x volume (v)

= 7850kg^3 x 0.02048m^3

= <u>160.768kg</u>

3.1.2 THE CRANKSHAFT

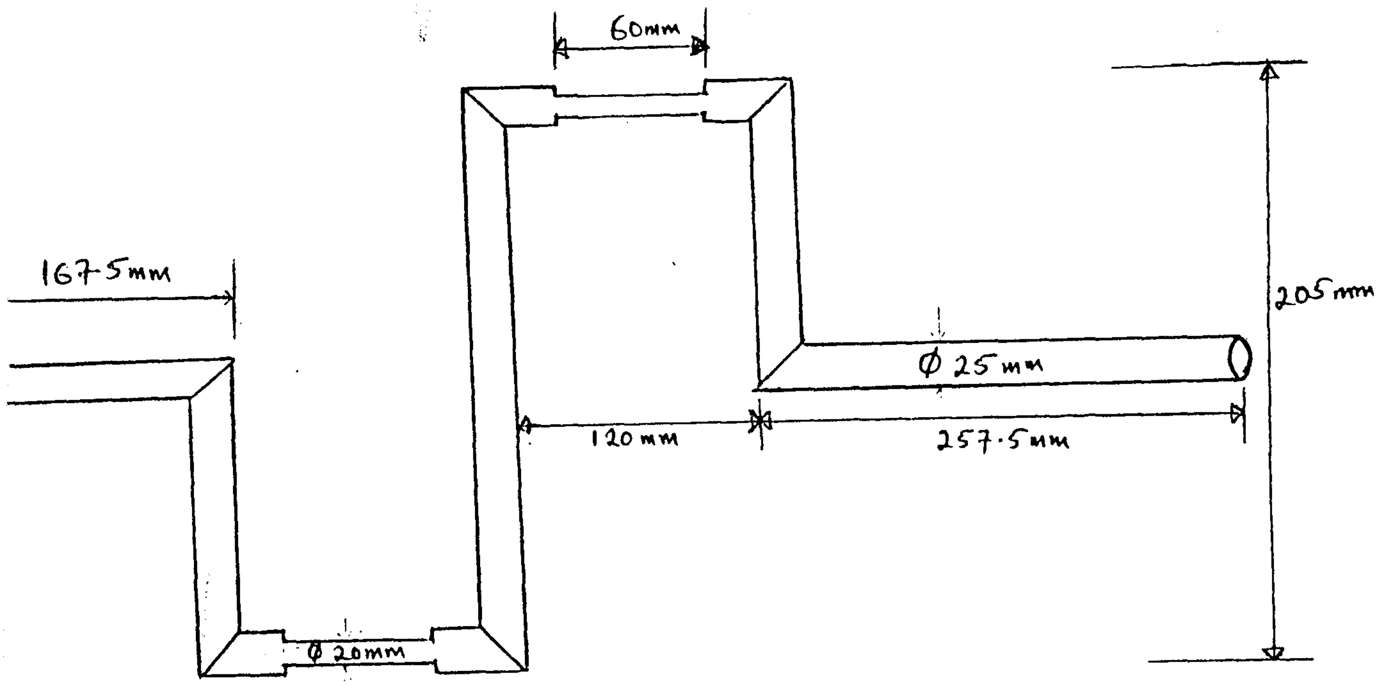


Fig.3.2 - Crankshaft

The crankshaft is dimensioned as above with the cranking portions stepped machine from 25mm to 20mm to hold the connecting bar bush bearing firmly. It is one of the important component of the machine which controls both the cutting blade and the open and close plate by converting the circular motion of the turning handle to a reciprocating motion through the connecting rod. It is a mild steel rod with density of 7850 kg/m^3 and diameter of 25mm. Other dimensions are on the sketch.

3.1.3 BALL BEARING HOUSING

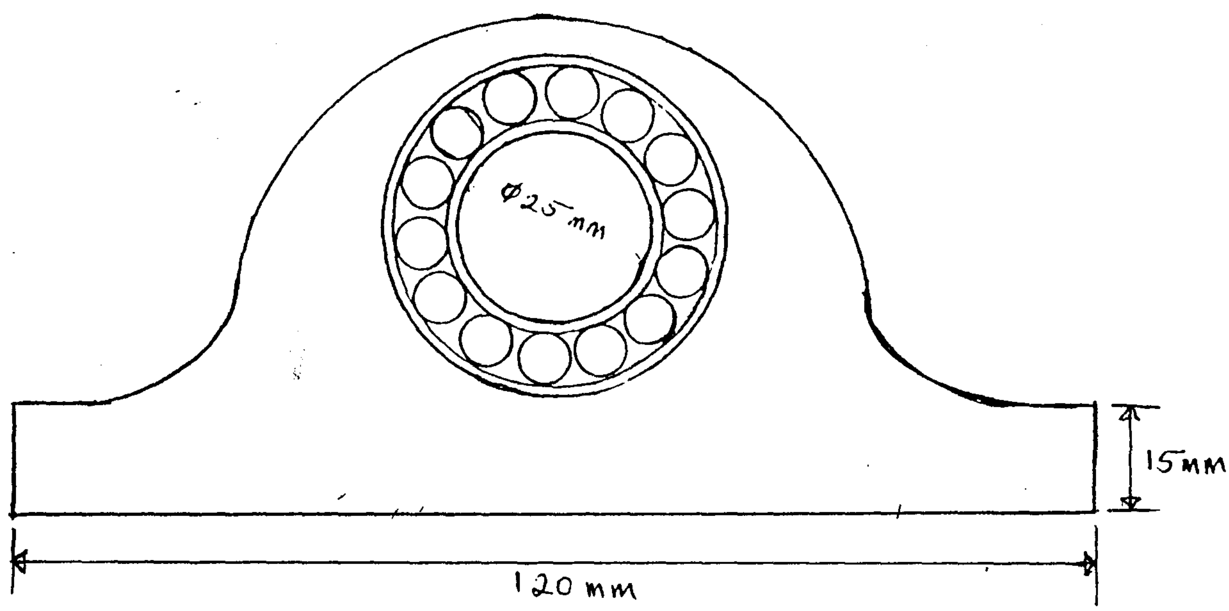
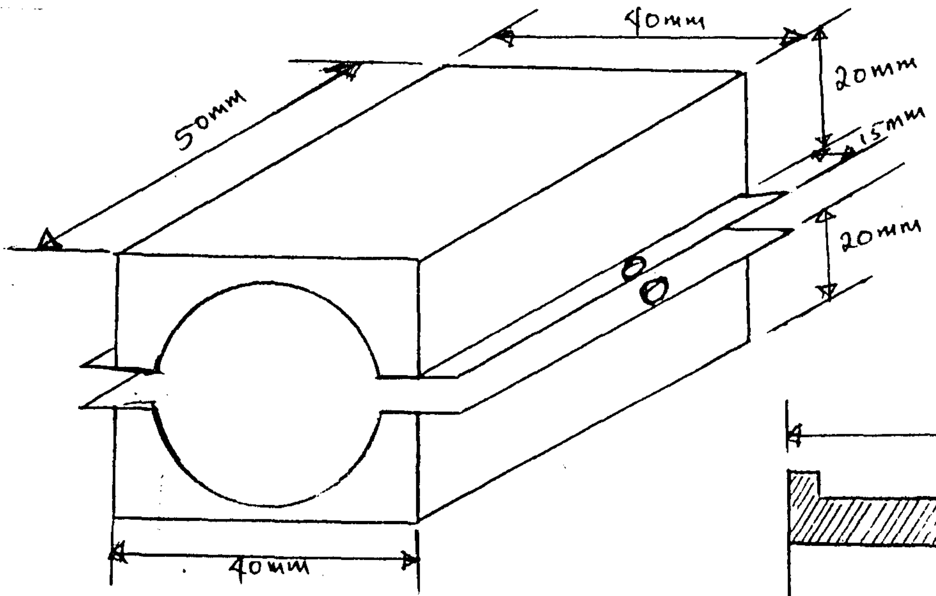


Fig.3.3 - Ball Bearing Housing

The above ball bearing housing is a casted material from aluminum. It serves the purpose of housing the ball bearing which holds the crankshaft on the frame/table. It uses the bearing no. 6205 and can be tightened to the table with the aid of bolts and nuts.

3.1.4 SPLIT BUSH BEARING AND HOUSING



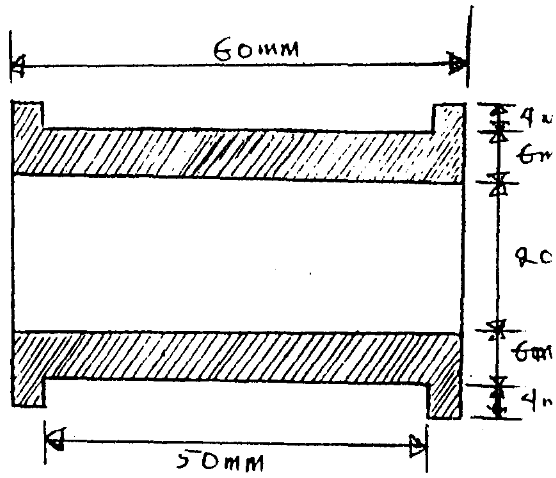


Fig.3.4 - Split Bush Bearing and Housing.

The split bush bearing is given dimensions as above and designed in such away to have flanges at both ends which is used to hold the housing firmly. The bush has 6mm thickness with 4mm flange round it's edges. It is made of brass with low coefficient of friction. The housing is also splited in which one bracket is welded perpendicular to the connecting bar. The two brackets can be tightened together with crankshaft and bushing inside using bolt and nuts. The housing is made from mild steel square bar which is bore into 32mm diameter and splited into two and has a density of 7850kg/m^3. While the split bush bearing is made from brass with a density of 8600 kg/m^3.

Mass (m) of the housing = volume (v) x density (ρ)

V = Area (A) x height (h)

$= 40^2$mm x 50mm

$= 80000\text{mm}^3$

$= 0.00008\text{m}^3$

Mass (m) = ρ & V

= 7850x0.0008

= <u>0.628kg</u>

3.1.5 CONNECTING BARS AND EXTENSION RODS

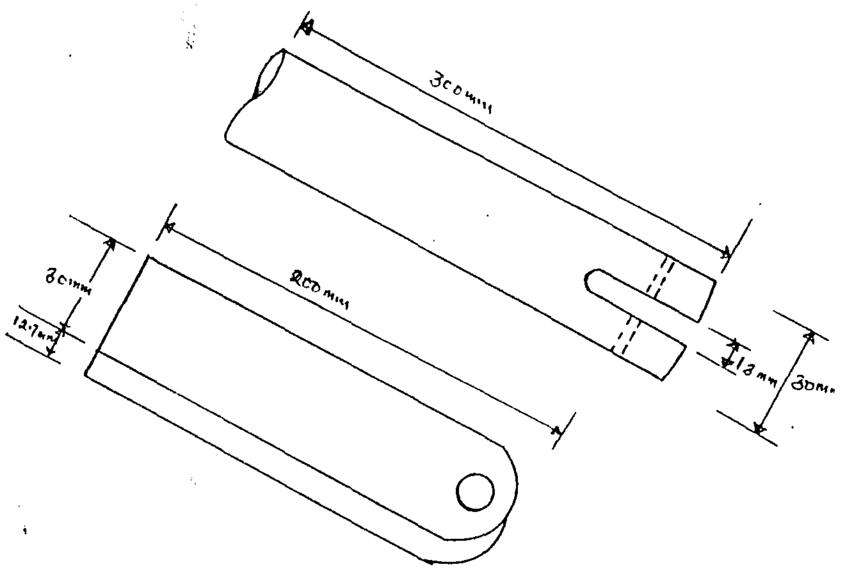


Fig.3.5 - Connecting Bars and Extension Rods.

The connecting bar is welded perpendicularly to the split bush bearing housing while the curve end is connected to the extension rod with the aid of pin to allow the angular movement of bar during the circular motion of the crankshaft, and also to facilitate the reciprocating movement of the extension rod. Both the rod and the bar are made of mild steel with density of 7850 kg/m^3.

Volume of the rod (v) = Area (A) x height

Where Area (A) = $\frac{\pi D^2}{4}$ and D = 0.03m

$= \frac{\pi x (0.03)^2}{4}$

Area (A) = $0.00070695m^2$

Height (h) = 0.3m

Hence volume of the rod (v) = A x h

= 0.00070095 x 0.3

= $2.12x10^{-4}$ m^3

Thus the mass (m) of the rod = density (ρ)xVol. (v)

Mass (m) = ρ x v

= $7850x2.12x10^{-4}$

= <u>1.66kg</u>

Also the mass (m) of the bar = density (ρ)xVol. (v)

Where volume (v) = A x h

and height (h) = 12.7mm

= 0.0127m

Hence volume (v) = 0.006x0.0127

$= 7.62x10^{-5}m^3$

Thus the mass (m) = density (ρ)x volume (v)

$= 7850x7.62x10^{-5}$

= <u>0.598kg</u>

3.1.6 THE CUTTING BLADE

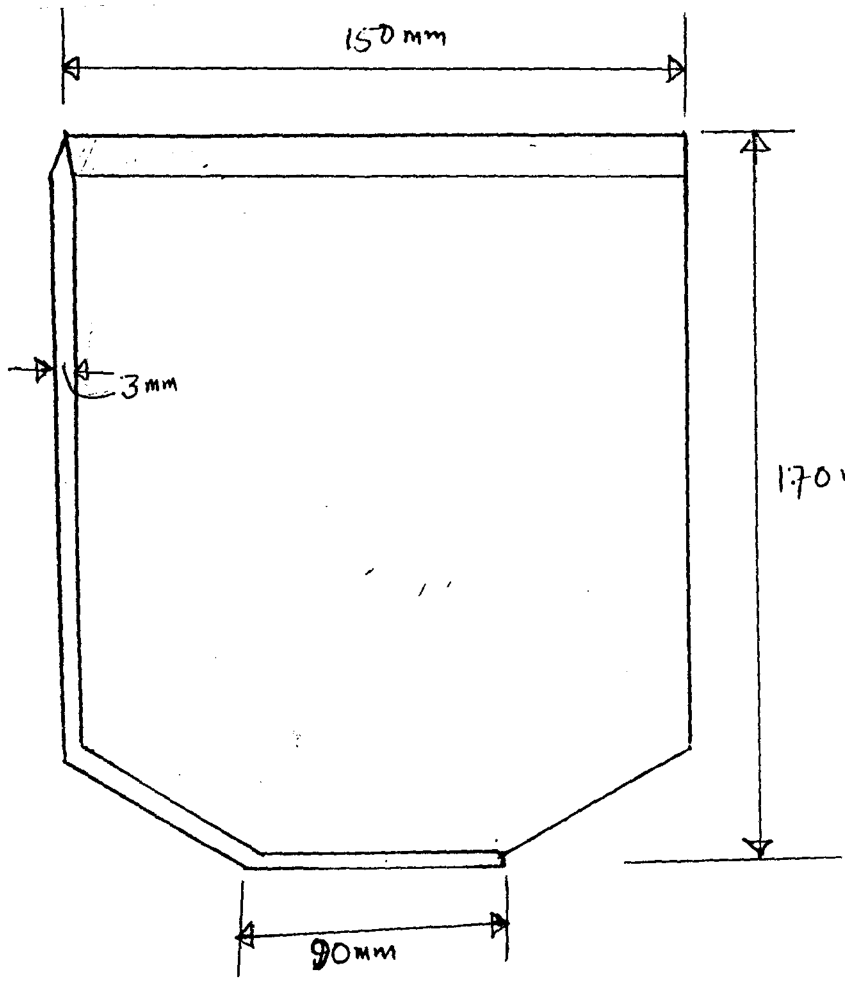


Fig.3.6 - Cutting Blade

The cutting blade is made of steel iron with cutting bevel angle of 30°. It has its dimension as above and thickness of 3mm. It is welded perpendicular to the other end of the extension rod, and cut the melon fruit with the reciprocating movement of the rod. Steel iron was selected so as to retain sharpness for long period and resist corrosion. It has a density of $7850kg/m^3$. Mass of the blade (m) = density (ρ) x volume (v)

Volume (v) = Area (A) x thickness (h)

Where Area (A) = Length x Breath

$= 0.150m \times 0.170m$

$= 0.0255m^2$

but thickness (h) = 0.003m

Hence volume (v) = 0.0255x0.003

$= 7.65 \times 10^{-5} m^3$

Thus mass (m) $= \rho \times v$

$= 7850kg/m^3 \times 7.65 \times 10^{-5} m^3$

= <u>0.60kg</u>

3.1.7 EXTENSION ROD SUPPORT BEARING HOUSING

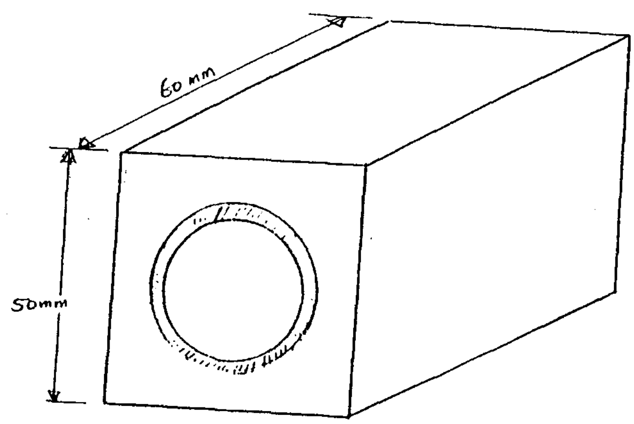


Fig.3.7 - Extension Road Support Bearing Housing

This is a square bar with a given dimensions as above. The bar is bored in to 38mm diameter with a sleeve-like bush bearing inside, the bush is also bored into 30mm diameter. The square bar or housing is welded to a cross on the table to serve as support and also guide to the extension rod during its reciprocating motion. The housing is made of mild steel with density of $7850 kg/m^3$.

Mass of the housing (m) = density (ρ) x volume (v)

Where volume (v) = Area (A) x height (h)

$= 0.05^2 \times 0.05$

$= 1.25 \times 10^{-4} m^3$

Hence mass (m) $= \rho \times v$

$= 7850 \times 1.25 \times 10^{-4}$

$= \underline{0.98125 \text{ kg}}$

3.1.8 OPEN AND CLOSE PLATE

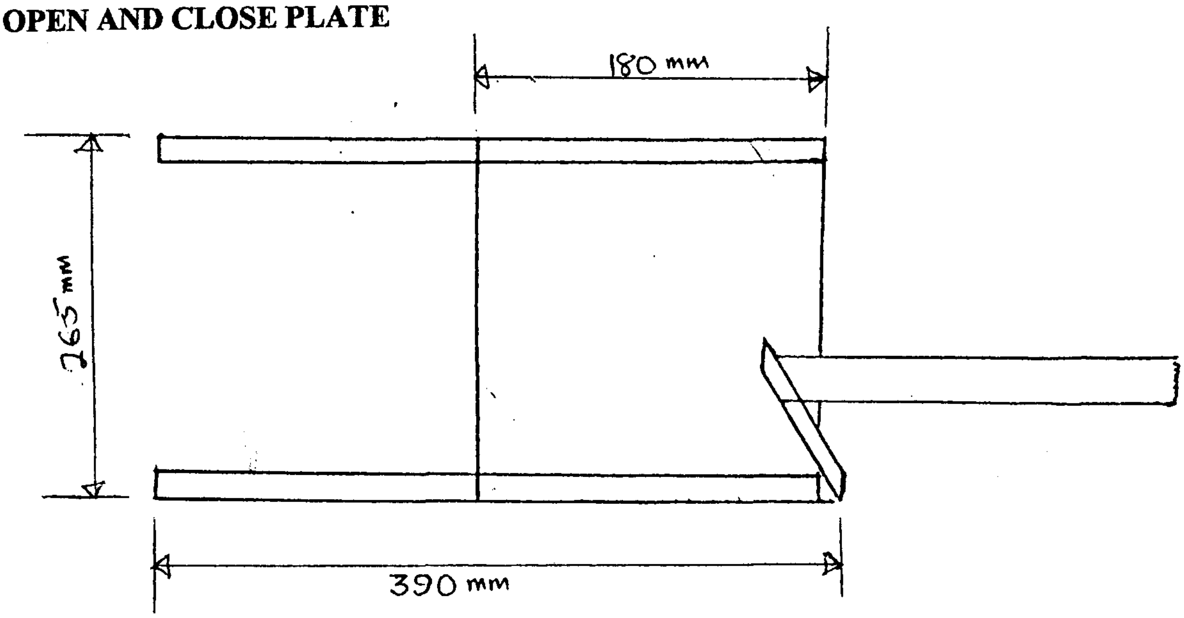


Fig.3.8 - Open and Close Plate.

The open and close plate has the given dimensions as above. It is located below the feeding hopper. As it opens, it releases the already cut melon fruit and simultaneously the blade will be cutting the melon fruits in the cutting chamber. When it closes, the blade is draw back to release the fruit on the plate or to the cutting chamber. The plate is made of mild steel plate with 2mm thickness and density of 7850 kg/m^3.

3.1.9 CRANKSHAFT TURNING HANDLE

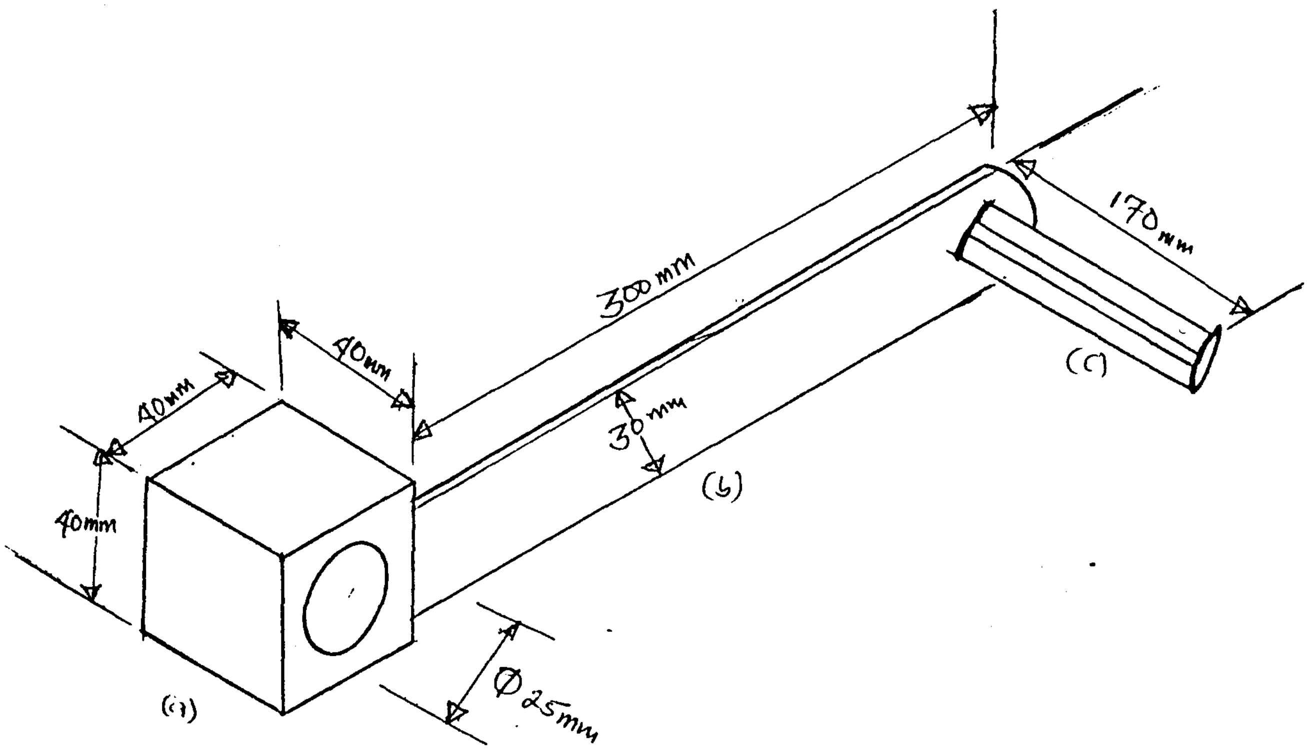


Fig.3.9 - Crankshaft Turning Handle

The crankshaft turning handle has the dimensions as above. Two factors that are involved while exerting a turning force are:

1. the magnitude of the force applied
2. the distance of it's line of action from axis or fulcrum about which turning takes place. The 300mm was selected as the distance of it's line of action from axis since a very large turning effect can be produced with a comparatively small force. It is made of wild steel with density of $7850kg/m^3$. It has a mass of density x volume, while volume can be calculated by dividing it into a, b. & c.

where $Va+Vb+Vc = V$

hence $Va = A \times h$

$= b^2 \times h$

$= 40^2 \times 60$

$= 96000mm^3$

$Vb = A \times h$

$= bxLxh$

$= 30x300x12.7$

$= 114300mm^3$

$Vc = A \times h$

$= \frac{\pi D^2}{4} \times h$

$= \frac{3.142x10^2}{4} \times 100$

$= 7855mm^3$

Thus total volume $V = 96000+114300+7855$

$= 2.18\text{x}10^{-4}\text{m}^3$

Therefore mass (m) = density (ρ) x volume (v)

$= 7850\text{kg/m}^3 \text{ x } 2.18\text{x}10^{-4}\text{m}^3$

= <u>1.713kg</u>

3.2.0 FRAME DESIGN

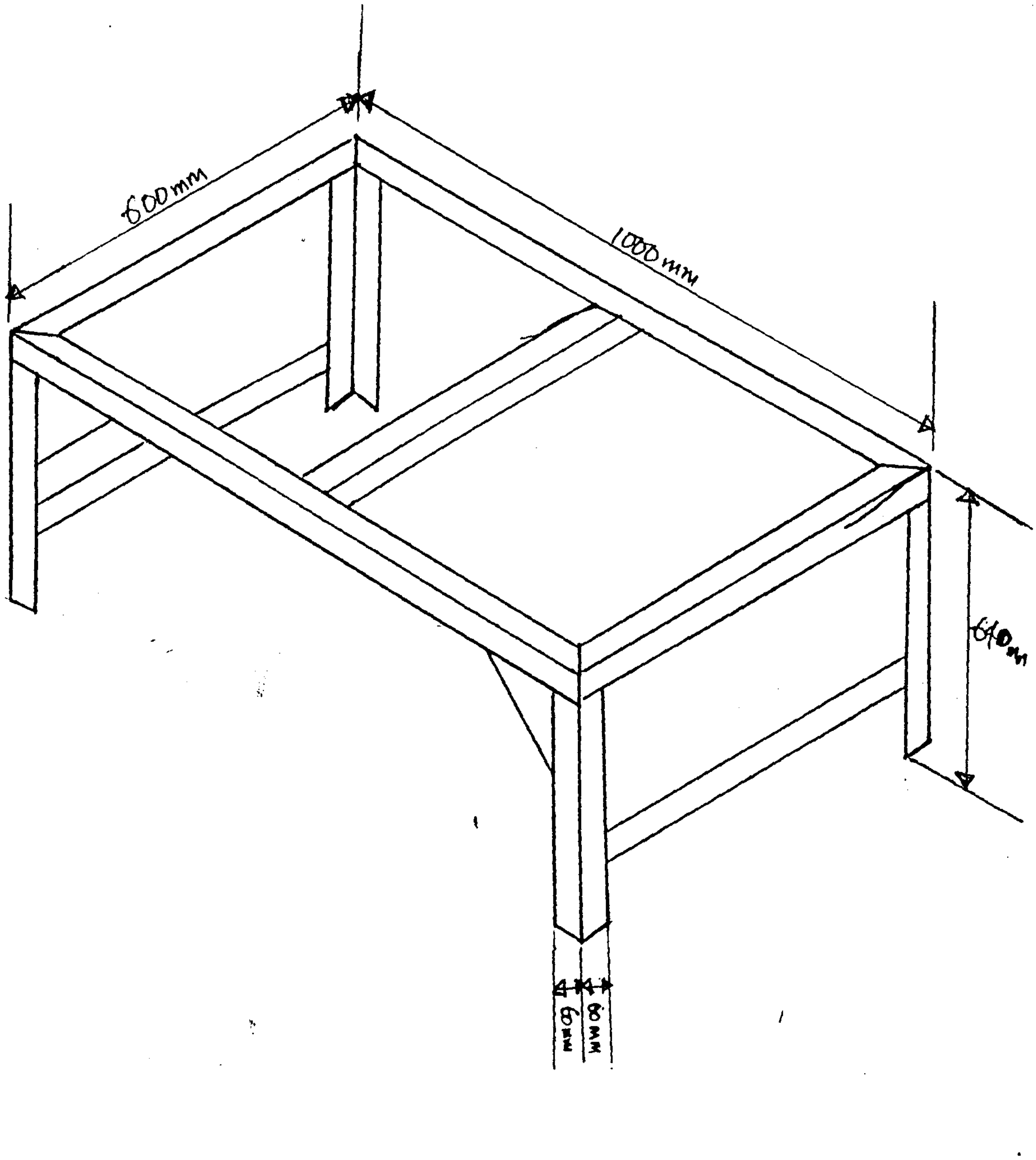


Fig. 3.10 - Frame

The frame was made from 60x60mm mild angle iron with density of 7850kg/m^3. It is comprise of four stands which are held in position by welding other angle iron pieces across so as to reinforce it. The frame has a total length of 1000mm, width of 600mm and height of 640mm from the ground.

The size selection and the dimension were based on the fact that it would be able to withstand the size and the weight of melon fruits and other components during operation and as well be balanced.

Weight of a length = volume x density (ρ)

= length x 2 breath x thickness x ρ

= 1000 x 2 x 60 x 3 x 7850

= 2.83kg

For 2 lengths = 2 x 2.83kg

= 5.65kg

Weight of a breath = Volume x density

= 600x2x60x3x7850

= 1.70kg

For 2 breaths and 2 braces of the same length

Hence weight = 4 x 1.70

= 6.80kg

Weight of a stand = Volume x density

= 640x2x60x3x7850

= 1.81kg

For 4 stands = 4x1.81

= 7.24kg

Hence the total weight of the frame is equal to weight of 2 lengths + 2 breaths + 2 braces + 4 stands.

Total weight = 5.65+6.8+7.24

= 19.65kg = 20kg

3.2.1 DESIGN CALCULATIONS

With reference to (Gitin,1986) Hand book of mechanical design (pp 527), it was reported that one-tenth of a horse power is the power that can be developed by an average human being working at a speed within the range of 0.8 to 12m/s.

But one horse power (1hp) = 746watts therefore, the power that can be developed by an average human being can be calculated as (pd) = 1/10 of 746 watts

= 74.6 watts

To convert watts to Newton we have

1 watt = 1Nm/s

but for a rotational speed m/s = angular velocity (w) = $2\pi n/60$.

Where n = no. of revolution/minutes = 12rpm.

For an average human being with 74.6 watts at a rotational speed of 12 rev/min the force (F) developed can be calculated as:

$$F = \frac{74.6 \times 60}{2 \times \pi \times 12}$$

$$F = \underline{59.4N}$$

Also the energy developed by an average human being with the handle of 0.3m distance from the shaft at force of 59.4N can be calculated as:

$$\begin{aligned} \text{Energy} &= \text{Force x distance} \\ &= 59.4\text{N} \times 0.3\text{m} \\ &= 17.8\text{Nm or Joules} \\ &= \underline{17.8 \text{ Joules}} \end{aligned}$$

3.2.2 SHAFT DESIGN

Since the shaft is inform of couple which has equal and opposite parallel forces, it is not possible to find a single force to replace it. A couple always produces a rotational forces and can only be balanced by an equal and opposite couple. (Ige, 1997).

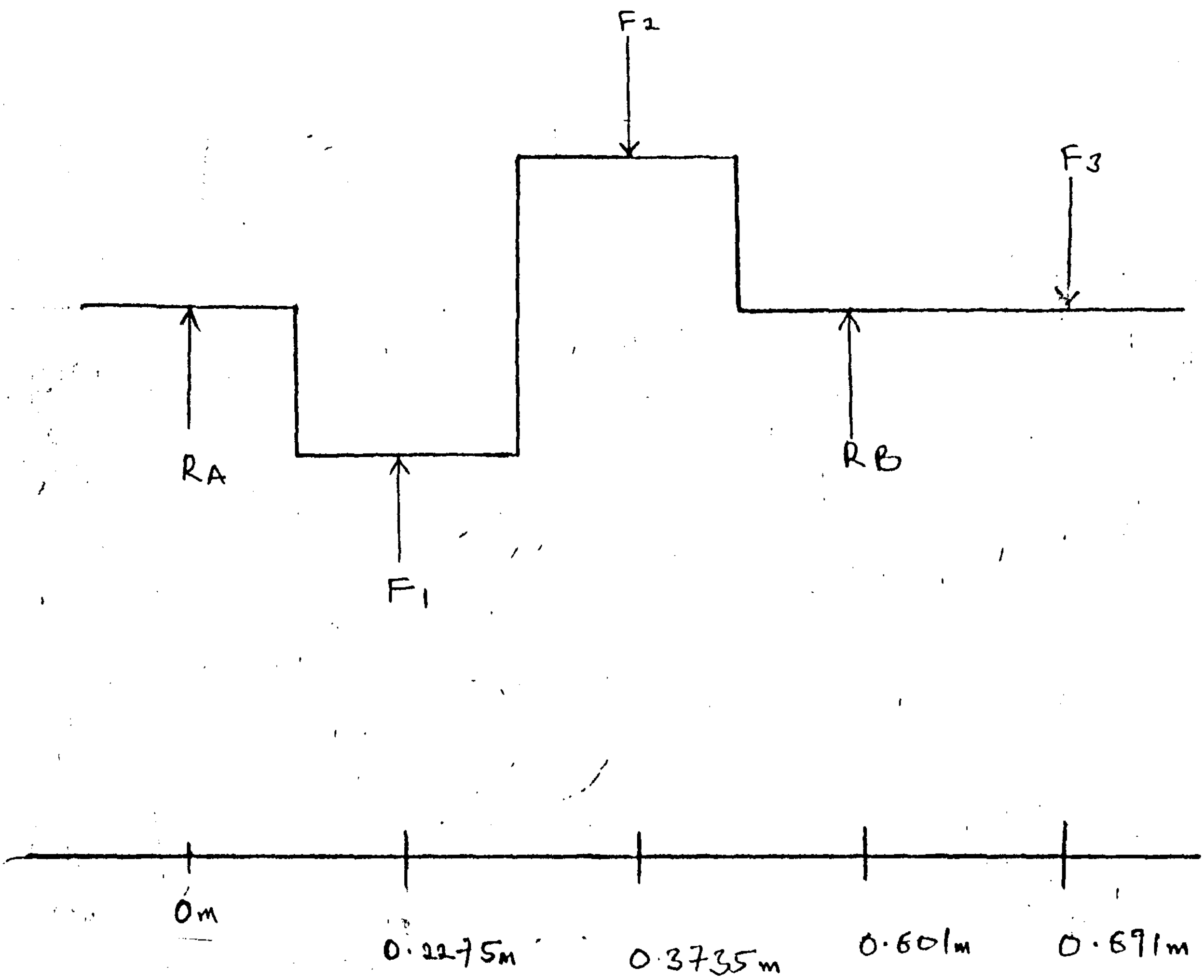


Fig.3.11 - Forces on Shaft

Where RA and RB are supporting stand reactions which acted vertically, F1 and F2 are equal and opposite parallel force and F3 is the applied force on the shaft.

Therefore, the sum of the forces in one direction is equal to the sum of the forces in the opposite direction. Hence we have:

$F1+RA+RB = F2+F3$

But $F1 = F2$

Therefore $RA + RB = F3$

Where F3 is the force developed by an average human being which is calculated to be 59.4N.

Thus $RA + RB = 59.4N$

$RA = 59.4N - RB$

Since the sum of the forces anti clockwise moments about any point is equal to the sum of the forces at clockwise moments about the same point. Then by taking moment about point RA.

We have $RB x 0.60/m = 59.4N x 0.69/m$

$$RB = \frac{41.0454Nm}{0.60/m}$$

$$= 68.295N$$

Therefore RA = 59.4N – RB

= 59.4N - 68.295N

=- 8.895N

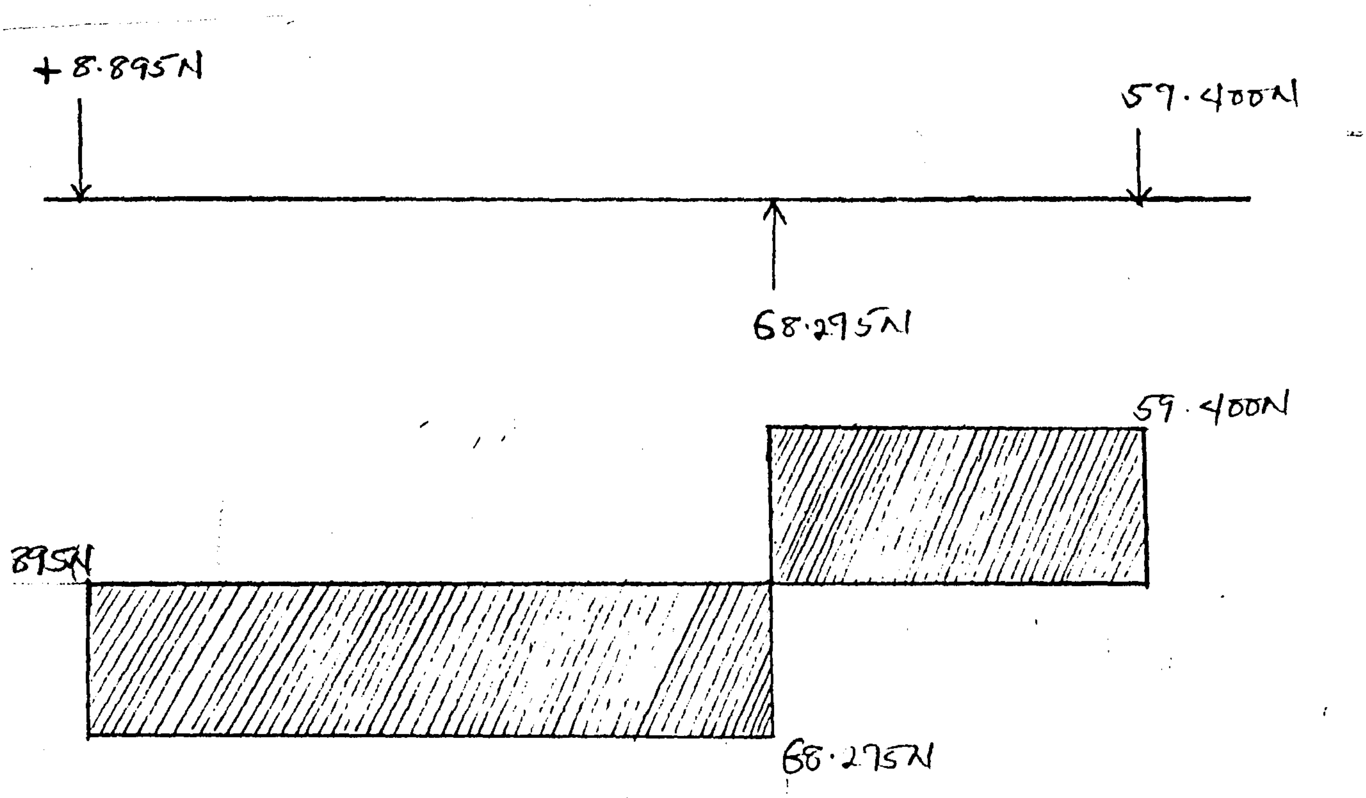


Fig.3.12 - Force Diagram

3.2.3 BALL BEARING SELECTION

1. Bearing size selection

To select being size we calculate the required capacity (Cr) and compare with standard capacity © on the table of approximate basic and static load rating Vs type and sizes table (marks standard handbook for mechanical engineers tenth edition.

Where $Cr = \frac{P(L_{10}N)}{Z}$

Cr = required capacity N

L_{10} = design rated life (h) from table, for Agricultural equipment it is between (3000 – 6000) from design life guide table (mark std hb).

N = Number of rev/min (12 r/m)

K = Constant, given to be (3) for ball bearing

Z = constant, given to be (25.6) for ball bearing

P = equivalent radial load.

And P = XR + YT

Where R = Radial load (N) (59.4N)

T = Thrust (axial load (68.295N)

And X and Y = Radial and thrust factors given from the table. (marks std hb) for single row ball bearing we have X = 1.0 and Y = 1.4

Thus P = 1.0 x 59.4N + 1.4 x 68.295N

$= 155.02N$

Therefore $Cr = 155.02 \; \frac{(6000x12)^{1/3}}{25.6}$

$= 2509.80$

By comparing (Cr) with capacities © on the standard table, the first bore size having:

1. Capacity (C) closer to (Cr) is 25mm with a corresponding C = 2420.0.
2. The. ball bearing limit (du), this is also given as du = bore (mm) x speed (rev/mm).

   Therefore du = 25mm x 12 rev/min

   = 300 mm/min.
3. Bearing Rated life L_{10} (hrs) is also given as $L_{10} = \frac{16700}{N} \left(\frac{c}{p}\right)^k$

L_{10} = calculated bearing rated life (hrs)

C = corresponding capacity of 25mm size selected from table (marks std hb)

P = equivalent radial load N.

K = constant (3 for ball bearing)

N = Number of rev/min.

Thus $L_{10} = \frac{1670}{12} \left(\frac{242.0}{155.0}\right)^3$

$= \underline{\underline{5296.5 \text{ hrs}}}$

3.2.4 ENERGY REQUIREMENT FOR CUTTING

The coefficient of sliding function of cutting blade and the melon fruits at 73% moisture is 0.35. for cutting a layer of melon fruit by a single knife edge with bevel angle of θ to the direction of cutting. The cutting energy is given by

Ec = ½ fas + fac (1 + μ tan θ) - (Yumnam, 1991)

Where f = cutting force per unit length

As = area of cross section over which material is compressed.

Ac = area of cross section which is cut

μ = coefficient of friction between blade surface and the fruit.

Let cutting force per unit length be equal to force developed by an average human being.

Thus f = 59.4N. (Ige, 1997)

The area of cross section which is cut (ac) is given as $\frac{\pi D^2}{4}$

where D = diameter of the melon fruit

= 150mm (for largest once)

$$ac = \frac{\pi (0.15)^2}{4} = 0.01767m^2$$

Also the area of cross section over which material is compressed (as)

$$As = \frac{\pi D^2}{4} \quad \text{let } D = 40mm$$

$$= \frac{\pi (0.04)^2}{4} = 0.0012568m^2$$

Then energy requirement (EC)

EC = ½x59.4x0.0012568+59.4x0.01767x(1+ųtan ϑ)

Where μ = 0.35

Then energy requirement (EC)

$EC = \frac{1}{2}x59.4x0.0012568+59.4x0.01767x(1+\mu tan\ \vartheta)$

Where $\mu = 0.35$

$\theta = 20^{\circ}$

$EC = 0.14931+1.049598\ (1+0.35\ tan\ 20)$

$= 0.14931+2.17698$

= 2.33 Joules

And force requirement for cutting is calculated from energy = force x distance where distance is the length of handle which is 300mm or 0.3m.

2.33 = force (F)x 0.3m

$$F = \frac{2.33}{0.3}$$

= 7.76N

3.2.5 MATERIALS AND METHODS

MATERIALS – The melon fruit slicer was tested with a total no of 15melong fruits. This was done in three sets, each set five melon fruits were used.

3.2.6 **TEST PROCEDURE** – The melon fruits were passed through the feeding hopper into the acting chamber, as the fruits comes into contact with the knife which was carried by the reciprocating rod, and the fruits were sliced into two and collected below the hopper as the open and close plate is opened.

The slicer was tested with a total of 15 fresh fruits and at the end of each sets of five melon fruits the time was noted and recorded as can be seen below:

First five set	-	10 seconds
Second five set	-	10.5 seconds
Third five set	-	9.5 seconds

Taking the average of the above data we have 10 seconds for five fruits.

Hence, from the above data the capacity of the machine can be calculate as slicer capacity

$$= \frac{5 \text{ fruits}}{10 \text{ seconds}} \times 3600 \text{ seconds.}$$

= 1800 fruits/hour

Also the efficiency $= \frac{\text{effective field capacity}}{\text{Theoretical field capacity}} \times 100$

Where Effective field capacity (EFC) is give to be total number of fruits sliced divided by the useful times during the operation. While the theoretical field capacity (TFC) is given to be total number of fruits sliced divided by less useful time, that is, time used in revolving after each cut and the time allow for the next melon fruits to fall into the cutting chamber.

3.2.7 CALCULATIONS OF EFFICIENCY

In testing the machine for one minute, it was recorded that 33 seconds was used for useful work and 27 seconds was used for less useful work for 30 melon fruits.

Therefore, effective field capacity (EFC) = $\frac{30}{33} \times 3600$

$= 3272.72$ fruit/hr.

Theoretical field capacity (TFC) = $\frac{30}{27} \times 3600$

$= 4000.00$

Efficiency (7) = $\frac{EFC}{TFC} \times 100$

$= \frac{3272.72}{4000} \times 100$

$= \underline{81.8\%}$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1.0 RESULTS

The slicer was tested with a total of 15 fresh fruits and at the end of each sets of five melon fruits the time was noted as below

First set	-	10 seconds
Second set	-	10.5 seconds
Third set	-	9.5 seconds

The differences in the times recorded above depends on the various factors which were discussed below.

4.1.1 DISCUSSION

The factors responsible for the differences in time taking to slice the same sets of melon fruit includes sharpness of the blade, low moisture content of the material, speed of the cutting blade and the feeding rate.

To slice the fruits easily with small amount of energy the blade must be sharped from time to time. Also some melon fruits has low moisture content, for example the dry season melons, since they manage to survive with little amount of water, they becomes stiff and difficult to slice unlike the raining season once. The speed of the blade also contribute to the differences because the faster the speed the easier it slice and finally if the feeding rate is not continuous it will affect the time.

4.1.2 THE SLICER CONTRUCTION AND MODE OF OPERATIONS

The slicer consist of the different components that makes up the machine. It consist basically feeding hopper, the crankshaft, connecting rods, the rods carrying blade and open and close plate and the handle are all mounted on the table.

The feeding hopper is made from mild steel plate of 2mm thickness and it is square in shape with 160mm each side, so as to achieve the vertical arrangement of melon fruits in it. This arrangement is important in order to drop one after the other during the operation. Also the selected height is 800mm to accommodate up to five fruits at a time and should not be too high which may make the feeding difficult. The crankshaft consist of two cranks in which one controls the cutting blade and the other one controls the open and close plate with the aid of connecting rods and extension rods. The handle is fixed to the crankshaft by the right handside with the aid of a bolt so that it can be removed when necessary. The table is made from mild steel angle iron of 60mm by 60mm. It is rectangular in shape with 1000mm in length, 600mm in breath and 640mm in the height from the ground to suite the working position while standing.

As materials (melon fruit) comes in through the hopper and reaches the cutting chamber where the hopper was closed with the aid of open and close plate, by the action of rotating motion from the handle which was converted to reciprocating movement of the blade with the aids of crankshaft, the blade moves into the cutting chamber and slice the fruit into two. Simultaneously, as the blade is moving in the open and close plate below the hopper will be opening to releases the already sliced fruits out of the chamber. So also as the blade is coming back to allow the next fruit to fall into the cutting chamber the plate will be closing to stop the fruit from fall down.

4.1.3 REPAIR AND MAINTENANCE

The machine was designed such that simple routine preventive maintenance repair can be affected when the need arises.

These maintenance includes frequent lubrication of the moving parts, tightening of loosen bolts and nuts, removing the blade to be sharpened when blunt, cleaning up the machine after use etc.

4.1.4 MATERIAL SELECTION AND COST ANALYSIS

In Engineering design, the economic benefit has to be put into consideration though, the selection of the materials which has to be very cheep and at the same time meet the specific purpose for which it is design for.

In designing the machine, the basic factors put into consideration are the choice of material, that is, availability and cost of materials, durability, ease of construction and operation. These have to be put into consideration in order to achieve the desired objective. The availability of the materials will reduce the constructional cost and hence will make the price comparatively low making it affordable for the intending users.

4.1.5 COST ANALYSIS

The cost can be classified into three:

1. Material cost
2. Labour cost
3. Overhead cost (such as transportation of the materials from one place to another).

The table below shows the cost of the material used for fabrication. This could be stated that the price listed were valid as at the time of construction but it could be subjected to changes due to market trend.

TABLE 4.1: MELON SLICER COST ANALYSIS

S/NO	COMPONENTS	MATERIALS	SPECIFICATION	QTY	PRICE(N)
1.	Hopper	Mild steel plate	1/8" plate (800x700)mm^2	1	2380
2.	Frame	Mild steel	Angle Iron (60x60)mm	2	2800
3.	Extension Rod	Mild steel Rod	30mm diameter 800mm length	1	1,950
4.	Bush bearing	Brass Rod	300mm length 50mm diameter	1	1,250
5.	Ball bearing housing	Aluminum casing	=	2	800
6.	Connecting bar	Mild steel sq.bar	Rectangular bar 1000mm length	1	2,000
7.	Crankshaft	Mild steel Rod	25mm diameter 700mm length	1	1,500
8.	Nut & bolts	Mild steel	=	-	200
9.	Cutting blade	Stainless steel	3mm thickness ('70x170)mm^2	1	1,500
10.	Ball bearing	Stainless	6205	2	500
11.	Handle	Mild steel	15mm Rod 300mm length	1	200
12.	Bush bearing housing	Milds steel	(50x50)mm 150mm length	2	1,000
	TOTAL				16,080

TOTAL COST OF FABRICATION = LABOUR COST + MATERIAL COST + OVERHEAD COST.

LABOUR COST = 30% of material cost, that is cutting of metals to the required size and welding of metals together cost about 15% of material costs while boring, grinding and turning of metals to the required size cost about 15% of material cost. Thus 30% of material cost is

$$= \frac{30}{100} \times 16{,}000$$

$$= 4800$$

OVERHEAD COST = 10% of material cost

$$= \frac{10}{100} \times 16{,}000$$

$$= 1{,}600$$

Hence, TOTAL COST = 16,000 + 4,800 + 1,600

= N22,400.00

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1.0 CONCLUSION

From the performance test with the slicer using three sets of melon fruits to test (each set consist of five melon fruits), it was seen to be satisfactory as the materials were sliced into two. It can be used to slice a melon fruits ranging from 70mm to 150mm in diameter.

From close observations and the results obtained, the effects of speed on power requirement varied with the cross-sectional area of the material, stiffness of the material and moisture content of the materials. Therefore making the times recorded different for the same number of melon fruits. Hence, it can be concluded that the objective of designing and constructing a melon fruits slicing machine has been achieved.

5.1.1 RECOMMENDATION

In view of the advancing technology in engineering, I will recommend that further design and fabrication of melon fruit slicer should be follow up with modifications to achieve greater results such modifications can be as following.

3.2 Adjustable blade so that less than 70 mm can also be sliced.

3.3 The slicer should be introduced to the local farmers

3.4 Nipple should be fixed to the moving parts for easer lubrication

3.5 Collecting plate can also be fixed below the hopper for easer collection of the sliced fruits.

3.6 A conic shape type hopper can be introduced so that more melons fruits can be fed at a time.

In view of the advancing technology in engineering, I will recommend that further design and fabrication of melon fruit slicer should be follow up with modifications to achieve greater results such modifications can be as following.

2.1 Adjustable blade so that less than 70 mm can also be sliced.

2.2 The slicer should be introduced to the local farmers

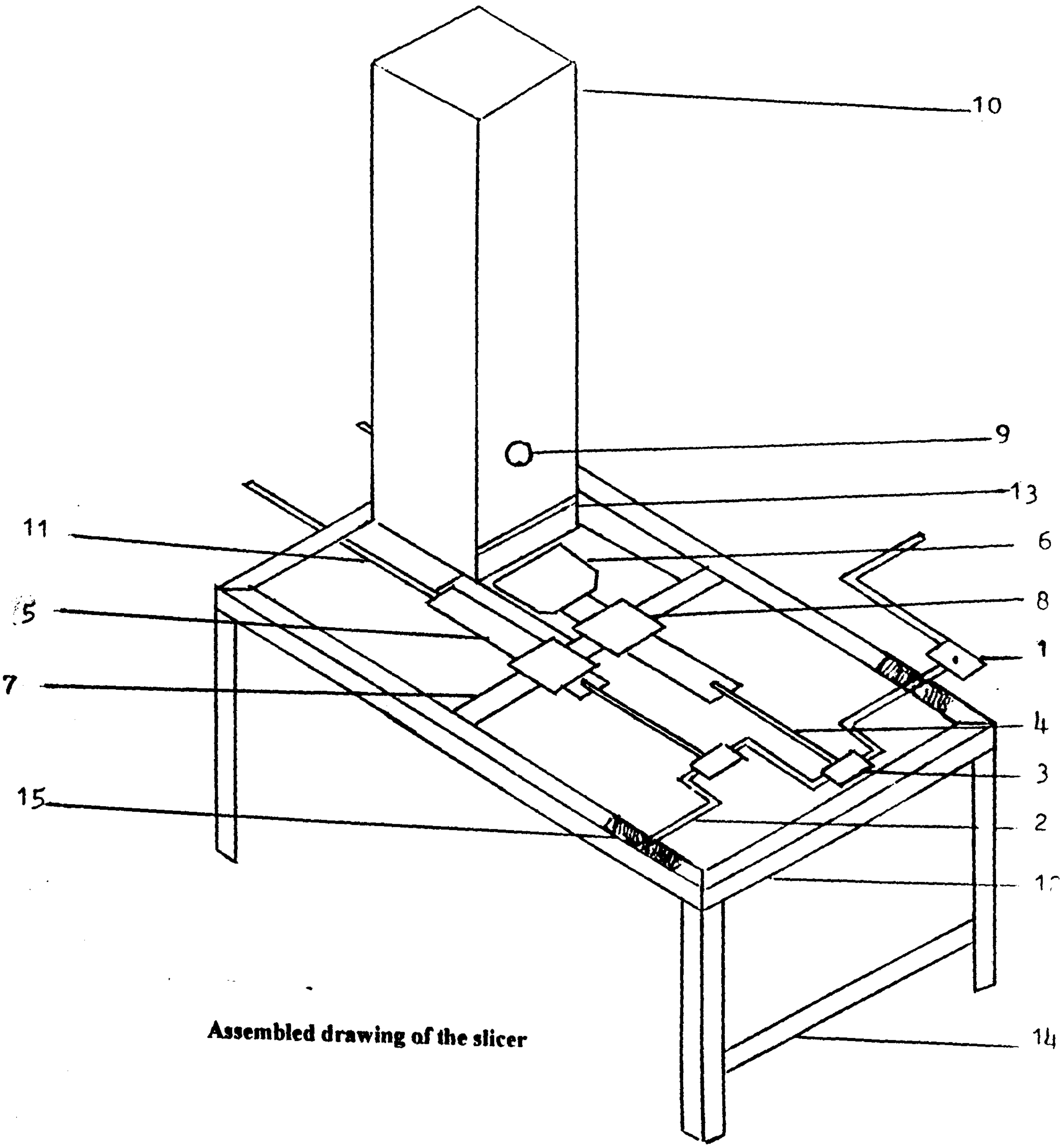
2.3 Nipple should be fixed to the moving parts for easer lubrication

2.4 Collecting plate can also be fixed below the hopper for easer collection of the sliced fruits.

2.5 A conic shape type hopper can be introduced so that more melons fruits can be fed at a time

(6) A wheel and pulling handle can also be introduced to it for ease movement from our place to another in the farm.

Finally, for further designing of the melon slicer one of the most important factors related to cutting energy is the sharpness of the blade and blades having bevel angles ranging from 20^0 to 30^0 will give the optimum energy requirement.



Assembled drawing of the slicer

<u>List of parts labeled</u>

1. Handle
2. Crankshaft
3. Split bush bearing housing
4. Connecting rod
5. Connecting rod extension
6. Metal blade
7. Extension support bar
8. Extension rod bearing housing
9. Blade observing hole
10. Hopper
11. Open and close plate
12. Frame
13. Cutting chamber
14. Brace
15. Ball bearing housing
16. Connecting pin

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