DESIGN AND CONSTRUCTION OF A GUAVA
FRUIT JUICE EXTRACTOR

BY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ENGINEERING SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY (BEING) DEGREE IN AGRICULTURAL ENGINEERING

DECEMBER, 1998

DECLARATION

I Taboingi S. Abubakar declare that this project is an original work of mine, and has never been presented elsewhere for the award of any degree. Information derived from published and unpublished works of others have been acknowledged in the write up.

....
SIGNATURE

....
DATE

CERTIFICATION.

I the undersigned, hereby certify that I have read, approved and do recommend for acceptance by the School of Engineering and Engineering Technology this project work titled "Design and construction of Guava juice extractor" by Taboingi, S. Abubakar.

.... 17:12:98.....

ENGR. (DR). D. ADGIDZI DATE
SUPERVISOR.

....

ENGR. (DR). M. G. YISA DATE
HEAD OF DEPARTMENT.

.... 17/12/98.......

EXTERNAL EXAMINER DATE

DEDICATION

This project is dedicated to my family, the family of Mr and Mrs Shikitan Maikoron and for my friends both in school and at home for individual concerned for my success.

ACKNOWLEDGEMENT

I wish to express my profound gratitude to the Almighty God for giving me the wealth of knowledge and stability to carry out this project work to completion.

My sincere thanks go to my supervisor Engr. Dr. D. Adgidzi who was always ready to read, criticise and offer alternative solutions at every stage of this work.

I also wish to thank the Head of Department Engr Dr. M.G. Yisa, the members of staff, both academic and non-academic and the entire students of the department of Agricultural Engineering for their academic and moral support throughout my stay in the Department.

My appreciation goes to my friend Joseph Adejo, John Obadofin Clifford of electrical and computer Engineering department, Mr and Mrs Pions Kolle of Women Commission FCT, Abuja, Engr Gbabo Agidi of NCRI-Badeggi-Bida, Niger State for his maximum support toward my project work.

Finally, I want to specially thanks my parents Mr and Mrs Shikitan maikoron and my sisters for their financial and moral support throughout my studies. My progress in life has been as a consequence of their encouragement and prayers. May the lord continue to bless them.

ABSTRACT

The work reported here presents design of a guava juice extracting machine. It is aimed at designing an extractor for use by the populace.

Many machines have been designed to carry out this function, however. This extracting machine is one of such to extract juice from guava fruit at relatively lower cost, less power consumption and whose materials can be afforded by the populace.

Suggestion are offered on the mode of operation of the plant, extraction condition of the juice and its quality as well as the procedure which if adopted and applied will go a long way to obtaining maximum yield of the juice and the economic benefit.

The efficiencies of the extraction when power transmitted is used up to 50.17% and it was carry out the rate of extraction very rapidly because of the large pressure exerted by perforated disc.

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CHAPTER ONE

1.0 INTRODUCTION

Fruit juice extraction is the process of squeezing the liquid content out of the flesh fruits. This process changes the physical nature of the fruits. This reducing the bulky nature of the fruits to the most essential liquid content, to ease effective storage and prevent unnecessary wastage.

It has been found that guava fruit juice's is very important in provision of vitamin C to the human body. The existing methods of processing of guava into fruit juice in villages and small scale level needs improvement both in term of quality, quantity and time. That is the focus of this project.

The development and evaluation of village and small scale guava juice extraction using power transmission is examined and design was carried out. Before the choice of the design and several design alternative has been studied and their advantages and disadvantages outlined, with the best design selected for extraction components of the press utilized were locally sourced and locally fabricated.

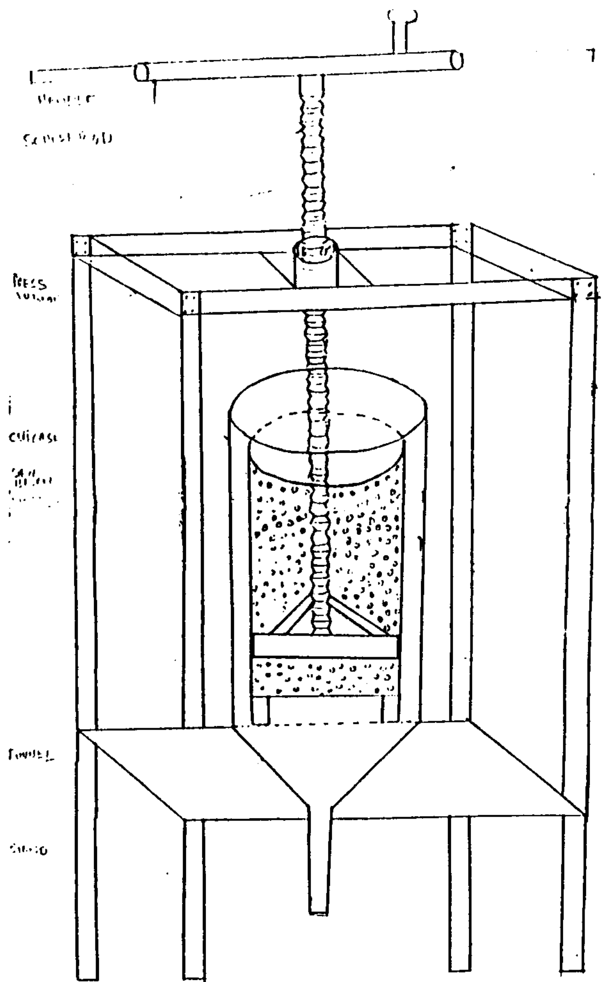
Methods of village level production of guava juice such as cleaning with water to remove the dirty on it, grinding or pounding was adapted with the pressing done with the guava juice fitter press. In the 2nd procedure it is put in a mushing cloth bags and hessians bags were used to serve as fittering medium and compared, it was found that the mushing cloth has a little advantage over hessian bags. It took about 7-10 minutes to finish one process of pressing. The fitter press was made with available material.

1.1 IMPROVED TECHNOLOGY

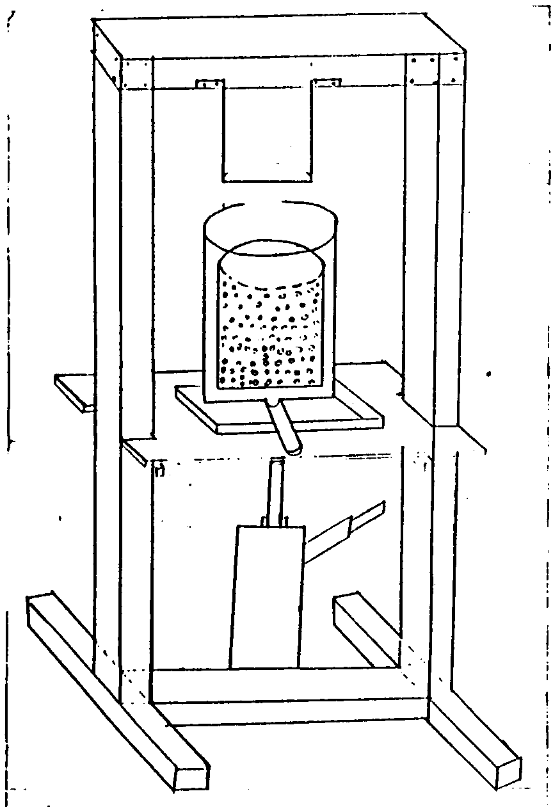
As technology continues to develop, there has been few machines, designed and constructed to carry out has task for the small scale processing of guava fruit juice, some at the pre-processing and juice extraction stage.

In the National cereal research institute Bida-Badeggi, work has been carry out on the Multipurpose juice extraction with the use of 10 tons hydraulic jack in fig II in the next page. It is operated manually, the guava fruit is ground to paste and taking it with consideration of the sized of the extractor cup. The paste is rapped in porcelein cloth and placed inside. The perforated extractor cup, with every assembled, are placed on a channeled iron and pressures applied. The fixed block helps to press the juice from the paste. This is time consuming and the quantity of juice will not be much compared to continuous types of design.

Another work has been carried out on a guava juice extractor with the use of a screw press is manually operated too, this machine is composed of a plunger (round steel plate) which is forced down by a screw and into a cylinder with a large number of small holes when the handle is continuously turned, the substance from which the oil is to be extracted is pressed slowly, as time goes on, pressure is high and juice is seen coming out. The advantage it has over hydraulic press is the presser moves easily



FRUIT JUICE EXTRACTOR (SCREW PRESS TYPE)



FRUIT JUICE EXTRACTOR (HYDRAULIC PRESS TYPE) and juice production is more than the hydraulic presser. But screw presses depend upon the size of the cage (which holds the product) average being 10kg per batch (juice extraction). Also it is believed to leave about 10 to 15% of juice after pressing.

In view of these machines reviewed so far, this project however, will incorporate the use of electric motor as a source of power. It has the auger served as mean of conveying the juice to the perforated sieve and a disc which serve as a continue process of extraction. It is fabricated with mild steel material of about 90%. It is easy to operated and maintain and needs installation on any where with a total material cost less. The machine is cheap and economically available to low income earners or rural dwellers for whom it is meant.

1.2 THE GUAVA (PSIDIUM GUAJAVA)

The guava is a member of the family myrtaceae and is biological name is psidium guajava. Cultivated guava has been know by several botanical names depend on the varieties, which is found available.

Guava is an important fruit throughout the tropics and has become naturalized in many areas. The fruit is very high in vitamin C and is also a rich source of vitamin A.

The fruit is a berry supported by calyx lobes. The exocarp is pule flashy of varying thickness and may be white, yellow, pink or red. In flavor they very from mild sweet flavored fruit suitable for desserts to highly acid ones suitable only for jelly making.

Adeniyi, Philippe and Rex, (1986), stated that, there is no reality statistical of guava fruit production in Nigeria. The acreage and production of fruits, can only hazard a guess from the study of arrivals of fruits in different local village markets and wholesale markets where most of the guava are grown in the Northern parts of the country. A rough estimate of the production is about 1000 acreage in hectare of the fruit total production of 261,170 metric tones and out of 38,240 acreage in hectare.

1.3 <u>ECONOMIC IMPORTANCE OF GUAVA</u>

(R.P. L.W Rice and H.O. Tindall 1986) stated that the flashing pulp may be stewed and used as a pie filling. After removing the seeds, the fruit is made into preserves, jams and jellies. The common wild, sour types makes the best jelly. The leaves of guava tree are used medicinally as an antidote to diathoea, and in dyeing and tanning leather.

1.4 <u>METHODS OF GUAVA JUICE EXTRACTION</u>

Akhigbe (1989) reported the basic processing operations involves in fruit juice extraction. The processes are explained below:-

The wholesome fruit are first sorted, to select the good fruits available for processing and protect the quality of the finished products.

When sorting attention must be paid on the following:-

i) Presence of foreign matter and excessively dirty materials

ii) Presence of mould and insect contamination

iii) Presence of fruits of other varieties

iv) Presence of undermatured fruit.

The sorted fruits are then washed to prevent filth that might contaminate it change the colour, aroma and taste product. The damaged fruits are discarded.

Moreover, the fruits are cut into small piece (either manually or mechanically) and into the hopper of the machine as it is in operation. The extracted juice while then be collected in a clear container or bucket while the residue will be discarded. As the juice are extracted, additive such as water will be mixed with it. The water then homogenized with the fresh juice in the mixing mechanism at the ratio of 1kg/litre of water to respectively. After thorough mixing the fruit juice, solution will be used for other purposes.

1.5 OBJECTIVES OF GUAVA JUICES EXTRACTION

The ultimate objective of this project are:-

i) Design and construct a simple cheap and efficient motorised operated guava juice extractor in both rural and urban dweller.

ii) To test and evaluate the performance of the machine and to reduce wastage of juice.

iii) to reduce the bulky fruit into juice which can easily be treated and stored effectively for longer time.

iv) Substantial rubbing and crushing of the employed material, high wear of the screw and trough and a high sensitivity to over loads, which can lead to load accumulation in the trough (especially at the bearing).

CHAPTER TWO

2.0 LITERATURE REVIEW

Series of work has been done on guava juice extractor in terms of design and construction to obtain an excellent performance. As a result of this different types of machine have been tried but yet the results are still far below expectation. And some of the existing ones are drawn in the next page.

In fig I, juice extracting using heat, can be made using a lidded kettle or pan with a rack on the bottom which supports a bowl or dish to catch the juice. Two boiled white cloths (mushin where possible), one of coarse weave and one of fine weaver, are fitted over the edge of the pan to hold a piece of strung grease proof. Paper put the fruit on the cloth to catch the condensation from the steam (Lehman Hardware, 1985).

In fig II, is a crusher mounted on top of fruit press. This lever operated press achieves a 25 litre/hour output when operated by one person. The crusher grinds and crushers in one operation out for juice (guava is 50kg per hour (GRET, 1985).

In fig III, Victoria squeezer, simple hand operated screw pullers are suitable for small scale production (courtesy of thorn EMI Domestic, electrical appliance UK, 1988).

In Fig iv, is a jelly bag, is used to pilter juices, syrups and jellies and makes them into crystal clear products. Care must be taken to ensure that the bag is clean and it should be thoroughly washed and boiled after use. (Joel Jackson 1985).

Juice Extractor

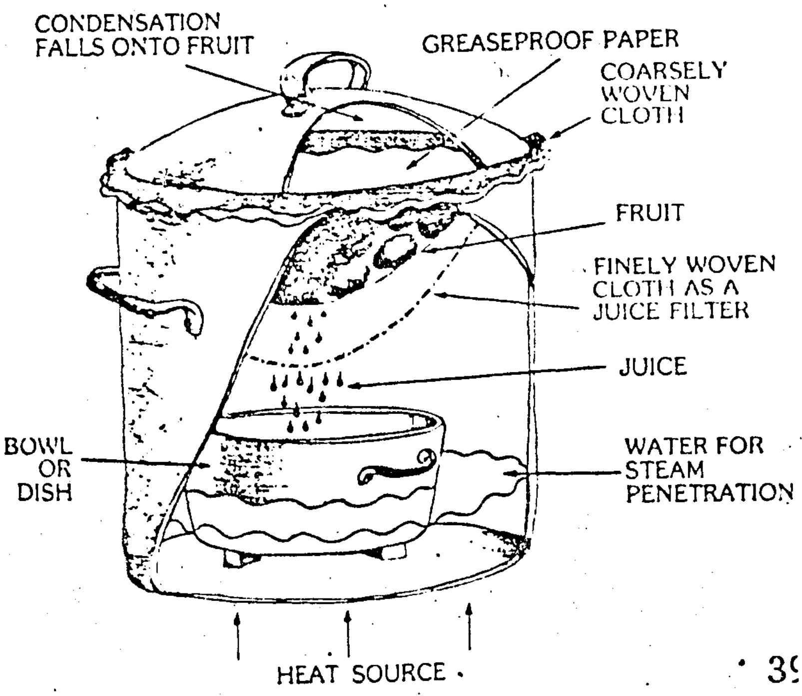


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FIG I JUICE EXTRACTION USING HEAT

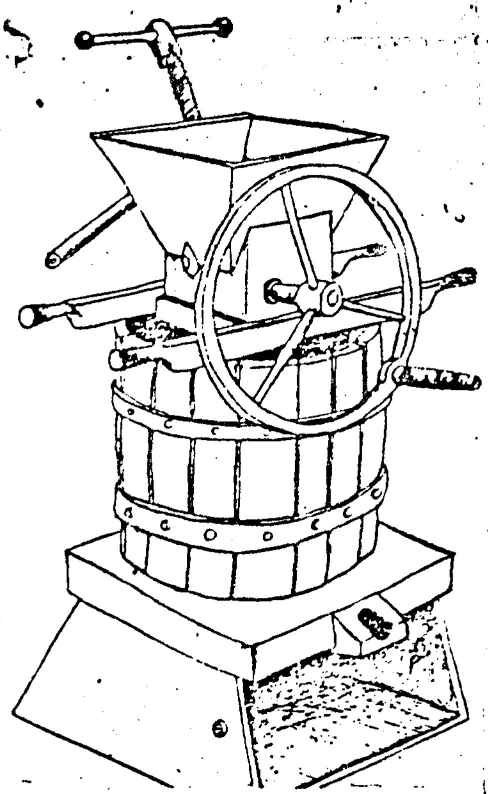

FIG II CRUSHER

Victorio Squeezer

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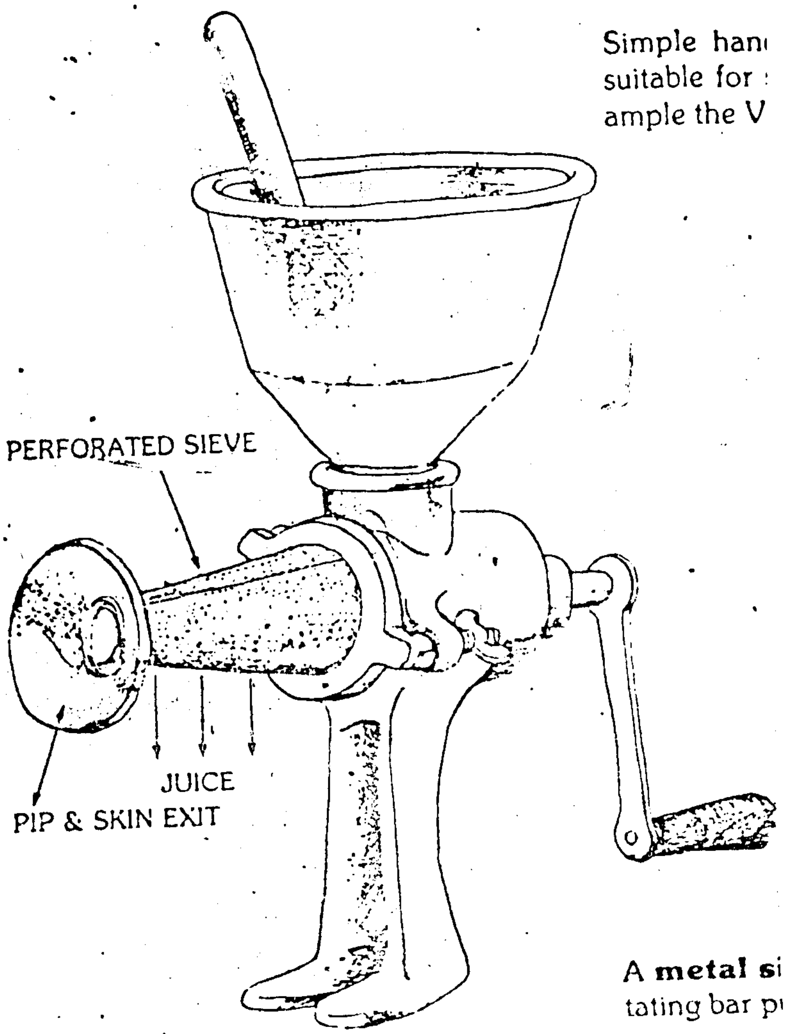

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FIG III VICTORIO SQUEEZER

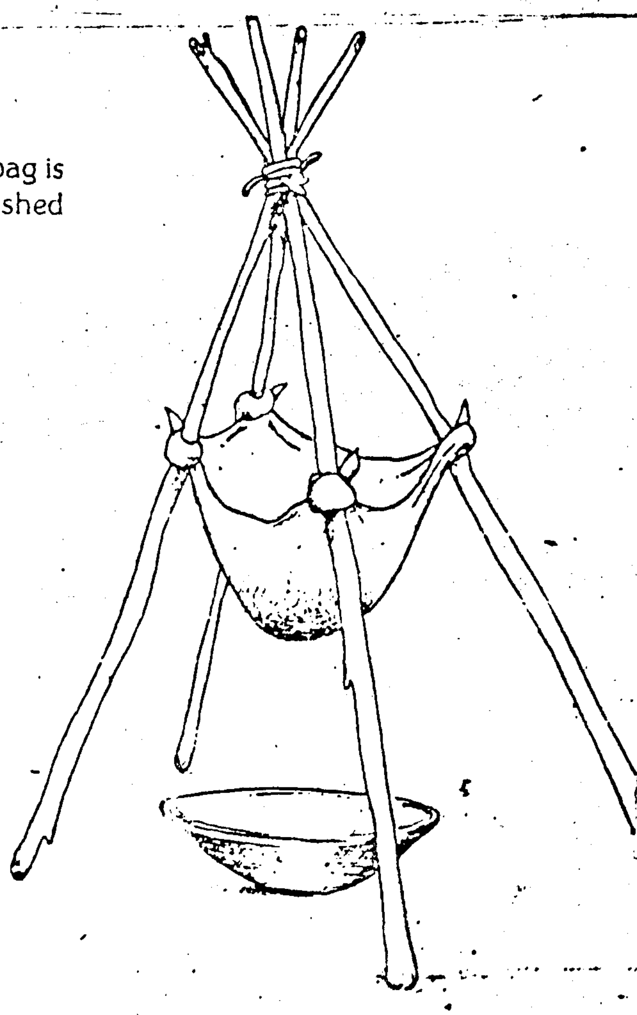


Fig IV JELLY BAG

Models of these machines are commercially available but are too expensive to purchase.

2.1 GUAVA PROCESSING AND UTILISATION

Kordylas, (1990) reported that method or procedures employed is bring about such changes in food are refer to as the technique of processing.

Guava is processing in order to:-

i) Improve it nutritive value and availability to body.

ii) Improve its digestibility, making it easier for body to break down the food while it is in the stomach.

iii) Improve the sanity/quality making it safer to eat by killing harmful micro-organisms.

iv) Create desirable flavorus which are pleasant to the taste and

v) To preserve it so allowing it to be kept over a period, saving time and energy.

The achieve the above mentioned traits, food processing sometimes causes certain desirable qualities in foods to be lost.

Method use in the preparation and processing of guava food are:-

i) The use of chemical compound

ii) The use of micro-organism

iii) Combination or mixing

iv) Separation and subdivision

2.2 JUSTIFICATION

The maintenance of the machine is necessary to enhance the performance, realiability and increase the viable life span of the machine. This can be done generally by immediate washing of the fruit processing parts and greasing or oiling of the metal surface, particularly the rotating parts to reduce friction and breakage.

The exposed or exterior parts should also be pointed to prevent corrosion.

Some adjustments are for proper performance of the machine before and some after operation. The parts stated below required, various adjustments, these are:-

i) **Engine seat**

The machine operating engines pulley should alligned with the driven. Pulley on the extracting shaft before the machine is bolted on the engine seat to ensure effective performance of the machine.

ii) **Belt Tension**

Ensure that the pulleys to which a belt is mounted aligns and the belt is not slack, but well tightened.

CHAPTER THREE

3.1.0 DESIGN FEATURES AND MODE OF OPERATION OF THE MACHINE

The basic features of the simple proto type guava juice extractor are illustrated systematically, in the figure below. From the design view point, it consist basically of the extracting assembly, extracting chamber or casing, the feeding hopper, pulley and belt drive, the prime mover (electric motor), the perforated casing where the juice is discharge, the bearing which serve as the supporting body as well as the shaft component. the design parameter of each of the extractor are discussed below.

3.1.1 PRIME MOVER (ELECTRIC MOTOR)

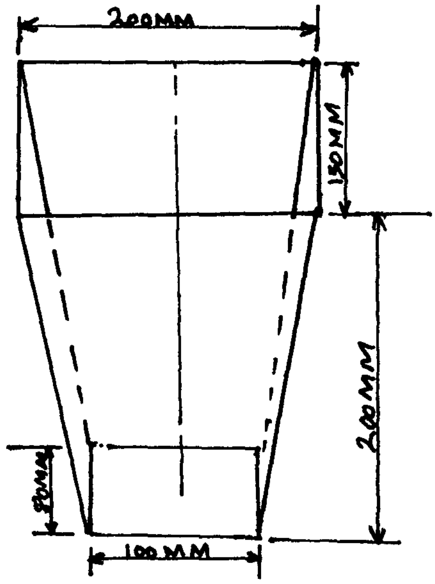
This is the major part of the machine in which the remaining parts are dependent on for commencement of operation. It has a power of 5kw and a speed of 1440 rpm. the electric motor will serve the purpose of generating the power to be transmitted by the belt in effective turning the shaft and by so doing, guava juice and the skin and seeds are separated out through the perforated casing and the skin and seeds are passes through the perforated disc plate at the extremely end of the casing and the content of the juice, and seed are collected in different compartment.

3.1.2 PULLLEY AND BELT DRIVE

These components will serve the purpose of transmitting power from one shaft to the other, the one attached to the motor and that attached to the extractor shaft. The rims of the drive pulley will be V-grooved, and the belt equally will be wedded selectioned (V-belt) smaller diameter by (d) attached to the motor have been selected to be 75mm and from calculation as can be seen in the calculation below. The pulley attached to the extractor shaft (D) is big at least about 4:1 compared to the smaller pulley, so that to accommodated the selected speed of the extracting shaft, which is selected to be 360 rpm. The maximum power on the belt was calculated.

3.1.3 HOPPER

This have dimensions of 150mm by 200mm and an opening of 80mm by 100mm a height of 200mm. It was welded to the extracting casing which is cylinderical in shape and serves the purpose of feeding the extraction the total volume of the hopper was calculated to be $1.2814886 \times 10^{-4} m^3$.



Feeding Hopper Fig(1)

3.1.4 **CASING (FRUSTUM)**

This have openings one from the hopper the other for the discharges. The frustum houses the shaft flute Auger that carries the conveyor.

The dimension of this frustum has been selected to be of length of 350mm. The component have two different metal structure. From the initial part of the component, is made from galvanised pipe of diameter of 812mm and length of 180mm, compiled to a galvanised metal sheet folded between the diameter 84mm and 70mm of guage 16. It narrowness for high extraction of gauge juice toward extreme and, and the perforated disc which is free from the casing and also serve the purposes of stoppage to the juice and the seed and skin separation. From wider and smaller sections respectively and from calculation the design volume was calculated which would accommodate the designed capacity of the extractor.

3.1.5 SHAFT IN THE EXTRACTOR

The extractor shaft has a welded hollow pipe and a metal rod (i.e Auger strips as conveyor, the rod was 390mm length and weighed, the height is distributed equal at that height and the length of shaft is 650mm and a diameter of 20mm from my calculation for safety instant of the normal 16mm from the calculation. The shaft plays the role of conveyor, transporting guava fruit (paste in chopped) fed through the hopper to the inner most cavity where it is crushed and pressed to extract it juice.

3.1.6 DISCHARGE OUTLET

The discharge outlet is forced open at compressive pressure of Auger, that is, when the crushed fruit would be pressed to the casing by the tangential force of the auger flute. The skin and seed is discharge at this pressure when juice would have been fully extracted from the guava fruit leaving well crushed skin and seeds. The discharged passed through the perforated casing and the skin and seeds is passed through the perforated disc.

3.1.7 PERFORATED CASING

It is compiled with the heat to the cylinder casing. The wall of the perforated component is made of available material which is the galvanised steel of gauge 14. So that to resist the pressure of the extracted material. For successfully extracting, by perforated opening all-over the frustum where it house a detachable disc which the seed passed through it at the extreme end of the shaft and the disc is supported by clip at the grooved of the shaft constructed.

3.1.8 BEARING HOUSING

Two bearing housing were produced using galvanised pipe, where one was welded to the cylinder casing while the other one was attached to extremely end of the shaft.

3.1.9 SUPPORT

This are metal mild steel sheet that are use to construct the support which give the machines the major balance. The support is welded to the machine firmly and is well balance to ignored vibration. It has equal length and width.

3.1.10 STAND

The stand was constructed using Angle metal iron which were welded to take the shaped of table.

3.2.0 DESIGN ANALYSIS OF MACHINE COMPONENTS

This design analysis is limited to the moving part only.

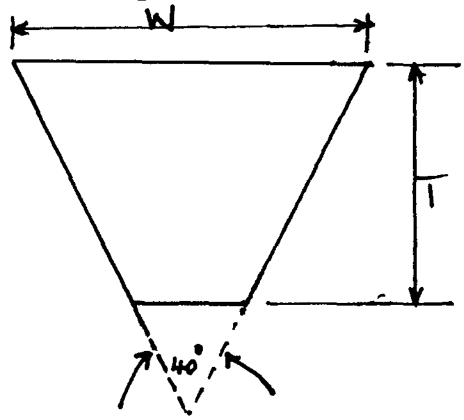
3.2.1 DESIGN OF BELTS AND PULLEY (MOTOR-FAN BELT AND PULLEYS)

ELECTRIC MOTOR: Speed (1440 rpm, rating (0.75kw, 1LP). The choice is based on availability and capacity which is enough for the work that is to be accomplished.

BELT SELECTION: A, V-belt (based on the usual load of drive 0.75 - 5kw power).

3.2.2 DETERMINATION OF THE MAXIMUM POWER OF BELT

Calculation of the belt speed.



Standard section of V-belts.

For v-belt A, the following are the data of the sections:-

Usual load of drive = 0.75 - 5kw

Recommended minimum pulley pitch diameter, d = 75mm

Normal top width, w = 13mm

Normal thickness, T = 8mm

Weight per meter = 0.100kgF

Belt speed, S = π dp N

Required fan speed = 360 rpm (selected)

Belt speed, S = π dp N

$$S = \frac{\pi(0.075 \times 1440)}{60} = 5665m/S$$

Required fan speed = 360rpm

1) Speed ratio; $V_s = \frac{n1}{n_2} = \frac{1440}{360} = 4$

2) Small diameter connection factor for arc of contact variation; Fb = 1.14 (based on speed ratio range (design data PSG Tech, 1982)

3) Calculation of the equivalent pitch diameter de.

de = dp x Fb

= 0.75 x 1.14 = 0.0855m = 85.5mm

85.5mm >dp. This value in within the expected range since it is greater than the minimum of 75mm.

4) Calculation of the maximum power of the belt A - selection.

For V-belt A, the maximum power is given by

$Kw = (0.455^{-0.09} - \frac{19.62}{de} - 0.765 \times 10^{-4} S^2)S$. Design data PSG Tech 1982).

Where S = belt speed = 5.65mls

de = equivalent pitch diameter = 0.0855m

$Kw = [0.45(5.65)^{-0.09} - \frac{19.62}{85.5} - 0.765 \times 10^{-4}(5.65)^2]5.65$

(0.385029938 - 0.229 - 0.002446)5.65

0.866kw == 0.87kw

To determine the larger pulley diameter.

Diameter of smaller pulley, d = 75mm (standard for "A" type belt).

Diameter of larger pulley, D = unknown

rpm of smaller pulley, n_1 = 1440rpm

rpm of larger pulley, n_2 = 360 rpm (selected) assumed efficiency $\int$ = 0.98

$$D = \frac{d_1 n_1 \int}{n_2} = \frac{75 \times 1440 \times 0.98}{360} = \underline{\underline{294mm}}$$

$$\text{Speed ratio} = \frac{D}{d} = \frac{294}{75} = \underline{\underline{3.92 = 4:1}}$$

NOTE: The speed ratio should be 4:1, hence the design pulley diameter are correct.

To determine the centre distance, C.

$\frac{C}{D}$ = $\underline{\underline{0.95}}$ (recommended $\frac{C}{D}$ ratio from PSG Tech data, 1982)

$$:. C = 0.95 \times 294 = \underline{\underline{2379.3mm}}$$

Calculation of (C minimum and C maximum).

Minimum centre distance Cmin = 0.55(D+d)+T

$$Cmin = 0.55(294 + 75)+ 8 = \underline{\underline{210.95mm}}$$

Maximum centre distance Cmax = 2(D+d) Cmax = 2)294 + 75) = $\underline{\underline{738mm}}$

Calculation of the normal pitch length of belt.

$$L = 2c + \frac{\pi}{2}(D+d)+\frac{(D-d)^2}{4c}$$

$$L = 2(279.3)+ \frac{\pi}{2}(294 + 75)+\frac{(294-75)^2}{4(279.3)}$$

$$L = 558.6 + 579.6 + 42.9$$

$$L = \underline{\underline{1181.12mm}}$$

The closest value ta the calculated length belt L = 1165mm with cross section approximately 1204mm (PSG design data, 1982).

The value of L (1168mm) is therefore used to calculated C to check whether the condition Cmin SC≤ Cmax hold

Calculation of the actual value of C

$$C = A + \sqrt{A^2 - B}$$

where $A = \frac{L}{4} - \frac{\pi(D-d)}{8}$

$292 - 144,91 = \underline{\underline{147.09}}$

where $B = \frac{(D-d)^2}{8} = \frac{(294-75)^2}{8}$

$B = \underline{\underline{5995.13mm}}$

$$C = 147.09 + \sqrt{(147.09)^2 - 5995.13}$$

$\underline{\underline{272.15mm}}$

Checking the condition

$Cmin \leq C \leq max$

$210.95 \leq 272.15 \leq 738mm$

The condition above is satisfied. This implies that the actual C is with in the range

$210.95 \leq 272.15 \leq 738.$

Calculation of the number of belt required from table (design data PSG Tech).

Correction factor for industrial service = Fa = 1:1

For light duty machine (PSG Tech data, 1982).

The value of the rating for the "A" type V-belt is Kw = 0.81(PSG

Tech data, 1982).

The value of correction factor, FC = 0.98

The arc of contact on smaller pulley.

Arc of contact angle B = $2\cos^{-1}\frac{(D-d)}{2c}$ (design data tech, 1982).

$$180 - 60^\circ \frac{D - d}{C} = 2\cos^{-1}\frac{(294 - 75)}{2 \times 272.15}$$

$$120^\circ \frac{(294 - 75)}{272.15} = 132.5^\circ$$

$$120(0.804)$$

$$96.564^\circ$$

The value for correction factor for the arc of contact, Fd = 0.72 (PSG design data, 1982).

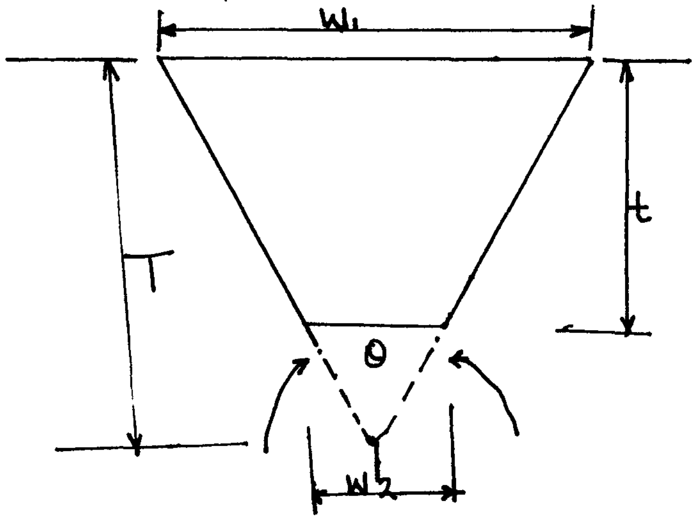
:. Number of belt required $Nb = \frac{P \times Fa}{Kw \times Fc \times Fd}$

$$= \frac{0.87 \times 1.1}{0.81 \times 0.98 \times 0.86} = 1.40$$

Number of belt 1

3.3.0 DESIGN OF FAN SHAFT

FAN BELT, PULLEY AND BELT TENSION



Belt dimension (standard section

The cross section of the belt driving the shaft is shown above,

Given for "A" V-belt width of belt, w_1 = 13mm

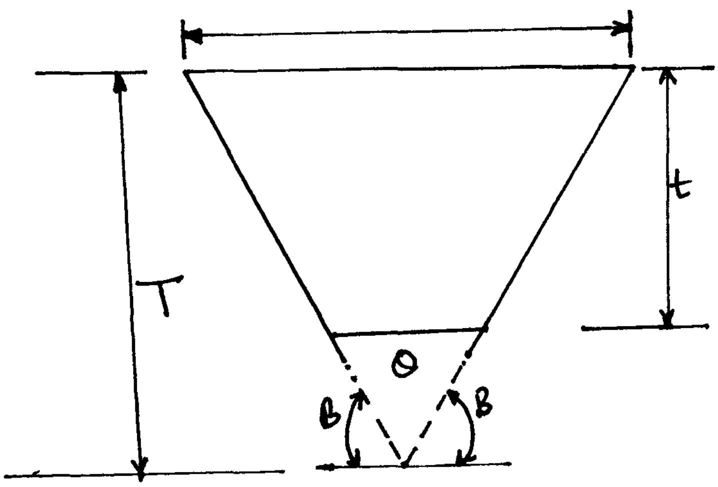
Nominal depth of belt t = 8mm

Sheave groove angle, θ = 40°

Density of leather belt ∫ = 970kg/m^3

Friction between the pulley and belt μ = 0.25

The determine the bottom width of belt, w_2



belt dimension

In the fig. above angle of wrap $\beta = \frac{180 - \theta}{2}$

$$= \frac{180 - 40}{2} = \frac{140}{2} = \underline{\underline{70^\circ}}$$

$T = \frac{1}{2} W_1 \tan \beta = \frac{1}{2} \times 13 \tan 70 = \underline{\underline{17.86mm}}$

By smaller triangle concept $\frac{w_2}{w_1} = \frac{t}{T} \Longrightarrow$

$$w_2 = \frac{w_1 t}{T} = \frac{13 \times 8}{17.86} = \underline{\underline{5.82mm}}$$

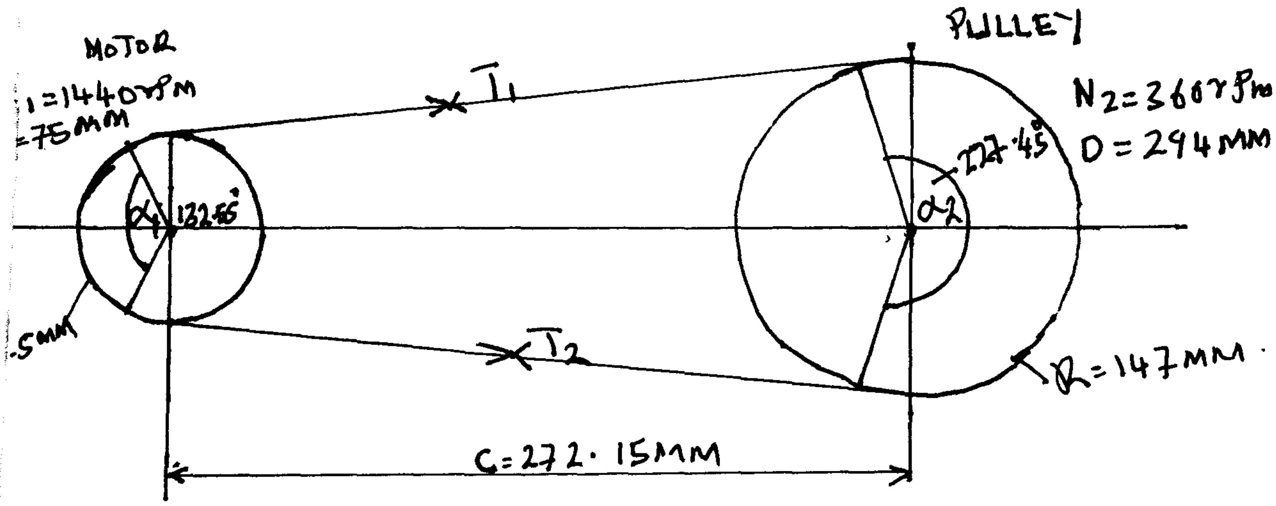
The belt cross-sectional area can be obtained as:

$$A = \frac{(w1 + w2)t}{2} = \frac{(13 + 5.82)\ 8}{2} = 75.28mm^2$$

mass per unit length, $M = \int \times A$

$= 970 \times 75.28 \times 10-6 = 0.073kg$

$= \underline{\underline{7.3 \times 10-2kg}}$



Angle of wrap and centre distance of belt

FAN-MOTOR V-BELT AND PULLEY

From the fig above.

d = diameter of motor pulley = 75mm

r = radius of motor pulley = 37.5mm

n_1 = speed of motor pulley = 1440 rpm

D = Diameter of extractor pulley = 294mm

R = Radius of extractor pulley = 147mm

n_2 = Speed of extractor pulley = 360rpm

C = actual centre distance = 272.15mm

Belt velocity = $V = \pi D n_2 = \frac{\pi \times 0.294 \times 360}{60}$

$= 5.54 m/s$

The maximum tension for leather belt, = T_1

$= 2 \times 10^6 N/m_2$ Schaum's outline series machine design)

To express T_1 in newton

T_1 = maximum tension x belt cross section area

$$2x\ 10^6 \times 75.28 \times 10^{-6} = 150.56N$$

To determine the arc of contact $\alpha\ 180 \pm 2\sin^{-1} \frac{(R - r)}{C} = 180 \pm$

$$2\sin^{-1} \frac{(147 - 37.5)}{272.15} = 180 \pm 47.45$$

α_1 = 180 - 47.45 = 132.55°

α_2 = 180 - 47.45 = 227.45°

$$\alpha\ 180 + 2\sin^{-1} \frac{(R - r)}{C} = 180 \pm 2\sin^{-1} \frac{(147 - 37.5)}{272.15} = 180° \pm 47.45$$

α_1 = 180 - 47.45 = 132.45°

α_2 = 180 + 47.45 = 227.45°

To determine allowable tension for v-belt

$$\frac{T_1 - mv^2}{T_2 - mv^2} = e^{u\alpha cosec} \frac{(\theta)}{2}$$

Where U = function between the belt and pulley = 0.25

Arc of contact degree

= Sheave groove angle, 40°

where $R = e^{u\alpha cosec} \frac{(\theta)}{2}$

and U function between belt and pulley 0.25.

The smaller value of α groven the design

:. α_1 given the design

$R_1 = e^{u\alpha cosec} \frac{(\theta)}{2}$

$$\theta = \frac{40}{2} = 20$$

$$R_1 = \frac{e(0.25 \times 132.55 \times \pi)}{\sin 20} = e^{1.691}$$

$$R_1 = 5.4294$$

The lower value (5.4294) is the allowable tension ratio for v-belt on pulley and it is the one that governs the design.

Centrifugal force in the belt is given by $T_c = mv^2$

Where, m -mass of pulley per unit length 0.073kg/m.

v = belt velocity = 5.54mls

$$\therefore \quad T_c = 0.073 \times (5.54)^2 = 2.248N$$

Determination of the belt tension the slack side T_2

$$\text{Given } \frac{T_1 - T_2}{T_2 - T_c} = R$$

$$T_2 = \frac{T_1 - T_c}{R} = T_c$$

$$T_2 = \frac{150.56 - 2.248}{5.4294} + 2.248$$

$$T_2 = 29.56446N$$

3.3.0 POWER TRANSMITTED BY BELT

$$p = \frac{(T_1 - T_2)\ V}{1000} = \frac{(150.56 - 29.56446)\ 5.54}{1000}$$

$P = 0.6703kw$

$P = 670.3W$

By conversion to horse power (hp)

$P = 9.6703Kw$

$$P = \frac{0.6703}{0.746} = 0.898525469hp$$

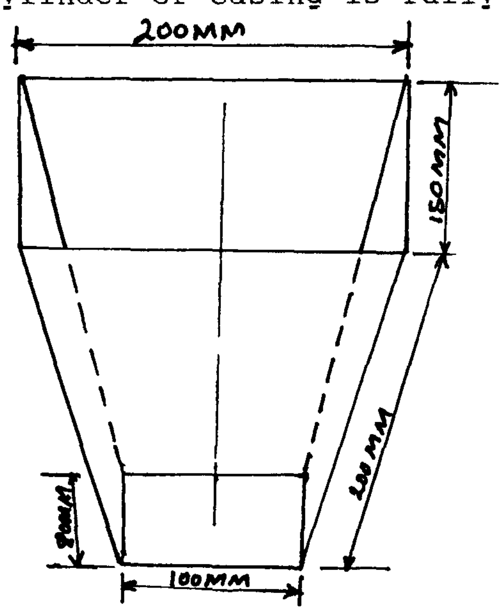
$\therefore \quad P = 1hp$

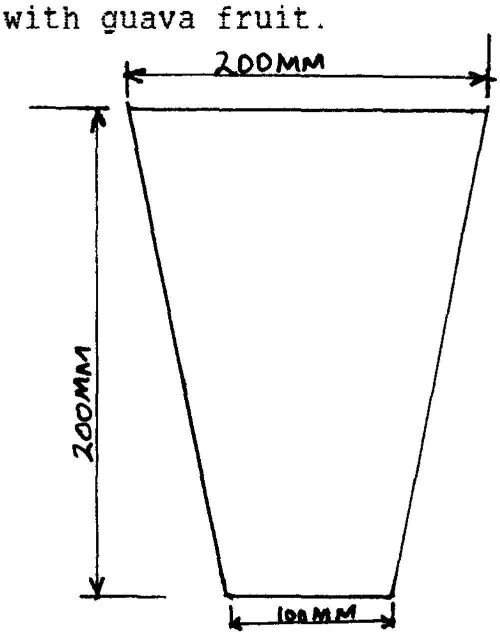
3.4.0 TO DETERMINE THE FORCE ACTING ON THE SHAFT

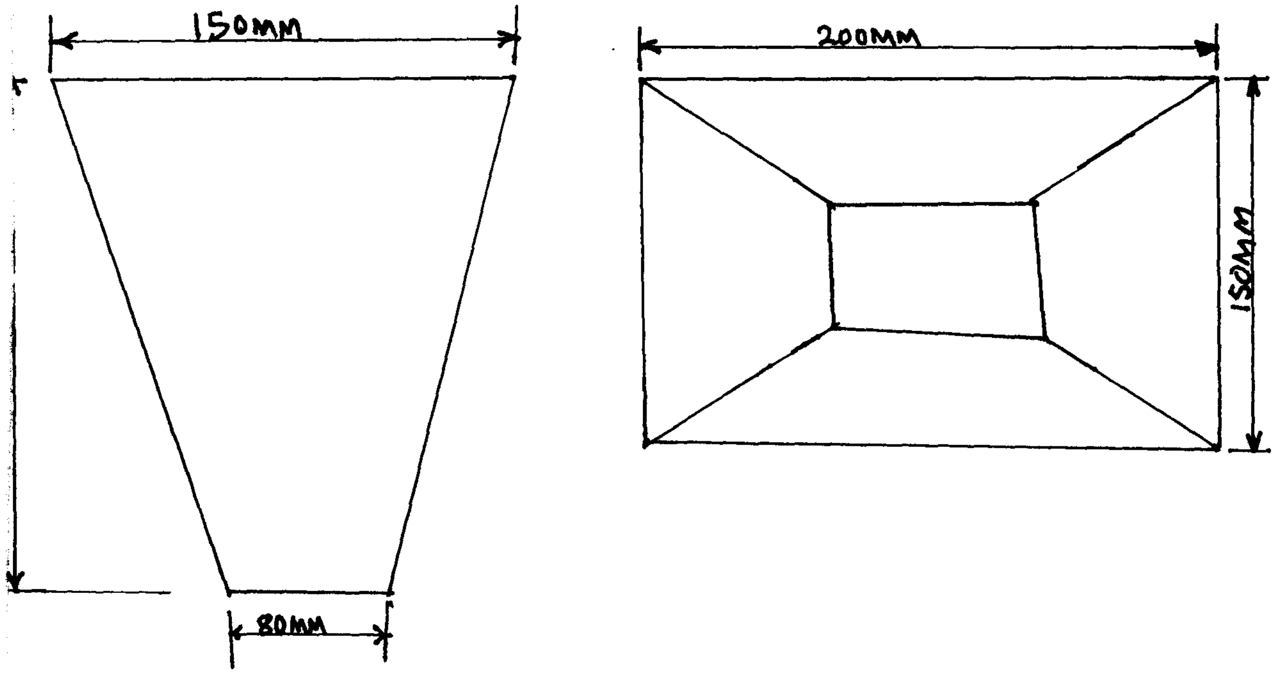
The force acting on the shaft is the sum of the force due to the weight of guava juice fruit fig and the weight of metal sheet uses for the auger fw and the weight of the pulley.

DESIGN OF HOPPER

Assuming that the volume of the hopper into the extractor cylinder or casing is fully loaded with guava fruit.







The weight of guava fruit to be feed inside the hopper will be:-

:. The mass of one red guava = 103.5g = 0.10359kg

:. For one guava

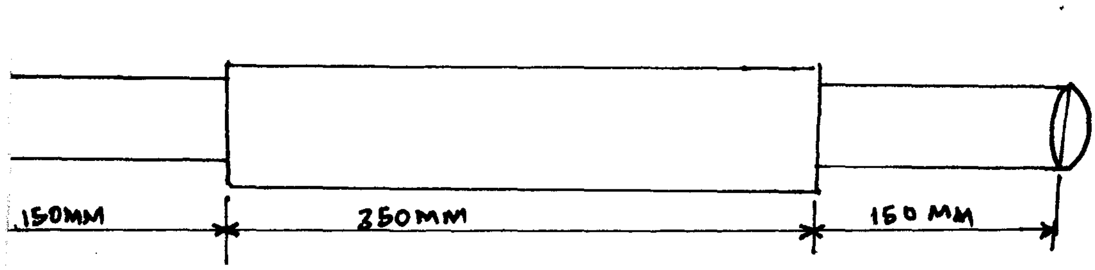
Where g = 9.81

Fg = 0.10359 x 9.81 = 1.01062N

then, the weight of 12 guava = 12.1946N which can be feed in the hopper.

The weight of the metal rod for the

auger construction and



Solid part of the rod, volume $= \pi r^2 h = \pi \times 10^2 \times 650$

$= \underline{2042 \times 10^{-4} m^3}$

the density of the rod is $7840 kg/m^3$

weight of the rod = 15.71N

weight of the hollow cylinder.

$$\text{Volume} = \frac{\pi}{2} ht(D_0 + d_1)$$

$$\frac{\pi}{2} 350 \times 2.526\ (46 + 40)$$

Weight of cylinder = 9.18N

weight of cylinder + iron = 24.896N + weight of the steel rope

weight = 2.14N = $\underline{27.035N}$

fw + fg = 12.1446 + 27.035 = 39.23N

Miscellaneous of 3N is allowed.

$\therefore$ Fw + Fg + 3 = $\underline{42.230N}$

C = Pulley centre distance = 272.15mm

Cmin = 210.95mm

$$\sin\theta = \frac{Cmin}{c} = \frac{210.95}{272.15}\ \ \underline{0.775124}$$

$O = Sin^{-1} = 0.775124$

$\theta = 50.816°$

The vertical and horizontal component of T respectively are.

$Tv = T\cos\theta$.

But $T = T_1 + T_2 = 150.56 + 29.56446 = 150.12N$

$T = 180.12N$

(from belt design)

$\therefore$ $Tv = T\cos 50.816°$

$Tv = 180.12 \cos 50.816$

$Tv = 113.80N$

$TH = T \sin\theta$ ==> $180.125in\ 50.186°$

$TH = 139.61N$

To determine the weight of the pulley volume of the pulley taken by the v-belt groove - belt cross-sectional area x π x D $75.28 \times 10^{-6}m^2 + 0.294 \times \pi = 6.95307 \times 10^{-5}m^3$.

Assuming a small hole of diameter 10mm at the centre of the pulley for the insection of the shaft volume of the pulley taken by this small diameter hole = $\pi r^2 W_1$

Where w_1 = width of the belt = 13mm.

r = radius of the small hole = $\frac{10}{2}$ = 50mm

$\therefore$ Volume of the pulley taken by the small diameter hole = $\pi(5 \times 10^{-3})^2 \times 13 \times 10^{-3}$

$= 1.0210 \times 10^{-6} m^3$

$= 1.0210 \times 10^{-6} m^3$
==============

Gross volume of the disc use for the pulley.

$\pi R^2 w \Longrightarrow \pi(0.147)^2 \times 13 \times 10^{-3}$

$= 8.8253 \times 10^{-4} m^3$
==============

:. Net volume of pulley = Gross volume of pulley - volume of the pulley taken by this small diameter hole - volume of the pulley taken by the v-belt groove.

:. Net volume of pulley = $8.8253 \times 10^{-4} m^3 - 1.0210 \times 10^{-6}$

Volume of the pulley taken by the v-belt groove

$= \pi(0.075) \times 75.28 \times 10^{-6} = 1.774 \times 10^{-5}$

:. Net volume of pulley $= 8.638 \times 10^{-4} m^3$

$= 9.638 \times 10^{-4} \times 2.710$

$= 2.34kg$
======

:. Weight of pulley = mass of pulley x g.

$= 2.34 \times 9.81$

$= 22.95/N$

$\Longrightarrow 22.955N$
=======

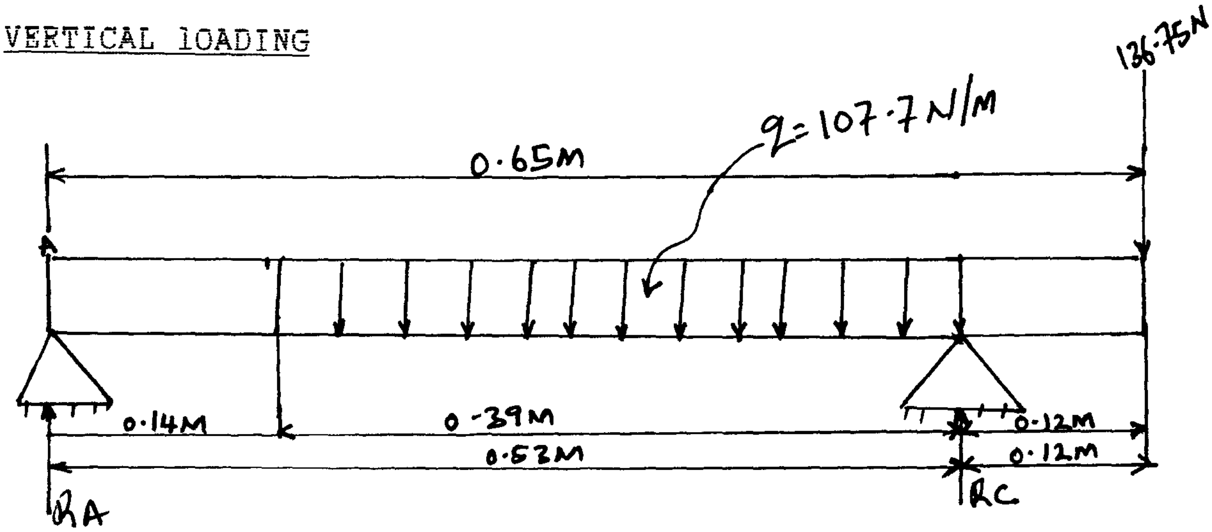
Total vertical load acting on the pulley.

TVT = 22.955 + 113.80N = 136.755N

TVT = 136.755N
========

3.4.1 **SHAFT LOADING**

VERTICAL LOADING



To determine reactions RA and Rc.

Taking moment about pont A

EMA = 0

$$0.53Rc - 0.39q(0.39 + 0.14) - 136.75(0.65) = 0.$$

$$0.53Rc = 14.07 + 88.89$$

$$0.53Rc = 102.96$$

$$Rc = \frac{102.96}{0.53} = \underline{\underline{194.25N}}$$

$$Rc = \underline{\underline{194.25N}} \quad - (1)$$

$$Emc = 0.53RA - q \times 0.39 \left(\frac{0.39}{2}\right) + 136.75\ (0.12) = 0$$

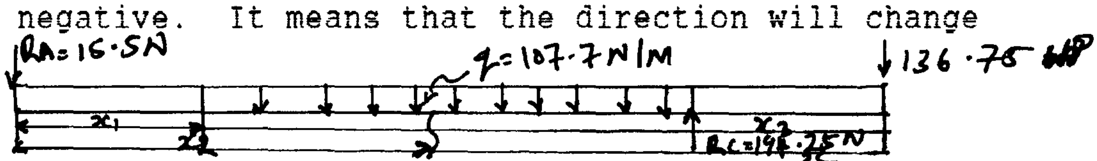
$$0.53RA = 8.19 - 16.41 = \underline{\underline{-8.22N}}$$

$$RA = \frac{-8.22}{0.53} = \underline{\underline{-\ 15.5N}}$$

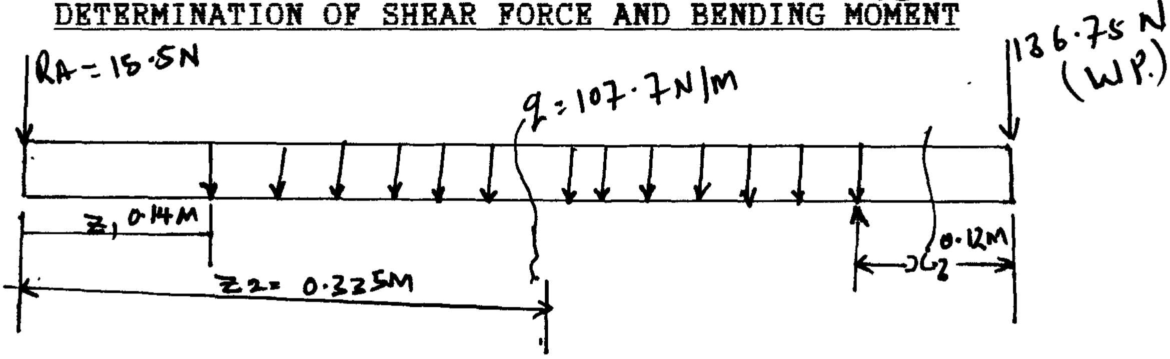
$$RA = \underline{\underline{-15.5N}}$$

Since RA as negative. It means that the direction will change

i.e



3.4.2 DETERMINATION OF SHEAR FORCE AND BENDING MOMENT



However, the shear force and bending moment can be determines as follows:-

For $0 \leq Z_1 \leq 0.14$.

Shear force, $Q_1 = -RA = -15.5N$

Bending moment; $m_1 = -RAZ_1$

When $Z_1 = 0$

$M_1 = 0$

when $Z_1 = 0.14$

$M_1 = -(15.5) \times 0.14$

$M_1 = -2.17NM$

For $0.14 \leq Z_2 \leq 0.335$

$Q_2 = -RA - q(Z_2 - Z_1)$

When $x_2 = 0.14m$

$Q_2 = -15.5 - 107.7(0.14 - 0.14)$

$Q_2 = -15.5N$

When $x_2 = 0.335$

$Q_2 = -15.5 - 107.7(0.335 - 0.14)$

$Q_2 = -15.5 - 21.0015 = \underline{\underline{-36.50N}}$

$Q_2 = \underline{\underline{-36.50N}}$

$M_2 = -RAZ_2 - \frac{q(x_2 - x_1)^2}{2}$

When $Z_2 = 0.14m$

$M_2 = -15.5(0.14) - \frac{107.7(0.14 - 0.14)^2}{2}$

$M_2 = \underline{\underline{-2.17rm}}$

When $Z_2 = 0.335$.

$M_2 = -15.5(0.335) - \frac{108.7(0.335 - 0.14)^2}{2}$

$M_2 = \underline{\underline{-7.24NM}}$

For $0 \leq x_3 \leq 0.12$

$Q_3 = Wp = 136.75N$

$M_3 = -WpZ_3$

When $Z_3 = 0$

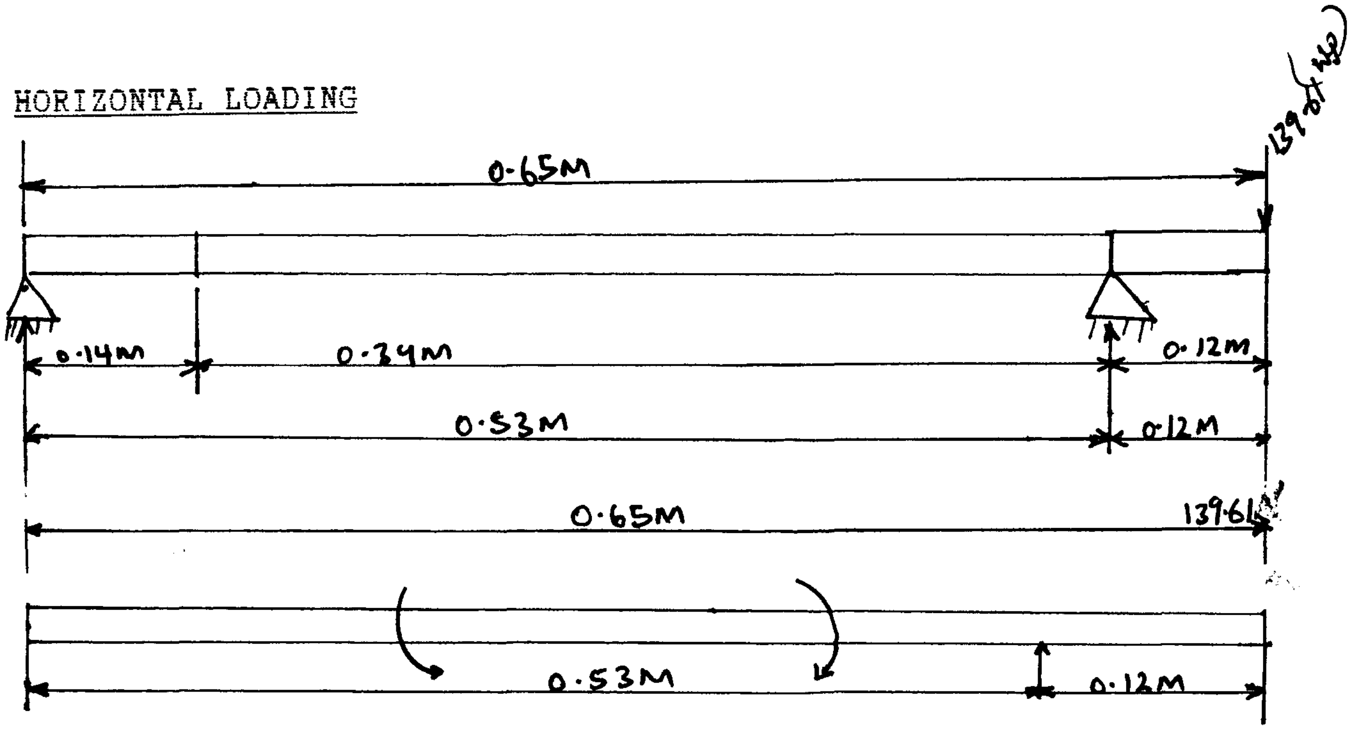
$M_3 = 0$

When $Z_3 = 0.12$

$M_3 = -136.75(0.12)$

$M_3 = \underline{\underline{-16.41NM}}$

HORIZONTAL LOADING



To determine the reaction RA and RC of the horizontal component.

EVF = 0 = RA' + RC" - 139.61N

RA' + RC' = 139.6N --------(2)

Taking moment about point A.

EMA = 0 - RC'(0.53) + 139.61 + 0.65

RC' = 171.22N

From (2)

RA' = 139.61 - RC' = 138.61 - 171.22

RA' = -31.61N

Since RA' as negative, it means that the direction will change i.e

Determination of shear force and bending moment.

Shear force

For $0 \leq Z_1 \leq 0.265m$.

$Q_1 = -RA' = -31.61N$.

$\therefore \quad Q_1 = 31.61N$

For $2.65 \leq Z_1, \leq 0.53m$.

$Q_2 = -RA - 0$

$Q_2 = -31.61N$

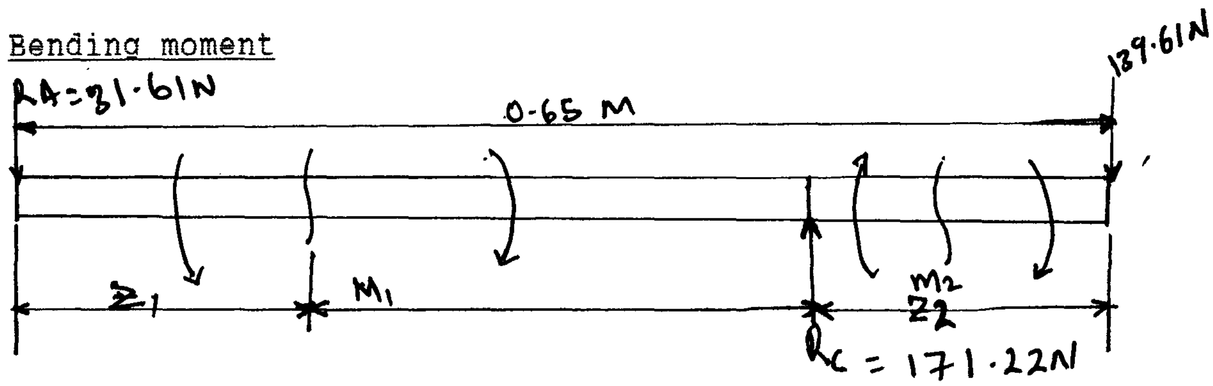
For $0 \leq Z_1, \leq 0.12m$.

$Q_3 = Q_2 + RC'$

$= -31.61 + 171.22$

$Q_3 = 139.61N$

Bending moment



Taking moment about A

$EMA = 0 - m_1 - 31.61Z_2$

$Z_1 = 0, 0.265, 0.53m$

For $Z_1 = 0$

$m_1 = 0$

For $Z_1 = 0.265m$

$m_1 = -31.61(0.265) = -8.37665N/M$

For $Z_1 = 0.53m$

$m_1 = -31.61(0.53) = -16.753N/M$

Taking moment about point C.

$EMC = 0\ m_2 + 139.61(Z_2)$

$m_2 = -139.61Z_2$

$Z_2 = 0,\ 0.06,\ 0.12m$

For $Z_2 = 0$

$m_1 = 0$

For $Z_2 = 0.6m$

$m_2 = -139.61(0.06) = -8.3766N/M$

$= -8.3766N/M$

For $Z_3 = 0.12m$

$m_3 = -139.61(0.12) = -16.753N/M$

Maximum bending moment at B is given by:

$$MB\ max = \sqrt{(-2.17)^2 + (-8.3766)^2}$$

$$= 8.653N/M$$

Maximum bending moment at C is given by

$$MC\ max = \sqrt{(-7.24)^2 + (-16.753)^2}$$

$$= 18.25N/M$$

Note

:. The maximum bending moment for the shaft taken place at point C i.e MC = 18.25N/M

For the belt drive, the torsional moment (torsque) is given by:

$$Mt = (T_1 - T_2)R$$

$$= (150.56 - 29.5644)\ 0.147$$

$$Mt = 17.7863NM$$

3.5.0 **DIAMETER OF SHAFT**

Diameter of a solid shaft having little or no axial loading,

the code equation reduces to $d^3 = \frac{16}{\pi SS}\sqrt{(Kbmb)^2 + (Ktmt)^2}$

(Design of mech Shamm's series)

:. where d = diameter of shaft

SS = Allowable stress for shaft without key way = SSmn/m²

Kb = Combined shock and fatigue factor applied to bending moment = 2.0.

Kt = Combined shock and fatigue factor applied to torsional moment = 1.5

Mb = Maximum bending moment = 18.25N/M

Mt = Maximum torsional moment = 17.7863N/M

$$d^3 = \frac{16}{\pi(55x10^{-6}}\sqrt{(20x18.25)^2 + (15x17.7863)^2}$$

$d^3 = 92599.23962 \sqrt{1332.25 + 7.11\ 793}$

$d^3 = 92599.23962 \sqrt{2044.04}$

$d^3 = 92 \times 10^{-8} \times 45.21$

$d^3 = 4.1864116 \times 10\text{-}6m$

$d = 0.016116867mm$

$d = \underline{16.12m}$

Therefore, based on the calculation, a solid shaft was used.

For safety d = 20mm

The diagram of the shaft designed for 20mm

3.5.1 DESIGN FOR TORSIONAL STRESS AND RIGIDITY

Torsional stress $T_{XY} = mt\ r/_J = \frac{16mt}{\pi d^3}$ (for solid shaft)

Where d = 20mm.

$$T_{XY} = \frac{16 \times 17.7863}{\pi(20x10^{-3})^3} = \frac{2845808}{\pi(20x10^{-3})^3} = \frac{90.58488}{\pi(20x10^{-3})^3}$$

$T_{XY} = 1.132311 \times 10^7 N/M^2$

$T_{XY} = 1.13 \times 10^7 N/M^2$

Bending stress, Sb (tension or compression) is

$Sb = Mb\ r/_L = \frac{32mb}{\pi d^3}$ (for solid shaft)

$$\frac{32 \times 18.25}{\pi(20\times10^{-3})^3} \quad \frac{584}{\pi(20\times10^{-3})^3} = 2.32 \times 10^7 N/M^2$$

$$Sb = 2.32 \times 10^7 N/M^2$$

Design of shaft for torsional rigidity. This is based on the permissible angle of torist which depends on application and varies about 0.3deg/m for machine tools to about 3deg/m for line shafting.

Angle of torist $\theta = 584mt\ ^{L}/_{Gd}4$

Where L - length of shaft

Mt = torsional moment, Nm

G = torsional modules of elasticity, $N/m^2 = 8.276 \times 10^{10}$

$$\theta = \frac{584617.7812 \times 65 \times 10^{-2}}{(20 \times 10^{-3})^4 \times 8.276 \times 10^{10}} = \frac{6751.679}{13241.6}$$

$\theta = 0.51°$

$\theta = 0.51°/m$

Since θ L 3°/m, therefore, deflection criterion is satisfied.

3.5.2 DESIGN OF SHAFT FOR LATERAL RIGIDITY

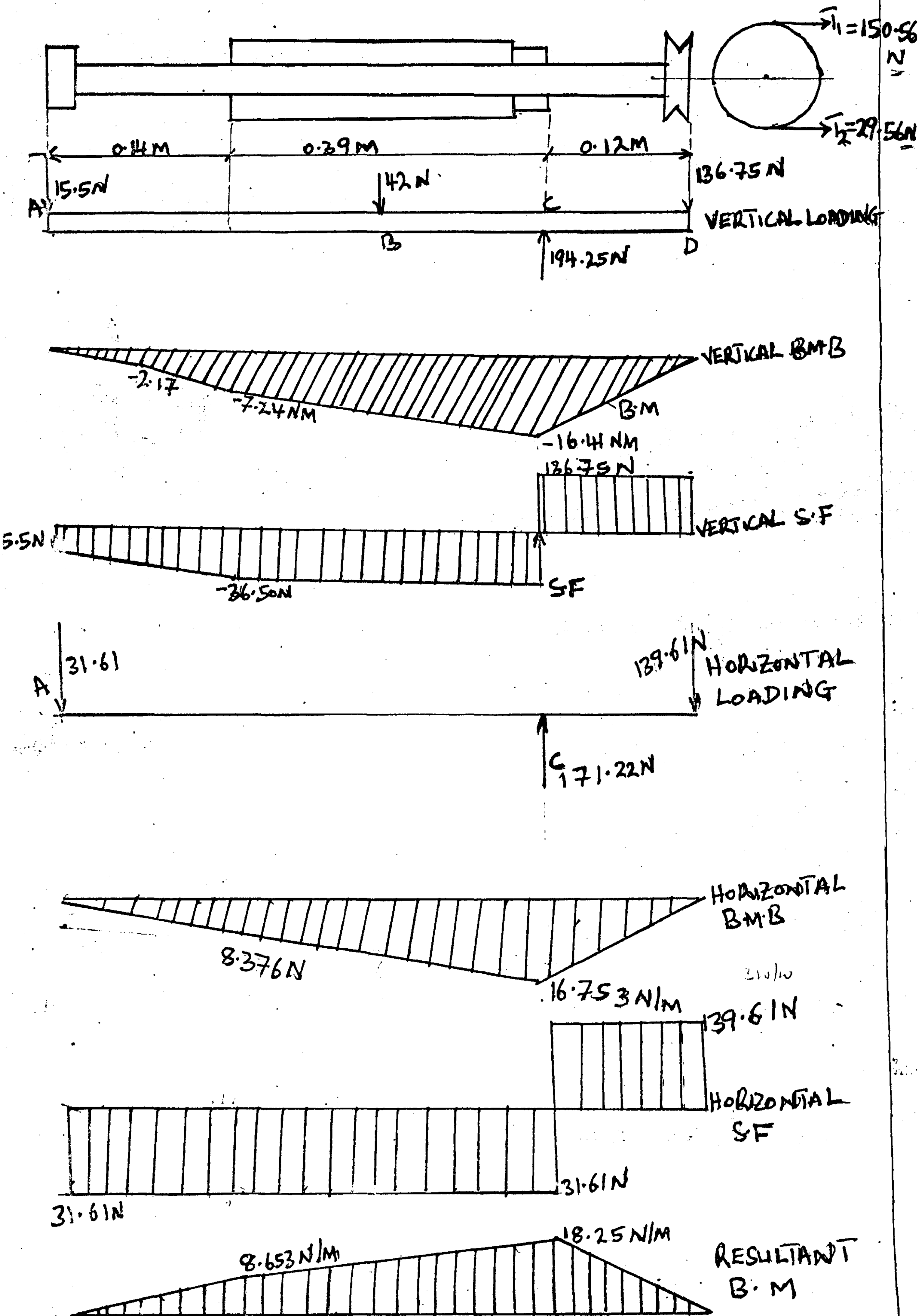
Based on the permissible lateral deflection for proper bearing operation, shaft alignment and other similar requirement.

The amount of deflection $\frac{d^2y}{dx} = \frac{Mb}{EI}$

Mb = bending moment, Nm

E = Modules of elasticity, N/M^2

I = rectangular moment of inertia m^4



T1=150.56 N
T2=29.56N
0.14M
0.39M
0.12M
15.5N
42N
136.75N
A
B
C
D
VERTICAL LOADING
194.25N
VERTICAL BMB
-2.17
-7.24NM
BM
-16.41 NM
136.75N
VERTICAL S.F
5.5N
-36.50N
SF
31.61
A
139.61N
HORIZONTAL LOADING
C
171.22N
HORIZONTAL BMB
8.376N
16.753 N/M
139.61N
HORIZONTAL SF
31.61N
31.61N
18.25 N/M
8.653 N/M
RESULTANT B.M

where E = modules of elasticity = 2.069×10^{11} N/m^2

Mb = Bending moment, m.

I = Rectangular moment of inertia, m^4

$$= \frac{\pi D^4}{64} = \frac{\pi(20\times10^{-3})^4}{64} = \underline{\underline{7.854 \times 10^{-9} m^4}}$$

3.5.3 DEFLECTION

$$\frac{32}{I \times N} = \frac{32}{7.854 \times 10^{-9} m^4 \times 2.064 \times 10^{11} N/m^2}$$

1.969×10^{-2}m

$\underline{\underline{0.01969\text{m}}}$

3.6.0 DETERMINATION OF THE RADIAL LOAD ON BEARING

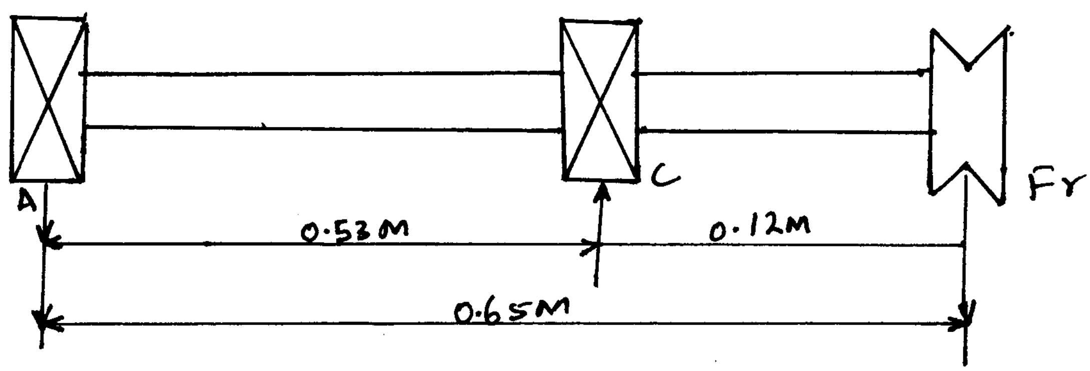


Fig I load on bearing

Power, P = 2πNT

where P = power, Kw = 0.75kw

N = Number of revolutions rpm = 360

T = Torque

but $P = 2\pi NT = 2\pi\ FrN$

$$Fr\ NR = \frac{P}{2\pi N}$$

$$\text{i.e } Fr = \frac{P}{2\pi NR} = \frac{P}{\pi Nd}$$

$D = 75 \times 10^{-3}m$

$$Fr = \frac{0.75 \times 1000}{\pi(360)75\times10^{-3}} = \frac{750}{\pi\times6\times75\times10^{-3}}$$

$$Fr = \frac{750}{1.4137}$$

$Fr = 530.52N$

Considering the loading summing forces vertically,

$\Sigma f = 0$, $Rc - RA = Fr = 530.52N$

Taking moment about A

$\Sigma MA = 0$, $0.65 \times fr - 0.53 \times Rc$

$0.65 \times 530.52 - 0.53RC$

$$Rc = \frac{0.65 \times 530.52}{0.53}$$

$RC = 650.64N$

Put the equation (2) into (1).

$RA = Fr - Rc = 530.52 - 650.64$

$RA = -120.12N$

The load on bearing C would be used to select the appropriate size bearing because is greater than the load at bearing A.

Therefore, in this design all load were in the same plane, which permitted the loads to be added or substracted. In many applications the radial forces are not all in the same direction or plane. Thus, the vertical and horizontal components of the radial force must be obtained for each bearing as in the design of shaft.

Since, the inner ring rotates and the direction of load is fixed. It is a case of circmyferential load on the inner ring, from the bearing table in deep groove ball bearing given later, we yet, corresponding to bearing No.6304 the following data.

Since the axial load is 194.25N and the radial load is 520.52N.

This implies that, the ratio $= \frac{Fa}{fr} = \frac{194.25}{530.52} = \underline{\underline{0.366}}$

The dimension of the bearing are:

Bore diameter, $d = 20mm$

outer diameter $D = 52mm$

Width diameter $B = 15mm$

Corner radius $r_1 = 1mm$

Radius $r_2 = 2mm$

Mass of the bearing = 0.69kg

Basic capacity, kgf for

Static (Co) = 765N

Dynamic (C) = 1250N

$\therefore \frac{Fa}{Co} = \frac{194.25}{765} = 0.0254$

In the bearing table, the value of $\frac{Fa}{Co}$ which is equal to the calculated value is 0.025 corresponding to the value of e is 0.22. The calculated value of $\frac{Fa}{Fr} = 0.37$ which is greater than 0.22. Hence, x = 0.56 and y = 2.0 and S = 1.5 from (PSG design data , 1982).

Determination of the equivalent load, P.

The equivalent load, P acting on the bearing P = (xfr + yfa)S..

Where as:-

x = Radial factor = 0.56

y = Thurust factor = 2.0

S = Service factor = 1.5

P = (0.56 x 530.54 + 2.0 x 194.25) 1.5.

P = 1028.4036N

Determination of the required life of bearing.

The required bearing life for an 8 hours daily operated machine = 20,000 hours (PSG design data, 1982).

$$L = \frac{\text{Number of resolution of shaft/hours x bearing life}}{\text{1 million}}$$

$$\frac{360 \times 60rps \times 20000 \text{ hours}}{1 \times 10^6}$$

$L = 432.00$ hours

3.6.1 DETERMINATION OF THE DYNAMIC CAPACITY OF BEARING

The basic dynamic capacity is the constant radial load that any bearing is 90% of the bearing population will carry for 500 hour at 33⅓ rps (one million revolutions) with out evidence of fatigue from table.

$\frac{C}{P} = 12.9$ at 360 rpm and 20000 hours

$C = 12.9 \times P$

$C = 12.9 \times 1028.4036 = 13266.41N$

3.7.0 FRAME DESIGN

Determine the total load to be carry by the frame.

1) Weight of the cylinder

Value of steel used for cylinder wall, Vcw is calculated thus.

$Vcw = \pi ht (R + r)$ or $1.5708ht (D + d)$

$$Vcw = \frac{\pi}{2} ht (D_0 + d)$$

h = length of cylinder = 180mm

t = thickness of cylinder = 4.5mm

d_0 = diameter of out side cylinder = 82mm

d_i = diameter of internal side cylinder = 73mm

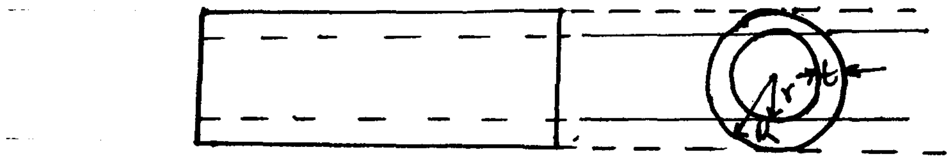


Fig ①

$$v = \frac{\pi}{2} \times ht\ (D_0 + d_1)$$

$$= \frac{\pi}{2} \times 180 \times 4.5(82 + 73)$$

$$\frac{\pi}{2} \times 180 \times 4.5\ (155)$$

$$v = 197213.4 \times 10^{-9} m^3$$

$$= T.\ 972 \times 10^{-4} m^3$$

Since Sst = $7840 kg/m^3$

===> weight of cylinder

wt = Vcw x Sst x g

$= 1.9721 \times 10^{-4} \times 7840 \times 9.81$

mass = 1.5462kg

wt = 1.5462 x 9.81

wt = 15.16776N

Area of the cylinder

$$\frac{\pi}{4}(D^2 - d^2)$$

$$\frac{\pi}{4}(82^2 - 73^2)$$

Area of the cylinder = 1.0956 x 10-3m²

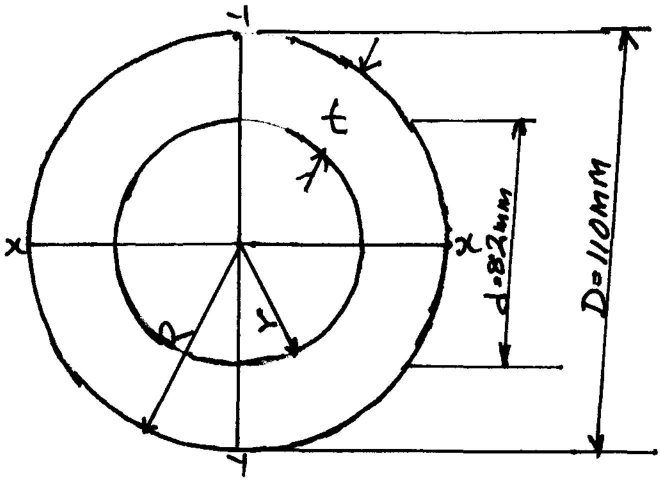


Fig 2

The metal sheet is welded to the cylinder casing which serve as a support, where the nut and bolt are fastening together as a support.

The volume of the metal sheet = vms

$$Vms = \frac{\pi}{4}(110^2 - 82^2) \times 2.526$$

$$= \frac{\pi}{4}(12100 - 6724) \times 2.56$$

$$= \frac{\pi}{4}(5376) + 2.526$$

$Vms = 1.06655 \times 10^{-5} m^3$

Metal use is mild sheet of density $7840 kg/m^3$

Mass of hollow circle = Vms x Sst

$= 1.06655 \times 10^{-5} \times 7840$

$= 0.0836kg$

Wt = mass x acceleration due to gravity.

Wt = 0.0836 x 9.81

Wt = 0.82030N for each

iii) Bearing load

Mass of bearing from the table of deep groove ball bearing of 10mm of diameter. The mass of the ball bearing is 0.069kg of designation of 6304 of matra mechanical design handbook (1985).

Weight of bearing, Wb = 0.069 x 9.81

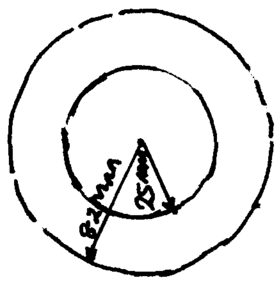
Wb = 0.67689N

Taking weight of bearing and housing

wbh = (0.67686 + 2.50) x 2 + 1.802 = 8.20N

because of 3 bearing

Weight of the chamber closured which attached to the bearing housing.



The volume of the metal sheet closure;

$$V_{mc} = \frac{\pi}{4}(D^2 - d^2) \times t$$

D = 82mm

d = 25mm

t = 2.526mm

$$\frac{\pi}{4}(D^2 - d^2) \times t$$

$$\frac{\pi}{4}(82^2 - 25^2) + 2.526$$

$12099.9022mm^3 = 1.21 \times 10^{-5}m^3$

The density of the metal use, which is a mild sheet of gauge 12.

Mass of mild steel use = Vmc x Sst

$= 1.21\ 10^{-5} \times 7840$

= 0.09485616kg

Weight of the chamber closured which attached to the bearing housing.

wt = Mc x 9.81

wtc = 0.930538929N

0.931N

Total weight of the components of the hopper and material carry on the cylinder.

i) Weight of hopper = WH = 9.85598N

ii) Weight of the closure = Wtc = 0.931N

iii) Weight of the cylinder = wt = 15.16776N

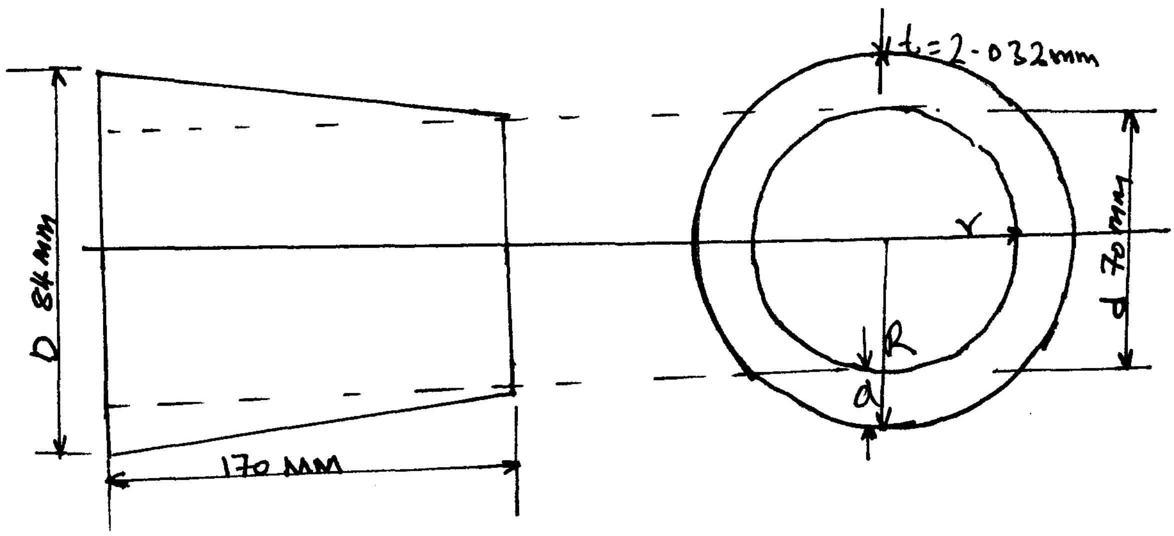
iv) Weight of the compiling ;ate = 0.82030N

v) Weight of bearing and housing = 8.20N

Total weight of the component of the extraction chamber is = 35.05N

vi) To determine the weight of the perforated casing. In the fig below:

This part of the perforated for a frustum of a cme.



The use of gauge 16 metal mild sheet which has a thickness of 2.032m.

Total thickness is 2.032 x 2 = 4.064m

Do = D + 2 + = 88.064mm

do = d + 2 + = 70 + 4.064 = 74.064mm

$$Vo = \frac{\pi}{12} h(Do^2 + Do + do + do^2)$$

$$\frac{\pi}{12} \times 170(88.064^2 + 88.064 \times 74.064 + 74.064^2)$$

Where as

Vo = outside volume of frustrum of a cone = 7

Do = Outside diameter of the big side = 88.064mm

do = Outside diameter of the smaller side = 74.064mm

h = height of the frustrum of a cone = 170m²

$$V_o = \frac{\pi}{12} \times 170(88.064^2 + 88.064 \times 74.064 + 74.064^2)$$

$$V_o = 44.5058(19813.84115) = 881830.8515mm^3$$

$$V_o = 8.82 \times 10^{-4} m^3$$

Where as

$$VI = \frac{\pi}{12} h(D_1^2 + D_1 + d_1 + d_1^2)$$

VI = Internal volume of the frustum of a cone = 7

Di = Internal diameter of bigger side = 84mm

Di = Internal diameter of smaller side = 70mm

$$VI = \frac{\pi}{12} \times 170(84^2 + 84 + 70 + 70^2)$$

$$VI = \frac{\pi}{12} \times 170(7056 + 5880 + 4900)$$

$$VI = 793807.1597mm^3$$

$$VI = 7.938 \times 10^{-4} m^3$$

Where as

Vt = total value of the frustum of a cone

Vt = Vo - Vt

$$Vt = 8.82 \times 10^{-4} - 7.938 \times 10^{-4}$$

$$Vt = 8.82 \times 10^{-5} m^3$$

by using of mild steel metal of density of 7.840kg/m^3

Mass of the frustum of cone.

$M = Vt \times St$

$M = 8.82 \times 10^{-5} \times 7840$

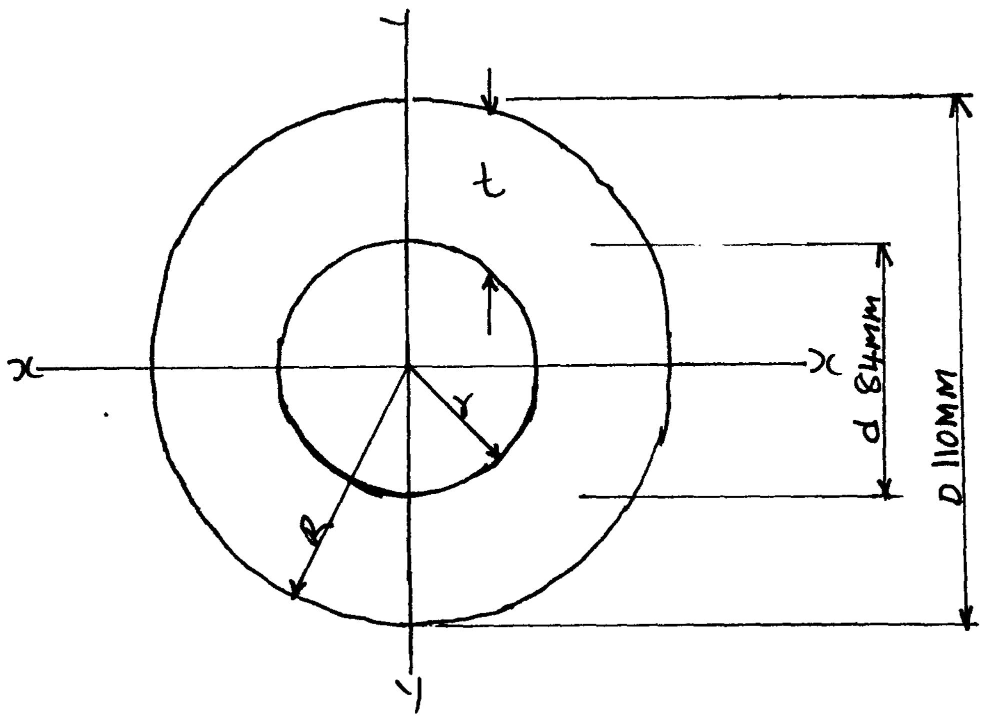
$M = 0.6914885kg$

Weight of the frustum of a cone

$Wt = m \times g = 0.6914880 \times 9.81$

$Wt = \underline{6.7835N}$

v) To determine for hollow circle of a metal sheet of gauge 12, which the thickness is assumed to be 2.526mm.



The metal sheet is welded to the cylinder casing which serve as a support, where, the nut and bolt are fastening together as a support which complete both the cylinder casing and the perforated cone casing.

The volume of the metal sheet = Vms.

$$Vms = \frac{\pi}{4}(D^2 - d^2) \times t$$

D = 110mm

d = 84mm

t = 2.526mm

$$Vms = \frac{\pi}{4}(110^2 - 84^2) \times 2.526$$

$$\frac{\pi}{4}(12100 - 7056) \times 2.526$$

$$Vms = 1.000687 \times 10^{-5} m^3$$

The density of metal use, which is a mild steel of gauge 12.

Mass = Vms x Sst.

$= 1.000687 \times 10^{-5} \times 7840$

Mass = 0.07845kg

wt = mass x g

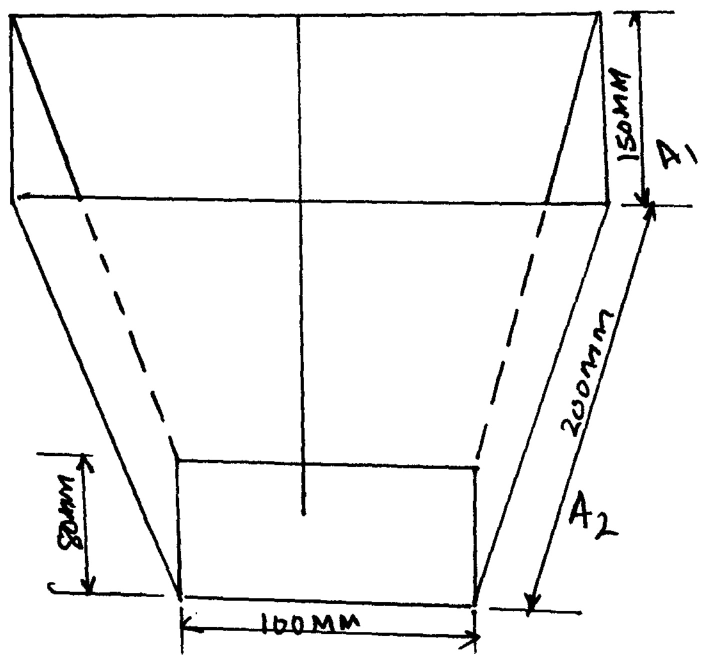
where g = 9.81

= 0.078 x 9.81 = 0.7696N

Weight = 0.7696N

vi) <u>To determine weight of hopper.</u>

The hopper is determine as a frustum of a pyramid.



The hopper is constructed with carbon mild steel of gauge 18 which is 1.219mm.

The volume of the hopper feeder.

$$Vp = \tfrac{1}{3}h\ (A_1 + A_2 + \sqrt{A_1 + A_2}\ )$$

To calculate for A_1 (Area 1) top

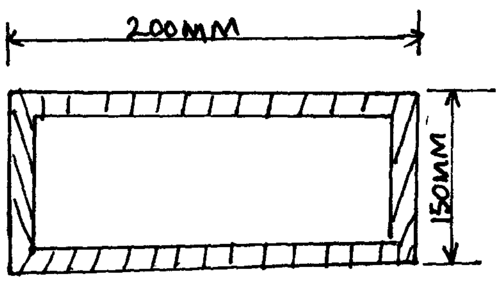


Fig above is for top rectangle

Length of the outer portion Lo = 202.438mm

Width of the outer portion Bo = 152.438mm

Length of the internal port Li = 200mm

Width of the internal portion Bi = 150mm

Total area of the top = Area of the outer portion - Area of internal

$AT_T = Aa - Ai$

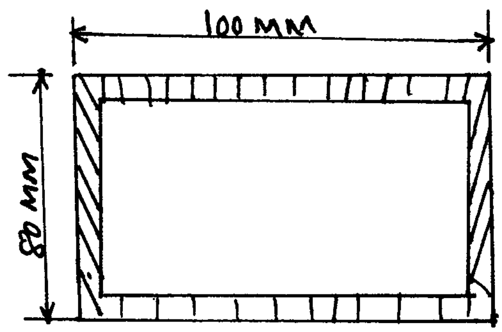
$AT_T = (La \times Bo) - Li \times Bi$

$AT_T = (202.438 \times 152.438) - (200 \times 150)$

$30859.24384 - 30000$

$AT_T = 859.24384mm^2$

while the total area of the bottom at the fig below.



Length of outer portion Lo = 102.438mm

Width of outer portion Bo = 82.438mm

Length of internal portion Li = 100mm

Width of internal portion Bi = 80mm

Total area of the bottom = Area of the external - Area of internal.

$AT_B = Ao - Ai$

$AT_B = (Lo \times Bo) - (Li \times Bi)$

$AT_B = (102.438 \times 82.438) - 100 \times 80$

$= (8444.783844 - 800)$

$AT_B = 444.783844mm^2$

The total volume of the hopper

$$V = \frac{h}{3} (AT_T + AT_B + \sqrt{AT_1 \times AT_2})$$

V_4 = volume of hopper =

h = height of hopper = 200mm

AT_T = total area of the top portion = $859.24384mm^2$

AT_B = total are of the bottom portion = $444.7838mm^2$

$$V_4 = \frac{200}{3} (859.24384 + 444.783844 + \sqrt{859.24384 \times 444.783844})$$

$$V_4 = \frac{200}{3} [1304.027684 + \sqrt{382177.7781}]$$

$$V_4 = \frac{200}{3} [1304.027684 + 618.205288]$$

$V_4 = 128148 - 8648m^3$

$V_4 = 1.2814886 \times 10^{-4}m^3$

Since, the density of mild steel sheet use in the design of hopper,

$Sst = 7840kg/m^3$

$g = 9.81$

Mass of hopper = V_H x Sst

$= 1.2814886 \times 10^{-4} \times 7840 = 1.0046871$kg

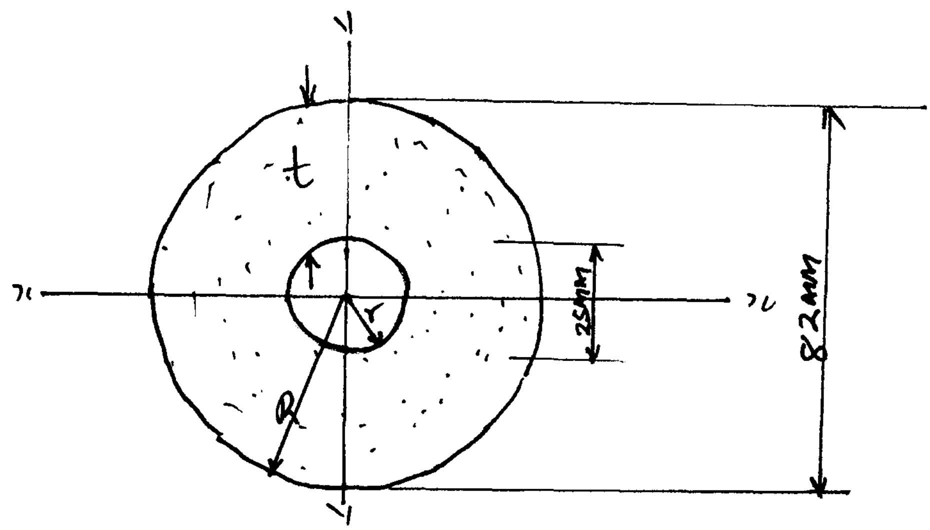
Mass = 1.0046871kg

Weight of hopper.

Wt = Mass x g = 1.0046871 x 9.81

= 9.85598N

vii) Total weight of the cylinder casing closed side where the bearing housing is located, that is the plate cover in fig below:-



The metal use for the construction is gauge 12 which the thickness is assume to be 2.526mm. The metal is welded to the cylinder casing at the bearing housing to protect the shaft from rubbing against the wall of the housing.

The volume of the metal sheet plate vmp.

t = Thickness

$$Vmp = \frac{\pi}{4}(82^2 - 25^2) \times 2.526$$

$$\frac{\pi}{4}(6724 - 625) \times 2.526$$

$Vmp = 12099.90222mm^3$

$Vmp = 1.209902 \times 10^{-5}m^3$

Metal use is carbon mild steel of density of

$Sst = 7840kg/m^3$

$Mass = Vmp \times Sst = 1.209902 \times 10^{-5} \times 7840$

$= 0.09486kg$

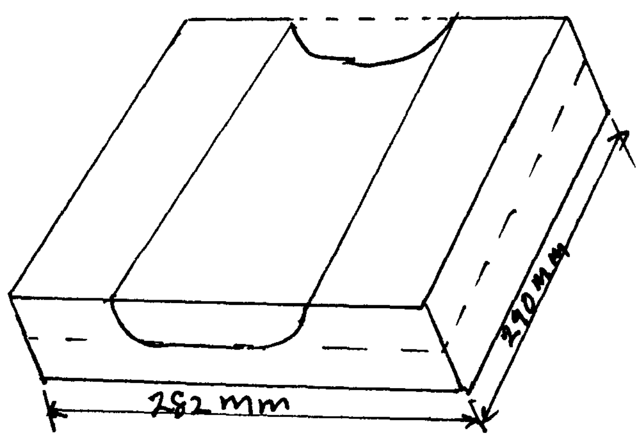
Weight of the metal plate.

Wt = mass x acceleration due to gravity.

wt = 0.094863233 x 9.81

wt = 0.93060832N
===========

viii) a) Weight of the support of the



from the fig 1 above

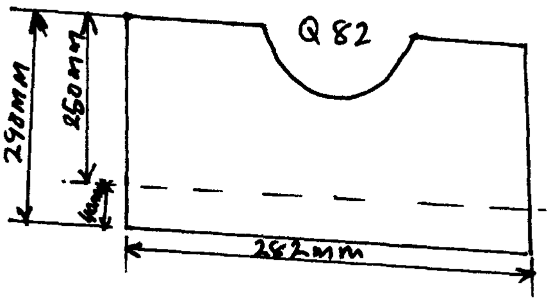
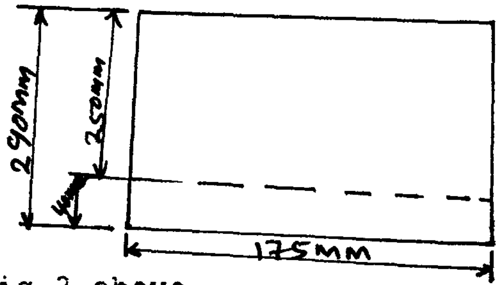


Fig 2



From fig 3 above.

To determine the weight of the metal sheet for the construction of the support.

The metal use for the construction is gauge 12 of 2.526mm thickness. This metal is welded to each other to give a firm stability to each other to support the weight of the machine.

The volume of the metal sheet.

Vms = Lms x wms x tms

where

Vms = volume of metal sheet =

Lms = length of metal sheet = 175mm

Wms = Width of datal sheet = 290mm

tms = thickness of metal sheet = 2.536mm

From the formula above

Vms = 290 x 175 x 2.526

Vms = 128194.5mm^3

Vms = 1.281945 x 10^{-4}m^3

Metal use which is carbon mild sheet of guage 12 and with a density of Sst = 7840kg/m^3

Mass = Vms + Sst

$1.281945 \times 10^{-4} \times 7840$

$= 1.00504488$kg

Weight of metal steel = mass x g

$= 1.00504488 \times 9.81$

$= 9.860N \times 2$

$= 19.719N$

In fig 2 above.

The volume of the semicycle is

$$Vsc = \frac{\pi\ d^2 scxtsc}{8} = \frac{\pi(82)^2 \times 2.526}{8}$$

Vsc = 6669.924788mm^3

The volume of the rectangular mild steel use for the support:

VR = LR x BR x TR

Where as

VR = Volume of rectangular support = ?

LR = length of rectangular support = 282mm

BR = Width of rectangular support = 200mm

TR = thickness of rectangular support 2.526mm

VR = 282 x 290 x 2.526

VR = 20657628mm^3

Total volume of the metal = VTR

VTR = VR - Vsc

From the equation above.

VIR = 206576.28 - 6669.924788

VTR = 199906.3552mm^3

The density of the mild steel (St) = 7840kg/m^3

mass of mild steel = density x volume

= 7840kg/m^3 x 1.9990635m^3

= 1.567266kg

Weight of mild steel of each side.

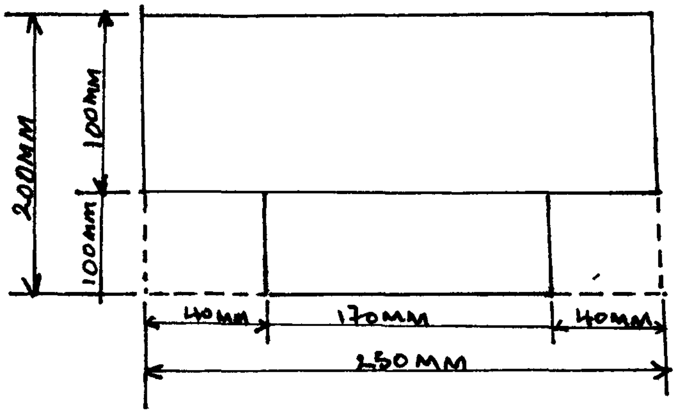
Mass of steel x g

1.567766 x 9.81 = 15.4N

There are two types of metal sheet that is welded at both side of the support.

2 x 15.4 = 30.80N

Weight of the top cover support.



Weight of the entire mild steel sheet of guage 12, where the thickness is determine to be 2.526mm.

Volume of the whole metal sheet.

Vws =Lws x Bws x tws

where as

vws = volume of whole sheet.

Lws - length of whole sheet = 250mm

Bws = width of the whole sheet = 200mm

Vws = 200 x 250 x 2.526 = 126300mm^3

The volume of the cutted part of the whole mild sheet.

Vcp = Lcp x Bcp x tcp

where as,

Vcp = colume of the cutted part

Lcp = length of the cutted part = 100mm

Bcp = width of the cutted part = 40mm

Tcp = thickness of the cutted = 2.526mm

Vcp = Lcp x Bcp x tcp

Vcp = 40 x 100 x 2.526 = 10104mm^3

Total volume of mild steel = Vws = Vcp

126300 - 10104

= 116196mm^3

=========

Total volume of mild steel = 1.16196 x $10^{-4}m^3$

Mass of the whole steel = VTW x St

= 1.16196 x 10^{-4} x 7540

= 0.91097664kg

Weight = of top cover support

= 0.91097664 x 9.81

Weight = 8.94N
=====

The total weight of the 2 mild steel cover

= 8.94 x 2

= 17.88N
=====

Determination of the weight of the disc on the diagram below.

The volume of the dics attached to the perforated coner

$$vd\ \frac{\pi}{4}\left(D_D^2 - d_d^2\right) \times t_d$$

where as

t = thickness = 2.526mm

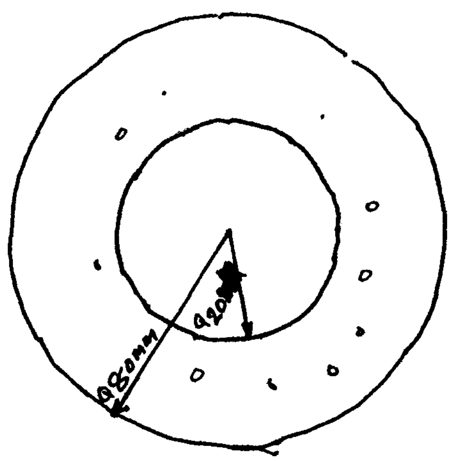
vd = volume of the disc

Dd = Diameter of the outer portion of disc = 20mm

dd - diameter of the internal portion of disc = 80mm

$$vd\ \frac{\pi}{4}\left(80^2 - 20^2\right) \times 2.526$$

$Vd = 11903.495mm = 1.19 \times 10^{-5} m^3$



The density of the mild steel use for the construction of the disk is $7840kg/m^3$

Mass = V x Std

= $1.1903494 \times 10^{-5} \times 7840$

= 0.09332kg

<u>Weight of the disc</u>

Wtd = Md x Std

Where as

Wtd = weight of disc = 7

Md = mass of disc = 0.09332kg

g = acceleration due to gravity $9.81M/s^2$

wtd = mb x

= 0.09332 x 9.81 = 0.9155N

The weight of the disc plate on the shaft is part of the miscellaneous weight of the load on the shaft.

And the total weight of the auger and the miscellaneous weight is 29.80N and that of the guava fruit is 12.20N which give the total of 42N of the weight of auger and the material on it.

Total weight of the support.

Wms + WTR + WTW

(19.719 + 30.80 + 17.88)M = 68.40N.

Total weight of extracting chamber compartment is 35.05N.

Total weight of the perforated frustum of cone = 6.7836m

Total weight of the material on the support = 110.2335N

Total vertical weight on pulley = 136.755N)

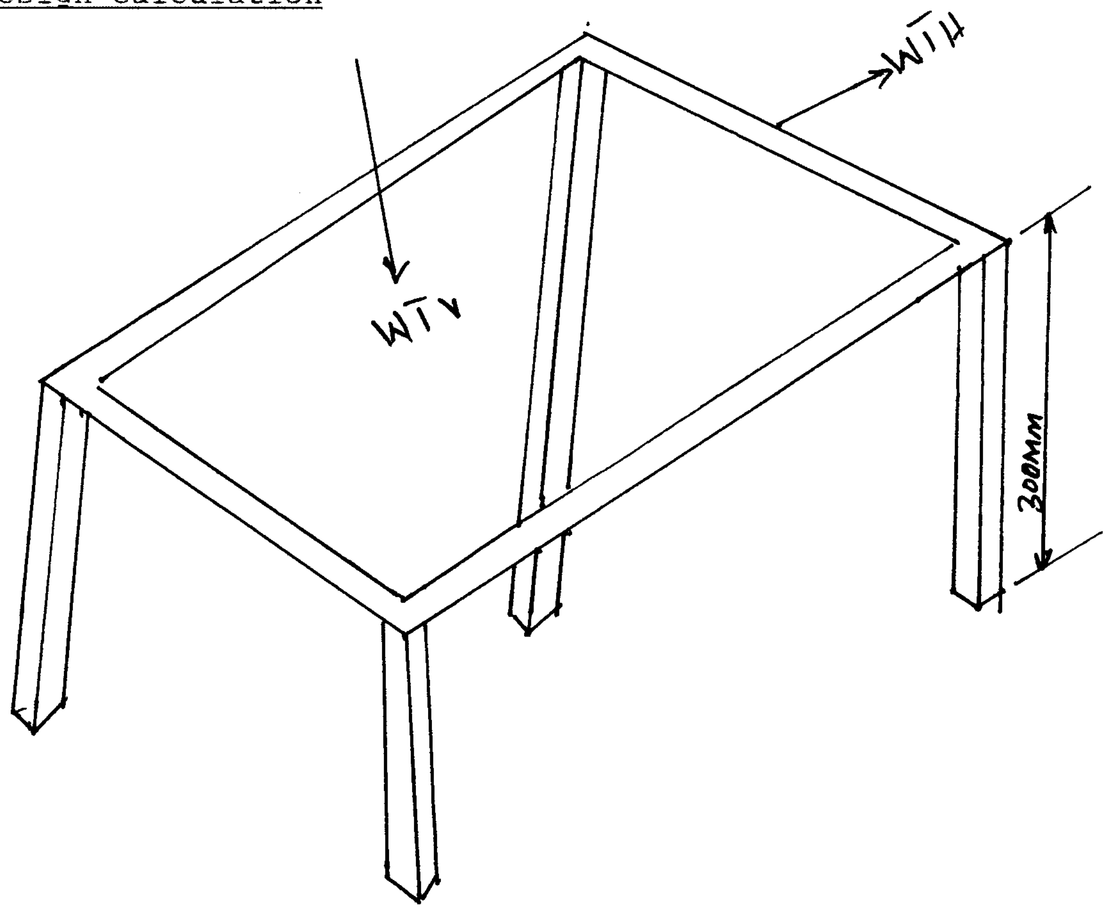
Total horizontal weight of shaft =139.61N)= 276.365 design force.

Total weight of material on the frame

= 110.2333 + 139.61 + 136.755

= 386.5985N

<u>Frame design calculation</u>



For axially and loaded frame, reference 12 give the condition for design as;

$$\frac{Fc}{Pc} + \frac{Fbc}{Pbc} \leq 1 \quad ----(1)$$

where Fc = actual axial stress

Fbc = actual bending stress

Pbc = allowable bending stress

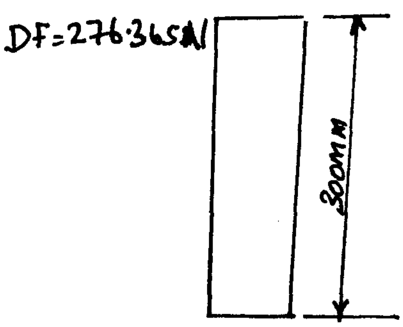
Pc = allowable axial stress

But $Fbc = \frac{M}{Z} \quad ------(2)$

Where m = moment

Z = sectional modules

Design force



M = Df x 300

M = 276.365 x 300

M = 83909.5Nmm

From table 3.17 of reference (9) select angle bar iron standard 15A 3535 (35 x 55) size AxB(mm)

Thus, reading from table, thickness it = 3.0mm

Sectional modules, $Z = 0.90cm^3 = 0.90 \times 10^{-3}mm^3$

Cross sectional area (AS) = $2.03 \times 10^2 mm^2$

Thus, substituting in equation (2)

$$Fbc = \frac{(82909.5)}{0.90 \times 10^3} N/MM^2 = 92.122N/mm^2$$

$$Fc = \frac{\text{vertical load on each leg (pv)}}{\text{Area of frame (AS)}} \quad \text{------(3)}$$

$$Pv = \frac{(386.755)}{4} N = 96.68875N$$

Substituting in Fc in equation -----(3)

$$Fc = \frac{Pv}{As} = \frac{(96.68875)}{2.03 \times 10^2} N/mm^2$$

$Fc = 0.47639N/MM^2$

From reference (g), the material use for design.

Material used, steel, grade C50 or 50C4

Ultimate stress, $\sigma ut = 800N/mm^2$

Yield strength $\sigma y = 0.65 \times \sigma ut$ ---(4)

$\sigma y = (0.65 \times 800)N/mm^2$

$\sigma y = 520N/mm^2$

Pc (allowable axial stress) = $(0.5 \times 520)N/m^2$

$Pc = 260N/MM^2$

The value of Pbc is selected from reference (12).

$Pbc = 165N/mm^2$

Substituting in equation (1)

$$\frac{Fc}{Pc} + \frac{Fbc}{Pbc} + \frac{0.47629}{260} + \frac{92.122}{165}$$

0.0018.32 + 0.558315

$0.56015 \leq 1$

Design condition is okay.

CHAPTER FOUR

4.0 TEST AND COST ANALYSIS

4.1 PROCEDURE

The machine was tested after it completion, so as to determine the performance efficiency of the machine. Some guava were bought and washed off the dirt. On it and taken to the laboratory for weighing. The weighing was conducted 3 times because the available container in the laboratory is small and can not contain reasonable amount of guava fruits to be weighed and for the fact that some guava might have lost their water content due to climatic condition. It was necessary to select different guava for each of the 3 times the weighing was carried out, so as to take care of any possible error that might occur. The same container was used for the 3-experiments.

Firstly, here the moisture content of the guava juice was determine with out addition of water.

The juice of the extract collected was recorded. Then in the experiment, the average value of the juice was determined.

Finally, a test was carried out to determine the effect decrease in quantity of juice mixed with water in different properties and the mass of extract collected over a given time was recorded.

4.2.0 **RESULTS**

Test for the efficiency and capacity of the machine.

Test machine production efficiency results. Firstly, trial: some guava fruit was cut into small pieces and places in the container.

Mass of empty container is M_1 = 2.45kg

Mass of container + guava fruit M_2, = 4.00kg

Mass of guava fruit M_3, M_2, M_1 = (4.0-2.45)kg = 1.55kg

When extracting the guava fruit with out water added to it. It only produce paste of equal mass of 1.55kg.

Secondly trial: Some guava fruit were cut into small piece and placed into the same container.

Mass of the container M_1 = 2.45kg

Mass of the container + guava M_2, = 3.70kg

Mass of the guava fruit M_3, (M_2,- M_1)kg = 1.25kg

Mass of the water + guava fruit M_4 = 2.25kg

Mass of water M_5, = m_4-M_3 = 1.0kg

Mass of extracted juice + container M_6 = 5.80kg

Mass of extracted juice M_7 (M_6 - M_1)=(5.80-2.45)kg = 3.35kg

Mass of the extract (residue) M_8 = 0.75kg

Thirdly, trial: Some fruit of guava were cut into small pieces, and places into the container.

Mass of the container M_1 = 2.4kg

Mass of the container + guava M_2 = 3.75kg

Mass of the guava fruit M_3 (M_2-M_1)kg = 1.30kg

Mass of water + guava fruit M_4 = 2.50kg

Mass of water $M_5 = M_4 - M_3 = 1.2kg$

Mass of extract juice + Container $M_6 = 5.80kg$

Mass of extracted juice $M_7 = (M_6 - M_1) = 5.80kg = 3.35kg$

Mass of the extracted (residue) $m_8 = 0.75kg$

But the same average quantity of water was use in test two and three which mass is 2.2kg.

The test is conducted 3 time and the average. Value of fruit and water use is before is 6.3kg while the mass of the extracted juice lout of the total mass is 3.35kg.

The fruit were loaded into the extraction machine, after weighing and transmitted power into it by the source of Auger which do the crushing and conveying of the fruit.

The auger was turned (articlockwise). This releases the pressing auger gradually and the guava juice were obtained as the wall of sieve sequeezies the guava fruit. Clean juice free of skin and seeds came out through the perforated sieve which retained the seed and the squeezed skins of guava. This seeds then passes through a perforated dics plate of large diameter than the seed. The juice was collected in the container and taken to the laboratory for weighing as in the result obtained above.

The machine performance efficiency.

$$Me = \frac{\text{Weighed of guava juice}}{\text{weighed of guava and water before extraction}} \times 100$$

$$\frac{3.35}{6.30} \times 100\%$$

$$ME = 53.17\%$$

The machine performance efficiency is 53.17%, and this shows that the result of the production is good and competent enough for the purpose of which it was manufactured.

Therefore, the extraction effective capacity of each extracting time was determine in 3 test and the average effective capacity was determine.

The implies that;

The average of 3.35kg of juice was produced in 20 minute, the cause is due limning cloth that cannot allow the juice to extract to some certained level.

Therefore;

20 minutes = 3.35kg

$$1 \text{ minute} = x = \frac{3.35}{20}$$

$$= 0.1675\text{kg}$$

It implies that in every 1 minute, there is about 0.1675kg of guava juice extracted.

1 min = 0.1675

60 min = x

$$x = \frac{60 \times 0.1675}{1}$$

x = 10.05kg/hr

The effective capacity = 10.05kg/hr

That is the quantity of juice produce in the machine process.

4.3.0 DISCUSSION OF RESULTS

The extraction rate test ran gave through the out put of the machine, at a concentration of one kilogram of guava fruit to one litre of water, as 10.05kg/hr. This value is low because of the concentration of the mixture.

The test to compare hard with machine extraction collected after 20 minute from hand press is very low compare to that of the machine. But the problem of the machine is because of the well fine limning cloth that do not allow the juice as such.

Thus, the output per unit time is higher for machine, than pressing with hand.

While the test gave us the efficiency of machine as 50.17%. Thus, extraction process is more efficient when the machine is well designed is used compare to using hands.

The final test results show that as the proportion of H_{20} added to the fruit increases.

i) The time of extraction is very fast in use machine.

ii) The volume or mass or extracted is very low, but the quantity of juice is greater.

It is therefore advisable to add water to the paste in a proportion equal out extraction on a given paste at least once before discarding the cake. This will give a higher out put or required quantity.

4.4.0 COST ANALYSIS

The word cost has many meanings in many different settings. The cost of manufacturing any product is of high importance to the designer. The cost include both direct costs (i.e cost of manufacture and labour) and indirect cost (over head cost) which are indirectly attributed to the manufacturer of a specific product e.g machine depreciation, heating and light costs.

Over head cost will be neglected because it is not very important in manufacture of this project.

4.4.1 MATERIAL COST

This is cost of the raw materials used in fabrication process inducing those which are purchased.

Material cost are subjected to charges due to instability market prices, because of this the price of parts or components fluctuate. Estimated natural cost and quality are as induced below as at time of purchase.

MATERIAL COSTING

S/No	Item description	Quantity	Unit Cost (Naira)	Cost (Naira)
1.	Angle iron ($1\frac{1}{2}$ x $1\frac{1}{2}$)	2	500 x 2	1000
2.	Mild steel sheat	$\frac{1}{4}$	2400	600
	i) guage 12			
	ii) guage 18	$\frac{1}{8}$	1200	150
	i) guage 14	$1/_{12}$	1800	128.60
3.	Bearing 6304	2	120x2	240
4.	Steel rod (θ 10 mm)	$\frac{1}{4}$	500	125
5.	Electrode (guage 12)	50 pieces	5 x 50	250
6.	Bolt & nuts (m13x1)	30 pieces	5 x 30	150
	Bolt & nuts (m10x1)	1	5	5
7.	Bearing housing	2	50 x 2	100
8.	Aluminimum paint (45oml)	2	130	260
9.	Shaft (θ 20mm)	$\frac{1}{8}$	1200	150
10.	Pulley belt A-type	1	200	200
11.	Plywood	1x12	80	80
	Total cost			3538.60

4.4.3 **LABOUR COST**

Labour cost is the cost of paying the employees for the production of the machine for the production of the machine parts. Now to establish labour cost this depend on the separation carried out on the machine which is the function of wages and time taken to carried out the operation and is base on hours. Craftsman placed on grade level 05/1 is being paid N2,500.00 per month on eight (8) working hour per day the project was complected in 10 days, the estimated working per hour is as follows:-

Total working hour per 10 days = 8 x 10 = 80 hours/day

Then total cost per hour = $\frac{2,500}{80}$ = 312.5 per day

:. Total cost of labour in 10 days = 312.5 x 8

= 250 per

The total cost of labour in 10 days = 250 x 10

= N2,500.00

Total cost of machine = material cost + labour cost

= 3538.6 + 2,500

= 6038.6

The calculated cost is relatively cheaper when compared to other juice extractor sold in the market which range from N8,000 to N10,000 or more.

4.5.0 GENERAL CONSIDERATIONS

The essence of design analysis is to under stand all the criteria involved in a design and manufacture. These criteria include aim of the project, application, selection and choice of materials.

SELECTION AND CHOICE OF MATERIAL

The essence of material selection is first to understand the application then characteristics of the ideal material to produce the most economical and safe component. Therefore, the selection of material was done based on the following criteria;-

1) Mechanical properties which involves strength, stiffness Rigidity) fatigue resistance, toughness and ductility.

2) Wear resistance

3) Formability and machinability of the selected material

4) Availability

5) Cost of material.

To achieve proper selection of material after critical observation and the above mentioned considerations a balance and comprises is struck between availability, under service condition and weight since this design is made with the ultimate aim of producing the component at a cheaper rate with less complexity and locally in school workshop, as such almost all the parts would be made of mild steel. Mild steel is the most widely used for general purpose work, it has a good machinability and weldability. The ultimate tensile strength of mild steel is about $800N/mm^2$, compressive strength $800N/mm^2$, shear strength of $520N/mm^2$, density of $7840kg/m^3$ (reference 9).

4.6.0 DESIGN LIMITATION

The major limitation of this design was finance, thus its small size, as the cost of the machine depended on the quality of material used. Due to the high cost of stainless steel, alluminimum paint was used to coat the mild steel used. However, stainless steel is the best material for this design.

Also, due to the fact that the power transmitted by the motor to the auger is not static (moves longitudinal), and that a heavier weight increase the power required need for operating the machine, the power transmission by motor to the auger rushed as assembly could balance easily.

CHAPTER FIVE

5.00 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

From the experiment and test carried out we observe that:-

i) The machine is easy to disassemble as joints in the well bolted and welded. It is easy to maintain.

ii) The guava juice extractor is portable and aesthetically attractive and simple to operate electrically.

iii) The efficiency of the machine produced to extract the guava fruit juice was higher, or compared to extracting with either screw or hydraulic type operated.

iv) The quality of juice obtained using the machine can be guaranteed.

v) The power requirement for operating the machine is quite efficient and thus, imposes vary little fatigue on operation.

vi) The cost of the machine is lower than N4000.00. It is this side value economically available to both rural and urban dwellers.

5.1.1 RECOMMENDATION

Having tested the machine and observed some problems in operation, I will recommend that the auger clearance should not be more than 1.5mm that is between the threaded part and the wall of the cylinder. The frame of the machine should be slanted not horizontal. This will prevent losses of energy to convey the juice to the outlet.

i) The machine have constant operating process because it does not have a regulator like that of the other machine operated in our domestic and industrial use.

ii) It has a permanent stability throughout it operation.

iii) The machine comprises of lot of compartment. They are bearing, hopper electric motor, frame, belt system and other compartment etc

iv) The motor pulley should be well aligned with the machine pulley for easy conveyers of powered transmitting.

v) The outlet should be supported by a disc which protect the juice from passing through. The juice can only be collected through the filter sieve.

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