PROJECT REPORT ON

DESIGN AND CONSTRUCTION OF A FORAGE CHOPPER

BY

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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 a forage chopper by Maduka, E. Arnold.

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DEDICATION

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

ABSTRACT

The work reported here presents the design and construction of a forage chopper for livestock.

The performance tests were carried out with the chopper using various forages (crop residues) both dry and wet.

The report also gives details of the construction and mode of operation of the chopper.

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Whatever the method of conservation, the forage has to be cut , chopping or laceration will improve fermentation, quality and digestibility as well as the nutritive values of silage. The chopping or reduction of the hay to smaller bits will also improve the quality of the hay for the livestock. Hence the need for the advent of a size reduction machine (forage chopper) which can chop grasses and legumes harvested for hay making.

It is easier to make good hay of crops that have been chopped short. Adequate consolidation is more easily attained if water content of forage (chopped) has been lowered to 25 percent so that the hay can be stored without mouldy or fermented and if suitable, silos are employed in storing the hay, there is less danger of wastage and it could be used to feed the livestock through out the year.

The simplest forms of device used for harvesting forage crops are the manual tools like the sickle and the scythe. The shape and size of sickle may vary considerably and primarily depends on the tradition in a particular area and the local blacksmith practice.

The serrated sickles although performs better are not used in Nigeria mainly because they are not readily available. The scythe is basically a long sickle wielded by the operator in a standing position and held by both hands. It is swung forcefully at the grass and cuts by impact action.

CHAPTER TWO

2.0 LITERATURE REVIEW

Forage choppers were invented as a device to work on the principle of size reduction to reduce or chop forage crops by compression force. The forage chopper is a regularly used piece of equipment in livestock farms. They can also be used for size reduction of farm residues for mulch, compost green manure or raw materials for hand made paper. (Finner and Ige 1997).

Some choppers, medium to high capacity are usually equiped with speed change gears and feeding units for adjustable chop length. These are appropriate for large livestock farms. Locally designed choppers in the phillippines and other developing countries in Asia are either manually cranked or power driven. They may be unsafe, inconvenient to use or excessively priced.

THE FLIPPER CHOPPER

A flywheel-type inclined axis chopper (acronymed FLIPPER) for small-scale rice and livestock farmers, was developed at the international Rice Research institute (IRRI) manila in the Pillippines. The prototype is belt driven by a 3.7kw (5 hp) engine and uses four angled blades rotating below a fixed counter- edged. Throw-in manual feeding is facilitated by a convenient hopper presenting the crop perpendicularly to the inclined blade housing and also by suction effect of the rotating

2.1.1 THE NATURAL PASTURES

The natural pastures can be grasslands and range lands which contains many plant species, some of which the animals may not eat. Since no effort is made to improve or care for the plants, many preferred species tend to disappear with intensive grazing.

The natural pastures includes

Range lands - An extended area of short grasses with scattered shrubs.

Bush pastures - Woody shrubs and small trees are scattered among medium to tall grasses as in the guinea Savannah belt.

Woodland pastures - Larger trees and other herbaceous plants are mixed with tall grasses.

Some shrubs and trees found in natural pastures provide additional feeds for animals and are known as browse plants. Some examples of pasture grasses includes - Gamba grass (Andropogan gayanus) carpet grass (Axonopus compressus) Rhode grass (chloris gayana) guinea grass (penicim maxima) and the pasture legumes includes centrocema pubescens, stylosanthes humilis, stylosanthes gayanensis, etc. (Anthony et al 1988).

2.12 FEEDSTUFF

The two main feedstuffs are roughages with high crude fibre content, and concentrates with low crude fibre.

ROUGHAGES - are fed fresh or in the form of hay or silage to supply some protein, energy, vitamins and minerals. The commonly utilized grasses are guinea grass, Elephant grass and giant star grass. Maize, millet and sorghum are usually chopped for making silage. The common legumes are centrosema pubescent stylosanthes. Etc.

CONCENTRATES - These feeds provides energy and protein needs Energy - cereals such as maize, sorghum, millet and their by-products and tubers such as yams, cocoyams and processed cassava roots are good sources of energy for livestock and are regarded as basic livestock feeds.

Protein - The major protein sources are soya bean meal, groundnut meal and cotton seed meal, palm kernel meal etc. The seed meal are obtained as a by-product after extraction of oil. Some protein is also obtained from roughages particularly from legumes and other small plants. The major source of animal protein in feed are fish meal, meat meal, blood meal and milk products.

(Anthony et al, 1988)

2.13 CHART FOR FEEDSTUFF

The charts below shows the types of feed stuff and the energy and protein sources.

2.14 DEVELOPMENT OF MACHINES FOR COLLECTING GREEN CROPS

The history of development of machinery for collecting green crops shows how rapidly machines can become obsolete. Green-crop loaders which delivered long crops onto the front or rear of the trailer and need a couple of men with hand forks to build a load were quickly superseeded by "One - man" loaders and self emptying trailers and by bukrakes; But it was not long before both of these were made obsolete by forage harvesters. One-man loader-wagons with facilities for chopping wilted windrowed crops reasonably short have some advantages and are increasingly used in both large and small farms. There is a wide choice of machines and methods ranging from simplicity of direct cutting and loading by means of flail forage harvester to more complex systems using "metered-chop" harvesters.

(Culpin, 1981.)

2.15 THE FORAGE HARVESTERS

The forage harvesters may be divided into three main groups, according to the mechanism that is used to cut or process the crop and to convey it to the trailer. (Culpin, 1981).

(a) Flail harvester - Simplest and cheapest

(b) Double chop harvester - A combination of flail and simple chopping mechanism.

(c) The "full chop or metered chop" harvester - usually fitted with a retractable time pick up

The essential component of a typical forage harvester are hours. Along with such changes in cylinder design are found simplified feed and delivery system. One simple design involves only three main rotating components viz, the pick up reel; an auger designed to pre-compress the swath as it passes to the cylinder and the larger diameter cylinder with blades designed to propel the crop effectively as well as to avoid major break-down. In another simple design, a very wide 'contra-rotating' cylinder is used in conjunction with a pair of feed rollers, such a design is claimed to eject foreign bodies such as small rocks and to use little energy in propulsion of the crop.(Culpin, 1986.).

Some of the newer designs achieve a high throughput in relation to power input, partly as a result of less chopping . The fineness and uniformity of chop are nevertheless adequate for the effective use of the improved mobile machines now available for silage removal, mixing and feeding .

With all high-output forage harvesters, effective and rapid adjustment of the discharge chute angle and of the flap are essential. (Culpin, 1986.).

2.17 DEFORMATION OF PLANT MATERIAL CAUSED BY CUTTING

The total force required to cut plant stems by unit width of blade can be divided into two stages: The initial crushing or compressing of the material before cutting and cutting of the compressed or crushed material.

The penetration of cutting knife into the material causes deformation.

The normal force acting on the inclined face of the knife is the sum of the horizontal and vertical components i.e. (Jekendra and Singh 1991)

$N = P_v \ \sin\theta + P_h \cos\theta$ - (1)

Where P_v and P_h are vertical and horizontal forces respectively.

Tangential forces arising on it is expressed as

$T_2 = \mu N$

$T_2 = N. \tan\phi$ - (2)

Where $\mu = \tan\phi$ (friction coefficient)

Tangential force on vertical side 'T_1 is given by

$T_1 = \mu P_h$ and vertical component of 'T'_2 is expressed as

$T'_2 = T_2 \cos\Phi$ - (3)

$= N. \tan\Phi \ \cos\theta$

$= \mu.N. \cos\theta$

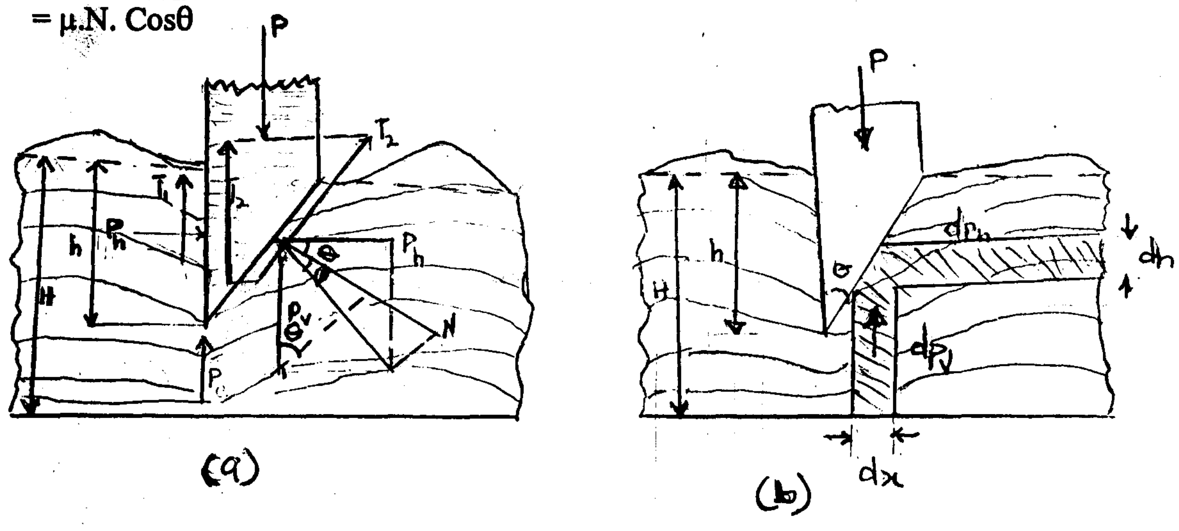


Fig (a) and (b) Shows Force relations for a knife penetrating into the plant material.

From (1) –

$$T^1_2 = \mu (P_v . \sin\theta \cos\theta + P_h \cos^2\theta)$$

A force p_e is created at instant of cutting on the knife edge by the material and is given by

$$P_e = \delta . L . \sigma_B$$

P_e is the initial cutting force.

Where δ = thickness of blade edge

L = Length

σ_B = Yield strenght of the material under the edge.

vertical equilibrium of the forces is expressed as

$$P = P_e + P_v + T_1 + T^1_2$$

The vertical and horizontal forces P_v and P_h are determined by integrating the elemental forces d_{pv} and d_{ph} are given as

$$P_v = E/2h.h^2 \tan\theta \qquad -(4)$$

$$P_h = \upsilon.E/2H.h^2 \qquad -(5)$$

Where E = mean modulus of deformation

υ = poison's ratio

h = Preliminary compaction thickness

H = total thickness of the material.

Thus the equilibrium can be re-written for unit length as

$$P = \delta.\sigma_B + (E/2H).h^2 [\tan\theta + \mu.\sin^2\theta + \upsilon(\mu + \cos^2\theta)] \qquad -(6)$$

The first term of equation gives useful cutting force and the second term expresses force used to overcome other sources of resistance.

The second term depends on square of 'h' lasting until the beginning of proper cutting. Its values varies linearly with layer thickness 'H'. The additional resistance increases rapidly, with increasing layer thickness and cutting efficiency is lowered.

A similar and most fundamental approach has been that of the action of blade in 2 phases:

(a) The initial crushing of the material before cutting is initiated and

(b) The cutting of the compressed material. The following expression, for the total force per unit width of blade F_1 required to compress and cut the material is reduced .

$$F_T = w.\sigma + E.\, Hc^2/2h\, [\tan\alpha + \sin^2\alpha + \mu_1(\mu + \cos^2\alpha)] \qquad -(7)$$

Where σ = compressive stress in the material during cutting

E = Modulus of Elasticity of the material

h= Depth of the material to be cut

Hc = Depth of which material is compressed before cutting

μ= coefficient of friction between blade surface and material

μ_1= coefficient of internal friction of the material

α= blade angle

W= Width of the blade angle

Thus, from the above equations, two forces are required to achieve the cutting (chopping) of a material (forage) i.e the crushing force and the cutting force.

(Jekendra and Singh, 1991)

2.18 OBJECTIVE OF THE STUDY

This study is aimed to achieve the following

1. To design and construct a forage chopper. A machine that will chop forage into bits for feeding of livestock.

2. To evaluate the performance of machine in terms of capacity and chopping performance.

2.19 JUSTIFICATION OF OBJECTIVES

The above objectives when achieved will be seen as a break through for the small - scale livestock farmers. Because the chopped forage will be available for livestock through out the year and the risk of animals grazing in the pasture field will be reduced or totally eliminated. As well, the livestock will have or be assured of palatable feeds all through the year.

CHAPTER THREE

3.0 DESIGN CALCULATIONS

3.1.0 V.BELT AND PULLEY DESIGN

Selected motor speed, $n_1 = 1440$ rpm

Required cutting speed $n_2 = 1200$ rpm

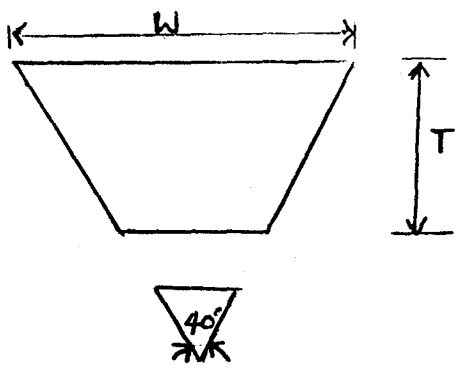
Belt selection: A-type v-belt with power range of 0.75-5kw and cross section gives

norminal top width , W = 13mm

Normal thickness T = 8mm

Weight per metre = (o.106 x 9.81)N

Sheave groove angle, $\theta = 40^0$ (for standard belt) (P.S.G Technical data, 1982)



The recommended pulley pitch diameter dp = 75mm (PSG technical data,1982)

Belt speed, $S = \pi \, dp \, n_1$

$= \pi \times 0.075 \times 1440/60$

$= 5.65$ m/s

The small diameter correction factor

$F_b = 1.14$ (P.S.G Technical data, 1982)

Equivalent pitch diameter, d_e = dp x Fb

= 75x1.14

= 85.5

= 85.5 > dp

The maximum power in kilowatt which 'A' grade V-Belt can transmit is given by the formula.

$KW = [\{0.45S^{-0.09} - 19.62/de - 0.765x10^{-4}S^2\}]S$ (P.S.G. technical data 1982}

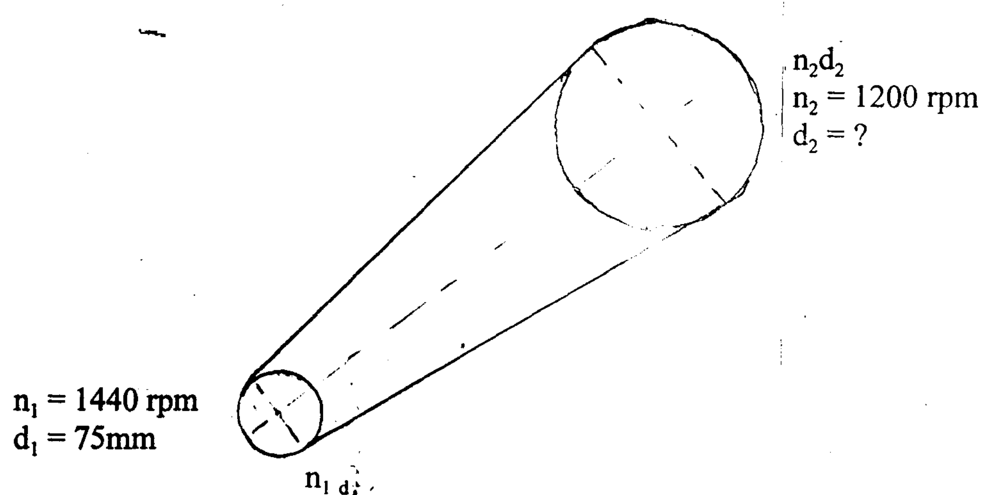
= [0.4.5x5.65-0.09 - 19.62/85.5 - 0.765 x 10^{-4} $(5.65)^2$]5.65

= [0.385029938 - 0.229473684 - 0.0024462800147]5.65

= 0.866

= 0.87 KW

3.1.1 DETERMINATION OF LARGER PULLEY DIAMETER



Diameter of smaller pulley d_1= 75mm (standard for "A" type belt) (PSG Technical Data, 1982.)

Diameter of larger pulley = d_2

rpm of smaller pulley = n_1 = 1440rpm

rpm of larger pulley $= n_2 = 1200$rpm

Assumed efficiency $\int = 0.98 = 98\%$

Diameter of the larger pulley is calculated from the formula below

$$n_1 d_1 \int = n_2 d_2$$

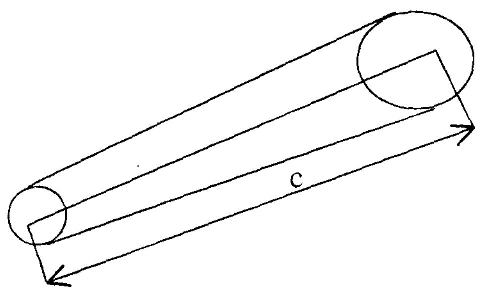
$$d_2 = n_1 d_1 \int / n_2$$

$$= 75x1440x0.98/1200 = 88.2mm$$

$$d_2 = 88.2mm$$

Speed ratio $= d_2/d_1 = 88/75 = 1.2:1$

3.12 DETERMINATION OF THE CENTRE DISTANCE



$c/d_2 = 0.9$ Recommended c/d_2 ratio (from PSG Technical data 1982)

$C = d_2 x0.9$

$= 88x0.9$

$= 79.2mm \simeq 79.0mm$

$C_{mnimum} = 0.55 (d_2+d_1)+T$

$= 0.55 (88 +75) + 8$

$= 97.65mm$

$C_{maximum} = 2(d_2+d_1)$

$= 2(88+75)$

$= 326mm$

$\therefore C_{minimum} < C < C_{maximum}$

$C_{minimum}$ is the minimum distance of the centre distance between driven pulley and the driver (Motor)

$C_{minimum}$ is the distance of the centre distance between the pulley and the driver.

C is the centre distance of belt.

3.13 DETERMINATION OF NORMINAL PITCH LENGTH OF BELT

The total belt length is obtained using the following formula.

$L = 2c + \pi/2\,(d_1+d_2) + (d_2-d_1)^2/4C$ (P.S.G Technical data 1982)

Where L = norminal length of belt or the total length of belt

C = Centre distance of belt

d_1 = Diameter of smaller pulley

d_2 = Diameter of larger pulley

$L = 2\,(97.65) + \pi/2\,(75 + 88) + (88 - 75)^2/4x97.65$

$= 195.3 + 256.0398 + 0.5335 = 450.97mm.$

The closest value to this calculated normal pitch length of belt if given as

L = 965mm with cross sectional area approximately $1001m^2$ (PSG design data, 1982)

The actual value of C (Centre distance) is given by

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

Where C_A = actual centre distance for the belt

$$A = L/4-\pi(d_2+d_1)/8$$

$= 965/4-\pi(88+75)/8$

$= 177.24mm$

$B = (d_2-d_1)^2 /8$

$= (88-75)^2/8$

$= 21.125mm$

$C_A = \sqrt{A^2-B}$

$= 177.24 + \sqrt{177.24^2 -21.125}$

$= 354.42mm$

The centre distance for the given belt length is 354mm

3.14 DETERMINATION OF NUMBER OF BELT

The value of the rating for "A" type V-belt is 0.81 (KW) (PSG Technical data 1982)

The correction factor for industrial service Fa = 1.1 for light duty machines (PSG Technical data.1982.)

The value for correction factor FC = 0.98

Arc of contact $\beta = 180-60(D-d)/C$ - (1)

Where $D = d_2$

$d = d_1$

$\beta = 2\cos^{-1}(D-d)/2C$ - (2)

Using (1) $\beta = 180-60(88-75)/354$

$= 177.80$

The value for the correction factor for the arc of contact $F_d = 0.99$ (PSG Technical data 1982 pg 7.68)

Number of belt required $N_b = P \times F_a / Kw \times F_c \times F_d$

$= 0.87 \times 1.1/0.81 \times 0.98 \times 0.99$

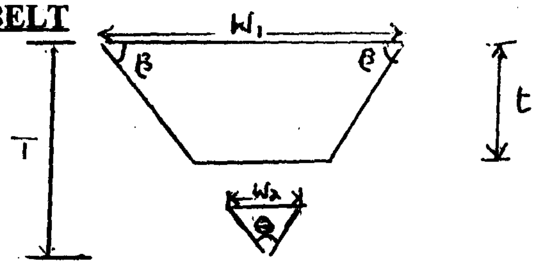
$= 0.957/0.785862$

$= 1.22$

$= 1$ belt

The number of belt required is one.

3.15 **DESIGN OF BELT**



Given: for "A" type V-Belt width of belt, $W_1 = 13mm$

Norminal depth of belt $t = 8mm$

Sheave grove angle $\theta = 40^0$

Density of leather belt $\rho = 970kg/m^3$

Friction between pulley and belt $\mu = 0.25$

To determine the bottom width of the belt

Arc of contact, $\beta = 180 - \theta/2$ (PSG Technical data, 1982)

$= 180 - 40/2$

$= 70^0$

$T = \frac{1}{2} W_1 \tan\beta$

$T = \frac{1}{2} \times 13 \tan 70^0 = 17.86mm$

By similar triangle concept

$$W_1/W_2 = T/t \quad N_2 \Rightarrow W_1 xt/T = 13x8/17.86 = 5.82mm$$

The belt cross sectional area can be obtained as

$A = (W_1 + W_2/2)t$

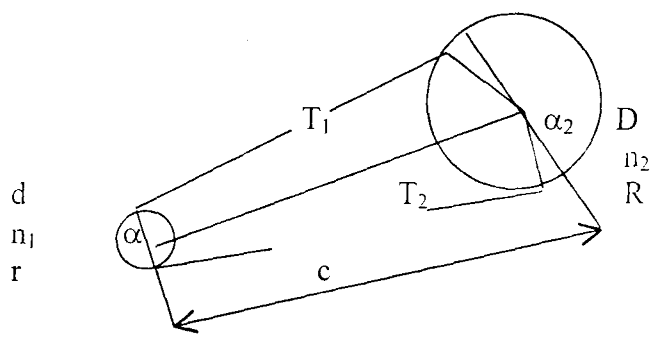
$= (13 + 5.82/2)8 = 75.29mm^2 = 75.29x10\text{-}6m^2$

Mass of unit length, $M = \rho \times A$

$= 970x7.529x10^{-6}$

$= 0.073kg/m$

3.16 **<u>THE DRIVER AND THE DRIVEN PULLEY</u>**



Where d = diameter of the driver (motor) pulley = 75mm

r = radius of the motor pulley = 37.5mm

n_1= Speed of the motor pulley = 1440rpm

D = Diameter of the driven pulley = 88mm

R = radius of the driven (forage) pulley = 44m

n_2 = Speed of the driven pulley = 1200rpm

C = The actual centre distance = 354mm

Belt velocity $V = \pi D n_2 = \pi \times 0.088 \times 1200/60$

$= 5.53 m/s$

The maximum allowable stress (tension) for leather belt

$T_1 = 2 \times 106 N/M^2$ (Schaum's series, machine design 1988)

T_1 = Maximum tension x belt (m) sectional area

$T_1 = 2 \times 106\ N/M^2 \times 75.29 \times 106 m^2 = 150.58\ N$

To determine the arc of contact α: (see diagram above

$$\alpha = 180 \pm 2\sin^{-1} (R-r)/c$$

$$= 180 \pm 2\sin^{-1} (44-37.5/354)$$

$$= 180 \pm 2\sin^{-1} 0.01836$$

$$\alpha = 180 \pm 2.1040$$

$$\alpha_1 = 180 - 2.1040 = 177.90^0$$

$$\alpha_2 = 180 + 2.1040 = 182.10^0$$

To determine the allowable tension for V-belt, the for below is used

$T_1 - MV^2 / T2 - MV^2 = e^{f\alpha}$ (Schaum's series machine design 1988)

Where $R = e^{f\alpha}$

F = friction between belt and pulley 0.25

The smallest of the α govern the design

α_1 governs the design because it is the smaller of the α

$R = e^{f\alpha}$

$= e^{0.25(177.90\,\Pi/180)}$

$= e^{0.7762351848}$

$= 2.17$

Centrifugal force in the belt is given by

$Tc = MV^2$

Where M = mass of the pulley per unit length = 0.073kg/m

V = belt velocity = 5.53m/s

$Tc = MV^2 = 0.073 \times (5.53)^2$

$= 2.23N.$

$T_1\text{-}Tc/T_2\text{-}Tc = R$. (PSG Technical data, 1982).

$T_2 = T_1\text{-}Tc/R + Tc$

$T_2 = 150.58+2.23/2.17 + 2.23$

$= 70.59N$

Power transmitted by belt is given by

$P= (T_1\text{-}T_2)V/1000$

$= (150.58 - 70.59)5.53/1000$

$= 0.4428KW$

$= 0.4428/0.746 = 0.60$ h.p

C = Pulley centre distance = 354mm

$C_{Minimum} = 97.65mm$

$Sin\theta = C\ min/C = 97.65/354 = 0.27584$

$= Sin^{-1}\ 0.2758$

$= 14.50^0$

The vertical and horizontal component of T respectively are $Tv = T\ Cos\theta$

But $T = T_1+T_2 = 150.58+70.59$ (see belt design)

$= 2\ 21.17N$

$Tv = T\ Cos\theta$

But $T = T_1+T_2 = 150.58 + 70.59$

$= 221.17N$

$Tv = T \cos\theta$

$= 221.17\ Cos14.50$

$214.12N \triangleq 214N$

and $T_h = T_v \sin\theta$

$= 214.12 \sin 14.50^0$

$= 58.60N$

The total vertical load acting on pulley $= 214N$

3.17 THE HOPPER DESIGN

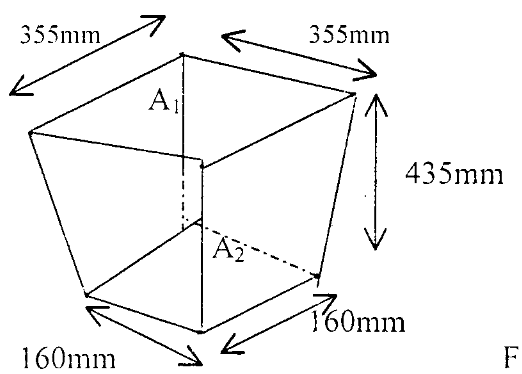


Fig. (a)

The hopper is dimensioned as seen above. This hopper is at the top of the rectangular casing or the chopping housing. It serves the purpose through which forages like Groundnut haulms and other leafy forages are fed into the chopper.

The volume of the hopper is given as

$$V = h/3\ (A_1 + A_2 + \sqrt{A_1 \times A_2}\ )$$

Where V = volume of hopper

A_1 = Area of the top

A_2 = Area of the base

$A_1 = L \times B$

$= 0.355 \times 0.355 \qquad = 0.126025m2$

$A_2 = L \times B$

$= 0.160 \times 0.160 = 0.0256m^2$

$$V = h/3\ (A_1+A_2 + \sqrt{A_1 \times A_2}\ )$$

$$= 0.435/3[(0.126025+0.0256) + \sqrt{0.126025 \times 0.0256}]$$

$$V = 0.031073625m3 = 3.10736 \times 10\text{-}2m3$$

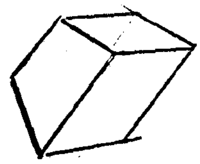
The hopper is made of mild steel with density of ($7.85g/cm^3$) $7850kg/m^3$

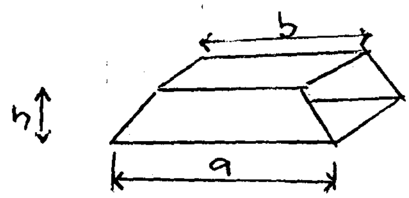
Hence $\rho = m/v$

$m = \rho \times v$

$= 7850 \times 3.1076 \times 10^{-2} \times 9.81$

2392.9 N





The above (fig. b) is a feeding chute (hopper) and is diemensioned as in the diagram above. It is located at the side of the cylindrical casing and inclined at 45^0. It is directly to the point of the flywheel carrying the cutting blades.

serve the purpose through which forage materials like the corn stalks, millet stalks will be fed to the chopper. The material for the chute is made of mild steel with density 7850kg/m

$$A = \tfrac{1}{2}(a+b)h$$

Where A = area

b = top length of figure

a = Base length of figure

h = Height

$$A = \tfrac{1}{2}(a+b)h$$

$$= \tfrac{1}{2}(255 + 155)75$$

$$= 15375\text{mm}^2 = 15.375\text{m}^2$$

$$V = A \times h$$

$$= 15.375 \times 0.075$$

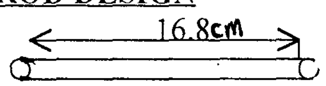
$$= 1.153\text{cm}^3 = 11531\text{mm}^3$$

Therefore weight of chute $= \rho \times V \times 9.81$

$$= 9750 \times 1.1531 \times 9.81$$

$$= 110291.0\text{N}$$

3.18 ROD DESIGN



ϕ10mm

The rod is cylindrical in shape, 10mm in diameter and 168mm in length. It is this rod that will carry the beaters with spacers in between them. The rod is made from mild steel with density of 7850kg/m^3

$$V = A \times L.$$

Where V = volume

A = cross sectional area

L = length

$A = \pi d^2/4 = \pi x\,(0.01)^2/4 = 7.85 \times 10\text{-}5\ m^2$

$V = A \times L$

$= 7.85 \times 10^{-5} \times 0.168$

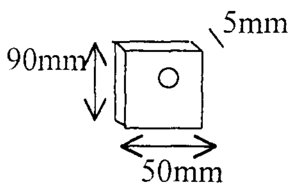
$= 7.85 \times 10^{-5} \times 0.168 \times 6. = 8.48 \times 10^{-5}\ m^3$

Total weight of rods (6) = $\rho \times V \times 9.81$

$= 7850 \times 8.48 \times 10^{-5} \times 9.81$

$= 6.5321N$

3.19 **THE BEATERS**



The beaters are three in number on each rod and is dimensioned as seen above. The beaters is 5mm thick and they serve the purpose of beating the materials and also achieving the reduction of the size of the forage that are fed through the hopper

L = 90mm = 0.09m

W = 50mm = 0.05m

h= 5mm = 0.005m

$V = L \times B \times h$

$= 0.09 \times 0.05 \times 0.005 = 2.25 \times 10^{-5} m^3$

Weight of the beaters $= \rho \times V \times 9.81 \times n$

Where ρ = density of the material

V = volume

n = total number of the beaters.

Weight of the beaters $= 7850 \times 2.25 \times 10^{-5} \times 9.81 \times 18$

$= 31.188N$

3.20 THE FLYWHEEL DESIGN

The flywheel is one of the most essential component of the forage chopper. It carries the blade which does the chopping of the forage, the flywheel are two in number and is shaped into hexagonal form. A Shaft of 20mm in diameter runs through their centre. The flywheel is made of a mild steel material of $7850kg/m^3$ density.

Thickness = 5mm =0.005m

Diameter = 250mm = 0.290m

Area $= \pi D^2/4$

$= \pi x (0.250)^2/4$

$= 4.908x10^{-2}m2$

Volume = Area x thickness

$= 4.908 \times 10^{-2} \times 0.005$

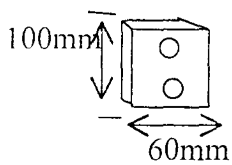
$V = 1.478 \times 10^{-4}m3$

Weight of the flywheels $= \rho \times V \times g \times n$

$= 7850 \times 1.478 \times 10\text{-}4 \times 2$

$= 11.382$ N

3.21 DESIGN OF THE CUTTING KNIFE



The cutting blade is as illustrated above, it is 3mm thick and sharpened at one end. The optimum cutting energy requirement is obtained with blades at bevel angles 200 to 300. The cutting blade are two in number and firmly attached to the flywheel with bolts and nuts.

L = 100mm = 0.1m

B = 60m = 0.06m

h = 3mm = 0.003m

$V = L \times B \times h$

$= 0.1 \times 0.06 \times 0.003$

$= 1.8 \times 10^{-5} m^3$

Density of the material (mild steel) = $7850 kg/m^3$

Weight of the knives $= \rho \times V \times g \times n$

Where ρ = density of material

V = volume

g= acceleration due to gravity

n = number of blades.

Weight of the knives $= 7850 \times 1.8 \times 10^{-5} \times 9.81 \times 2$

$= 2.772N$.

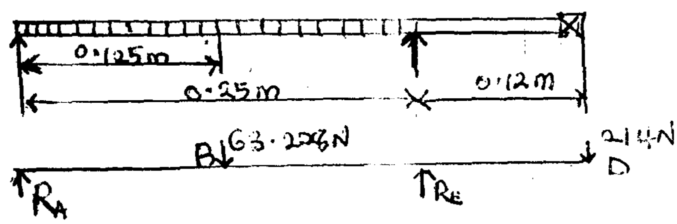
The total weight that will be acting on the shaft is the weight of the two flywheels, weight of the two knives, weight of the beaters, weight of the rods including the weight of the pulley as earlier calculated.

The total weight on shaft $= 22.763 + 2.772 + 31.188 + 6.5321$

$= 63.228N$

3.22 THE SHEAR FORCE AND BENDING MOMENT

The shaft is 0.37m in length and 20m in diameter. The shaft has a distributed load from one end to 0.25m i.e the position of the two flywheel carrying the rods across and the beaters on them. At the other end of the shaft is a point load i.e the pulley load on the shaft.



$\sum F_v = 0 \qquad R_A + R_c - 63.228 - 214$

$\sum F_v$ summation of vertical forces

$R_A + R_c = 63.228 + 214 = 177.228$

$\sum M_A = 0 = 63.228 \times 0.125 - Rc \times 0.25 + 214 \times 0.37$

$0.25R_c = 63.228 \times 0.125 + 214 \times 0.37$

$R_c = 87.0835/0.25 = 348.334N$

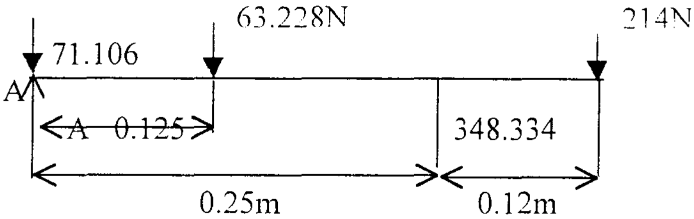
$R_c = 348.334N$

From (1) $R_A + R_c = 277.228$

$R_A = 277.228 - 348.334$

$= -71.106$

<u>CONSIDERING THE VERTICAL LOADING</u>

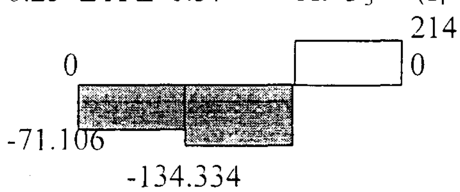


<u>FOR THE VERTICAL SHEAR FORCE DIAGRAM (V.S.F.D.)</u>

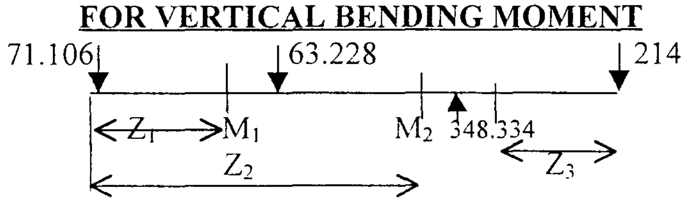
$0 \leq X \leq 0.125$ $X: F_1 = -71.106N$

$0.125 \leq X \leq 0.25$ $X: F_2 = f_1 - 63.228 = -134.334N$

$0.25 \leq X \leq 0.37$ $X: F_3 = (f_1 - f_2) + F_3 = -134.334 + 348.334 = 214N$



3.23 <u>**FOR VERTICAL BENDING MOMENT**</u>



$\Sigma M_A = 0$ $M_1 - 71.106Z_1 = 0$

$M_1 = 71.106Z_1$

$0 \leq Z_1 \leq 0.125$

for $Z_1 = 0$ $M_1 = 0$

for $Z_1 = 0.125$ $\quad M_1 = 71.106 \times 0.125$

$= 8.88825Nm$

$\Sigma M_A = 0, \; M_2 - 71.106Z_2 - 63.228\,(Z_2 - 0.125)$

$M_2 = 71.106Z_2 + 63.224\,(Z_2 - 0.125)$

For $0 \leq Z_2 \leq 0.25$

For $Z_2 = 0.125$, $M_2 = 71.106 \times 0.125 + 63.224\,(0.125 - 0.125)$

$= 8.88825$

for $Z_2 = 0.25$, $M_2 = 71.106 \times 0.25 + 63.224\,(0.25 - 0.125)$

$= 71.106 \times 0.25 + 63.224\,(0.125)$

$= 25.6795$ Nm

$\Sigma M_C = 0 \quad M_3 - 214Z_3 = 0$

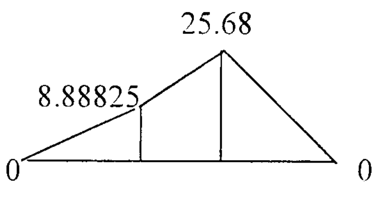
$M_3 = 214Z_3$

$0 \leq Z_3 \leq 0.12$

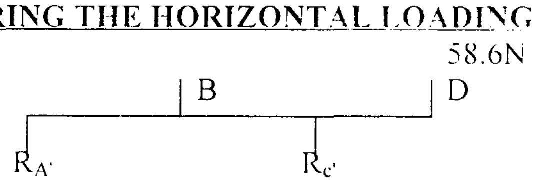
for $Z_3 = 0$ $\quad M_3 = 0$

$Z_3 = 0.06$ $\quad M_3 = 214 \times 0.06 = 12.84Nm$

$Z_3 = 0.12$ $\quad M_3 = 214 \times 0.12 = 25.68Nm$



3.24 CONSIDERING THE HORIZONTAL LOADING



$\Sigma F_v = 0 = R_{A'} + R_{c'} - 58.6$

$RA' + Rc' = 58.6N \quad -(1)$

$\Sigma M_A = 0, \quad -Rc' \times 0.25 + 58.6 \times 0.37$

$Rc' = 58.6 \times 0.37/0.25$

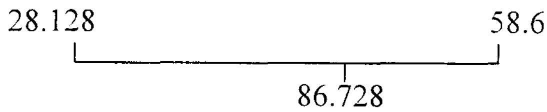
$= 86.728N$

from (1) $\quad R_{A'} + Rc' = 58.6$

$R_{A'} = 58.6 - Rc'$

$= 58.6 - 86.728$

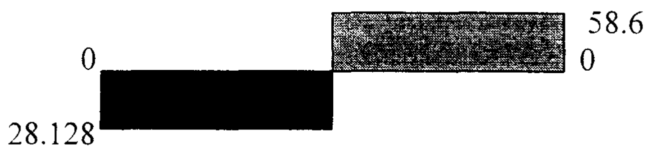
$= -28.128N$



for horizontal shear force diagram

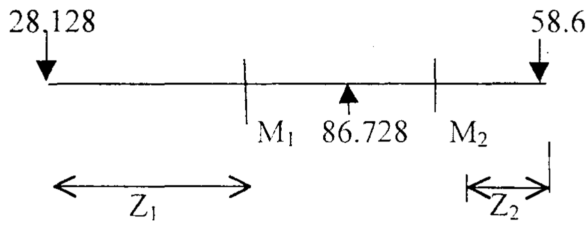
$0 \leq X \leq 0.25m$: $\quad F_1 = -28.128N$

$0.25 \leq X \leq 0.37m$: $\quad F_2 = F_1 + 86.728 = -28.128 + 86.728 = 58.6N$



Horizontal Share Force Diagram

3.25 FOR HORIZONTAL BENDING MOMENT



$\Sigma M_A = 0. \quad M_1 - 28.128\, Z_1$

$M_1 = 28.128\, Z_1$

$0 \leq Z_1 \leq 0.25m$

for $Z_1 = 0, M_1 = 0$

$Z_1 = 0.125, \quad M_1 = 28.128 \times 0.125 = 3.516$ Nm

For $Z_1 = 0.25 \quad M_1 = 28.128 \times 0.25 = 7.032$ Nm

$\Sigma M_C = 0, \quad M_2 - 58.6Z_2$

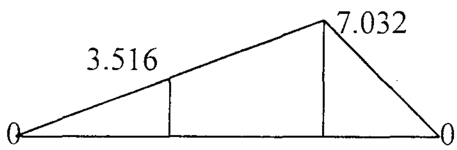
$M_2 = 58.6\, Z_2$

$0 \leq Z_2 \leq 0.12$

For $Z_2 = 0, M_2 = 0$

$Z_2 =- 0.06, \; M_2 = 58.6 \times 0.06 = 3.516$ Nm

$Z_2 = 0.12, \; M_2 = 58.6 \times 0.12 = 7.032$



H.B.M.D

The maximum bending moment at B is given by

$M_b = \sqrt{(8.888.25)^2 + (3.516)^2}$

$= 13.052$Nm

The bending moment at C is given by

$Mc = \sqrt{(25.68)^2 + (7.032)^2}$

$= 26.625$ Nm

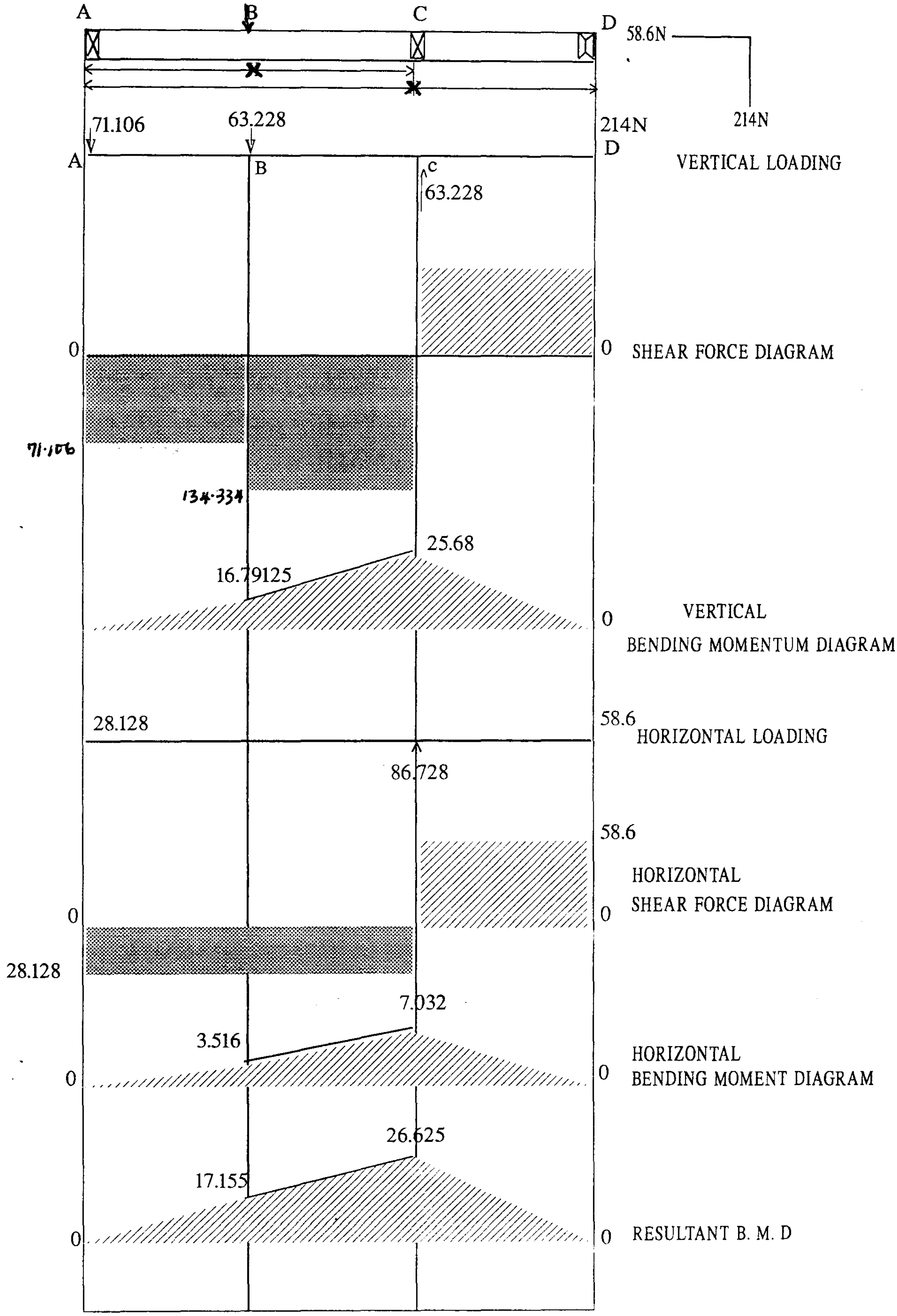
The maximum bending moment is at C

Therefore Maximum Bending moment $M_B = 26.625$ Nm

For the belt drive, torsional moment torgue is given by $\quad M_t = (T_1 - T_2)R$

where R = radius of pulley diameter $\quad = (150.58 - 70.59)0.044$

$= 3.5195$ Nm


A
B
C
D
58.6N
214N
71.106
63.228
214N
A
B
D
VERTICAL LOADING
c
63.228
0
0
SHEAR FORCE DIAGRAM
71.106
134.334
25.68
16.79125
0
VERTICAL
BENDING MOMENTUM DIAGRAM
28.128
58.6
HORIZONTAL LOADING
86.728
58.6
HORIZONTAL
SHEAR FORCE DIAGRAM
0
0
28.128
7.032
3.516
HORIZONTAL
BENDING MOMENT DIAGRAM
0
0
26.625
17.155
0
0
RESULTANT B. M. D

The diameter of the shaft is given by the equation

$d^3 = 16/\pi Ss \sqrt{(K_b M_B)^2 + (K_t M_t)^2}$

Where Ss = allowable stress = 40 x 106Nm for mild steel shaft with key ways

K_b = combined shock and fatigue factor for gradually applied bending moment =

1.5

K_t = Combined shock and fatique factor applied to torsional moment for gradually

applied load = 1.0

M_B = Maximum bending moment = 26.625Nm

M_t = Maximum torsional moment = 3.51956Nm

$d^3 = 16/ x\ 40x10^6 \sqrt{(1.5 \times 26.625)^2 + (1.0 \times 3.51956)^2}$

= 0.0172183m

= 17.2183mm for safe factor

Diameter = 20.00mm

3.26 TORSIONAL RIGIDITY FOR THE SHAFT

The torsional Rigidity for the solid shaft is given as

$$\theta = 584\ M_t\ L/Gd^4$$ (Schaums series machine Design 1988)

where

θ = angle of twist

M_t = torsional moment (Nm)

L = Length of shaft in (m)

G = torsional modulus of elasticity Nm^{-2}

D = shaft diameter

$\theta = 584 \times 3.51956 \times 0.37/80 \times 109 \times 17.2183$

$= (5.5211 \times 10^{-10})^0$ degree

Therefore the angle of twist for the torsional rigidity is within the allowable range, since permissible angle of twist varies from about 0.3 degree/m for machine tool shaft to about 3 degree/m for line shafting.

3.27 KINEMATICS OF BLADE DURING CUTTING

The energy consumed in shearing stems is normally less than 3% of total energy whereas chopping energy utilizes about 35%. The cutting energy requirement of forage crops is mainly affected by two factors, namely; physical and mechanical properties of plant stem and the cutter head parameters. At low cutting speeds cutting energy is a linear function of stalk diameter. However, the effect of moisture content has very little effect on shear energy for sharp blades.

The kinematic relations obtained during cutting by interaction of blade and plant stem is illustrated as below.

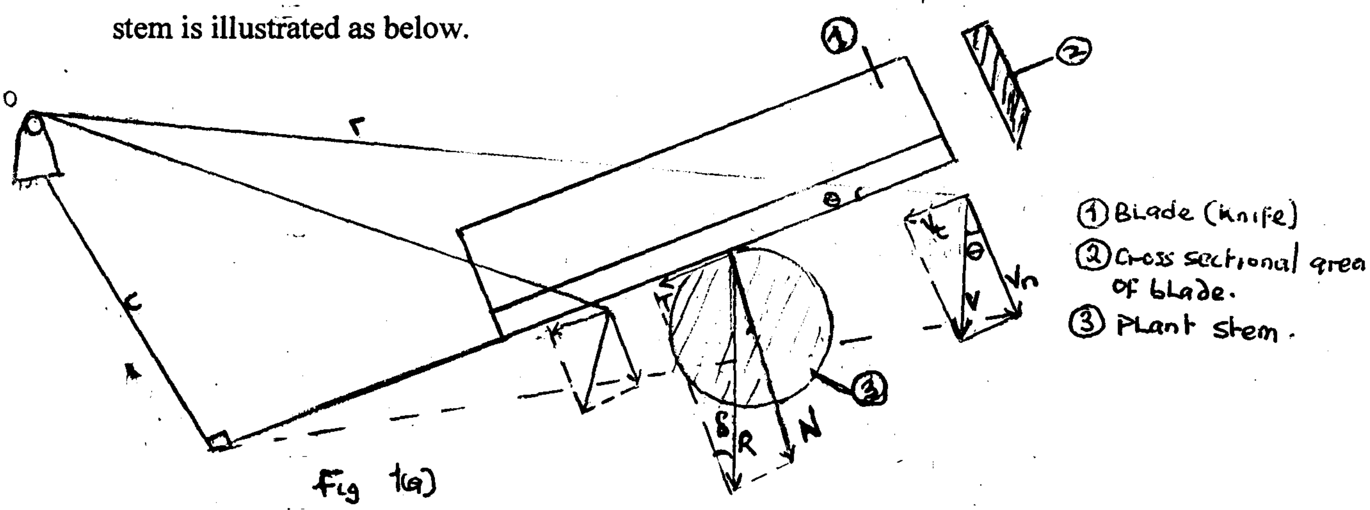


Fig 1(a)

A given point on the cutting edge of blade rotates around point '0' with a velocity 'V' which has tangential and radial components as $'V'_t$ and $'V'_n$ respectively

The angle of slide, 'θ' is given by

$$\tan \theta = V_t/V_n = C/\sqrt{r^2 - c^2}$$

where tan θ = sliding coefficient.

The peripheral force 'P' is given by

$$P = P_1 + P_2$$

$$= N \cos \theta + T \sin \theta \quad - (1)$$

where N = normal force acting to the cutting edge

T = tangential force

Also $N = P.L$ and

$T = \mu.N$

3.28 ENERGY REQUIREMENT FOR CUTTING

In rotary types of blades, the effect of centrifugal force is prominent and considerable amount of power is lost as friction energy in between the chopped material and periphery of the housing. The friction energy is expressed as

$$E_f = 4.848 \times 10^{-6}\ \mu.\beta . V^2$$

Where E_f = Frictional energy of material

μ = coefficient of sliding friction between chopped material and housing.

β - angle subtended by the average arc of housing periphery rubbed by the chopped material (deg)

V = periphery speed of impeller, m/s

The frictional energy is depended on the feed rate but increases as the square of the peripheral speed. The coefficient of sliding friction of chopper straw and legume silage at 73% moisture is 0.3 and 0.68 respectively.

For cutting a layer of forage material by a single knife edge inclined at an angle θ to the direction of cutting. The cutting energy is given by:

$E_c = ½.f.a_s + f.a_c\,(1 + \mu \tan \theta)$

Where

f = cutting force per unit length

a_s = area of cross section over which material is compressed

a_c = area of cross section which is cut

μ = coefficient of friction between blade surface and the material

The specific energy requirement for cutting forage falls broadly within a range of 1 - 5.5MJ/t of dry matter. The specific energy consumption of cutting head of a forage harvestor based on dry matter contents is expressed as:

$$E_d = \frac{enN}{\alpha V}$$

Where as on wet basis the specific energy is given as:

$$E_w = \frac{e}{\rho.L_m}\left(1 - \frac{M_W}{100}\right)$$

e = sharing energy per unit area of stem cross section

n = number of cutting blades in cutting head

ρ = specific weight of dry matter content of material

L_m = mean chop length

M_w = moisture content of material on wet basis

The specific cutting energy of 3.6 MJ/t is average for a mean chopped length f 25mm. A true dry matter density of $1.42 g/cm^3$ is considered as optimum.

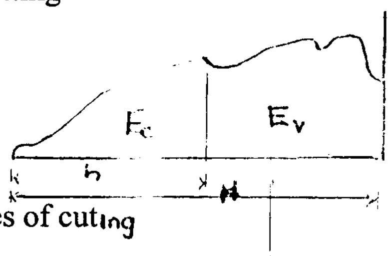
This is a linear fall of 'E_w' over a range of 'M_w' from 0 to 100% and for material drier than 30%. The specific energy reduces.

The total cutting energy requirement is the sum of two distinguished stages f cutting process. The first stage is preliminary compaction of the material until a pressure is reached at which the material under the edge yields, and the second stage is motion of edge in the material.(Jekendra and Singh, 1991).

The total work is given by $E = Ec + Ev$

Ec= energy required to compress up to distance h

Ev= energy required for effective cutting



Figure(2)a. Showing stages of cuting

3.2.9. <u>POWER REQUIREMENT</u>

The designer is confronted with problem of estimation of average power required to accomplish a given goal or target. With insufficient power estimate, the system design objectives will not be met, however with excess power supply this will only amount to waste of energy.

In cutting of animal feeds, the average power requirement, capacity, specific energy and percent chopped material of 25mm and 50mm length or less at 2mm clearance between blades and counter edge and four speeds of blade rotation has been experimented using the FLIPPER CHOPPER. This procedure has simplified designed calculations and it is presented in the table below.

Table 1. Average Power Requirement, Capacity, Specific Energy and Percent Chopped Materials of 25 and 50 mm Length or Less, at 2 Clearances between Blades and Counter-edge, and 4 Speeds of Blade Rotation

Speed (rpm)	Power (kW)	Capacity (kg/h)	Specific energy (kW-h/tonne)	Materials with length <25mm (%)	Materials with length <50mm (%)
(1) Napier grass, 70.9% MC wb. 2 mm clearance between blades and counter-edge.					
900	0.357[a]	865[a]	0.414[a]	20	84
1 050	0.448[b]	922.5[ab]	0.483[ab]	29	91
1 200	0.517[c]	1 012.8[bc]	0.513[b]	24	87
1 500	0.613[d]	1 113.8[c]	0.552[b]	30	94
F test	*	*	*	—	—
(CV)	(9.26)	(8.25)	(11.17)	—	—
(2) Napier grass, 80.9% MC wb, 1.5 mm clearance between blades and counter-edge.					
900	0.740[a]	900[a]	0.820[a]	29	85
1 050	0.789[ab]	930[ab]	0.848[a]	26	87
1 200	0.827[abc]	1 060[c]	0.781[a]	27	83
1 500	0.937[c]	1 186[d]	0.790[a]	29	84
F test	*	*	ns	—	—
(CV)	(7.68)	(4.54)	(7.81)	—	—
(3) Corn stalks, 62.7% MC wb, 2 mm clearance between blades and counter-edge.					
900	1.574[a]	890[a]	1.770[a]	31	87
1 050	1.799[a]	1 062[b]	1.697[a]	35	89
1 200	2.302[b]	1 148[b]	2.016[a]	23	93
F test	ns	*	ns	—	—
(CV)	(13.16)	(6.134)	(14.63)	—	—
(4) Rice straw, 47.8% MC wb, 0.5 mm clearance between blades and counter-edge.					
900	0.996[a]	394[a]	2.535[a]	29	64
1 050	1.023[ab]	466[b]	2.196[ab]	25	59
1 200	1.055[ab]	498[bc]	2.124[ab]	28	61
1 500	1.131[b]	584[d]	1.946[b]	17	62
F test	ns	*	ns	—	—
(CV)	(6.02)	(5.95)	(10.16)	—	—
(5) Rice straw, 65.9% MC wb. 0.5 mm clearance between blades and counter-edge.					
900	1.043[ab]	432[a]	2.417[a]	28	65
1 050	0.930[b]	488[ab]	1.910[a]	27	60
1 200	1.171[ab]	518[abc]	2.263[ab]	22	62
1 500	1.026[ab]	744[d]	1.475[b]	26	62
F test	*	*	*	—	—
(CV)	(7.43)	(15.22)	(14.38)	—	—

For each material and moisture content, in a column means followed by a common lettter are not significantly different at the 5% level by LSD.
F test: * = significant at the 5% level.
ns = not significant.
CV = coefficient of variance.

CHAPTER FOUR

4.0. TESTING THE MACHINE

4.1.0. MATERIALS AND METHODS

MATERIALS - The chopper was tested with dry guinea corn stalks, dried maize stalks, dried millet stalks, dried groundnut haulm's, dried rice straw, wet guinea corn stalks (43.75%) moisture content and wet potato stems.

4.1.1. TEST PROCEDURE

The stalk were passed through the feeding chute into the chopping chamber, as the stalk come into contact with the knives which are carried by the rotating flywheel, the stalks were chopped into bits and collected below, from the perforated screen. Each of the stalks (forage) i.e. guinea corn stalks, millet stalks, maize stalks was tested with the chopper over a period of time. (60s). For each of the experiment, the output was collected and weighed.

The groundnut haulms and the potato stems were also tested with the chopper, over the same period of time (60s). The groundnut haulms, rice straw potato stems were fed through the hopper.

4.1.2. .CALCULATIONS AND ANALYSIS

TESTING WITH GUINEA CORN STALK

The testing was done with guinea corn stalk for 60 seconds.

Weight of chopped guinea corn stalk before oven drying W_1= 0.04kg

Weight of chopped guinea corn stalk after oven drying W_2 = 0.025kg

$$\text{Moisture content} = \frac{(W_1 - W_2)}{W_1} \times 100\%$$

$$= (0.04 - 0.025/0.04) \times 100\%$$

$$= 37.5\%$$

CAPACITY

From the testing of the chopper using the guinea corn stalk the output per time can be obtained.

$$0.04kg - 60s$$

$$n - 1s$$

The output $= 0.04/60 = 0.00067kg/s$

For one hour (1hr) the output $= 0.00067kg/s \times 3600s$

$$= 24.12kg/hr$$

The output of the chopper using the guineacorn stalk at moisture content of 37.5% is obtained as 24.12kg/hr.

TESTING WITH POTATO STEMS

The weight of the potato stems were first taken using the weighing balance ($W_1 = 0.25kg$), the potato stems were poured into the chopper through the hopper and after60seconds. The chopped materials were collected below the perforated screen.

Weight of the chopped materials Collected below the screen,

$W_2 = 0.1kg$

Therefore weight not collected $= (0.25 - 0.1)$

$$= 0.15kg$$

These potato stems (chopped) were oven dried at 105^0c temperature for 6hrs and was weighed again $W_3 = 0.08kg$

$$M.C = \frac{(W_1-W_3)}{W_1} \times 100\%$$

$$= (0.25 - 0.08/0.25) \times 100$$

$$=68\%$$

where W_1 = weight of potato stems before chopping

W_2 = weight of potato stems after chopping.

W_3 = weight of potato stems after oven drying.

CAPACITY

The output of the chopper using the potato stem can be obtained as follows

0.10kg - 60s

nkg - 1s

Therefore output = 0.10/60 = 0.000017kg/s

The output in 1hr = 0.00017kg/s x 3600s

= 6kg/hr.

EFFICIENCY

Using the potato stem for testing, the stem was weighed before chopping (0.25 kg)and after chopping the collected or chopped materials from the screen was weighed (0.10kg). Therefore, the chopping efficiency can be obtained as follows

E = output/input x 100

= 0.1/0.25 x 100

= 40%

The differences in output or capacity of the chopper depends on various factors which includes the type of the forage materials. The stiffness of the material, the cross sectional area of the material, moisture content of the material and the speed of the blade or flywheel that carries the blade and also the feeding rate.

4.12 RESULTS AND DISCUSSIONS

From the performance of the chopper using the dry matters (forage), it was observed that almost all the materials fed into the chopper was chopped and collected below the perforated screen. The fleshy materials that was fed through the hopper was chopped conveniently only for some stems (wet) which could not come out through the perforated screen, though was softened enough for the livestock by the action of the beaters.

The differences in the output of the chopper depends on various factors which includes the stiffness of the materials, the cross sectional area of the material, the moisture content of the materials, the speed of the blade or flywheel that carries the blade and also the feeding rate of the materials

The tables below gives more detail of the materials chopped.

Table 1 : RESULT OF CHOPPED MATERIALS

S/N	MATERIALS	WEIGHT OF CHOPPED MATERIALS (kg)	TIME (S)	OUTPUT (kg/s)
1	Guinea corn stalk	0.04	60s	0.04/60 = 0.00067kg/s
2	Guinea corn stalk	0.05	60s	0.05/60=0.000083kg/s
3	Potato stems	0.25	60s	0.25/60 = 0.0042kg/s
4	Maize stalk	0.05	60s	0.05/60 = 0.00083kg/s
5	Rice straw	0.075	60s	0.075/60=0.00125kg/s
6	Groundnut stems	0.25	60s	0.25/60 = 0.0042kg/s
7	Millet stalks	0.05	60s	0.05/60 = 0.00083kg/s

TABLE 2: WEIGHT OF MATERIALS WHEN CHOPPED AND AFTER OVEN DRYING

S/N	MATERIALS	INITIAL WEIGHT (W_1) (kg)	FINAL WEIGHT (W_2) (kg)	DRYING DURATION	TEMPERATURE
1	Guinea corn stalk	0.04kg	0.025kg	6hrs	105^0c
2	Guinea corn stalks	0.05kg	0.025kg	6hrs	105^0c
3	Potato stems	0.25kg	0.08kg	6hrs	105^0c

Table 1. shows the results (weights) of the materials chopped over a period of time (60s) and the output.

Table 2. shows the result (weight of materials after chop and weight after oven drying.

4.13 THE CHOPPER CONSTRUCTION AND MODE OF OPERATION

The forage chopper consists of the different components that makes up the machine. it consists basically of the rectangular casing of which the shaft and the flywheel carrying the cutting blades (knives) are enclosed, the feeding hopper at the top through which the fleshy materials are fed to the machine, the feeding chute by the side the point at which the stalk materials are fed to the chopper. The pulley and belt drive, the prime mover the shaft, rod and beaters and as well the discharge unit which is a perforated screen with holes of 1.5mm in diameter.

Power is transmitted from the motor (prime mover) through the belt to the shaft and as the shaft rotates, the flywheel rotates along also and as well the beaters on the rods.

As materials comes in through the hopper the beaters by action of centrifugal force will spread out and will beat the materials and soften them in the process.

The stalks which are passed through the feeding chute gets in contact with the rotating knives on the flywheel and the materials are chopped and collected below the perforated screen.

The chopper also has handle and wheels, this will enable handling and movement from one position to another.

4.14 REPAIR AND MAINTENANCE

The design is made such that simple routine preventive maintenance repair can be affected when the need arises. As earlier stated, the design of the low cost forage chopper, the important criteria are simplicity, ease of fabrication, repair and ease of installation.

The maintenance includes cleaning up the chopper after use, tightening loosen bolts and nuts, removing the blade to be sharpened when blunt etc.

4.15 MATERIAL SELECTION AND COST ANALYSIS

In engineering design, the economic benefit has to be put into consideration through the selection of the materials which has to be very cheap and at the same time meet the specific purpose for which it is designed for. In designing the forage chopper, the basic factors put into consideration are the choice of materials, that is, availability and cost of materials, durability, ease of construction. These have to be put into consideration in order to achieve the desired objectives. The availability of the materials will reduce the constructional cost and hence will make the price comparatively low making it affordable for the intending forage chopper.

4.16 COST ANALYSIS

The cost can be classified into three

1. Material cost
2. Labour cost
3. Over head cost

The table below shows the cost of the materials 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.

S/N	COMPONENTS	MATERIALS	SPECIFICATIONS	QUAN-TITY	PRICE
1	Shaft	Mild steel	20 x 370mm	1	150.00
2	Iron sheet	Guage 16	Gauge 16	1	1.200.00
3	Flat bar	Mild steel	5mm thickness (100mm in length)	1	350.00
4	Iron sheet	Mild steel	Gauge 18 (100 x50)	1	500.00
5	Bolts and nuts	Mild steel	M10 and M12	32	360.00
6	Rod	Mild steel	10mm diameter	1	150.00
7	Flywheel	Mild steel	250mm diameter & 5mm wide	2	400.00
8	Handle	Mild steel	520mm by 390mm	1	100.00
9	Wheels	Mild steel	110mm in diameter	2	150.00
10	Electrodes		E12	120	300.00
11	Bearing		SW 6306	2	100.00
	TOTAL				**3760.00**

LABOUR COST

This is taken as 20% of the total material cost that is

labour cost = 20/100 x 3760

= **₦752**

OVERHEAD COST (O.C)

The overhead cost as 10% of the material cost for the fabrication expressed as

$$O.C = 10/100 \times 3760$$

$$= \textbf{₦376}$$

TOTAL COST OF FABRICATION (T.C)

T.C = Material cost + Labour cost + Overhead cost

= 3760 + 752 + 376

= **₦4.888.00**

From the above, the total cost of the construction of the forage chopping machine is (₦5.000) five thousand naira.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1.0 CONCLUSION

From the performance test with the chopper using various forage materials to test, it was seen to be satisfactory as the materials were chopped into bits. It can be used to chop as many forage as possible, both wet or dry materials.

From close observations and the results obtained, the effects of speed on power requirement varied with crop materials i.e. the different type of materials, the cross sectional area of the material, stiffness of the material and also the moisture content of the material. On the other hand this affected the output of the materials used. Hence, it can be concluded that the objective of designing and constructing a forage chopping machine has been achieved.

5.1.1 RECOMMENDATIONS

In view of the advancing technology in engineering, I will recommend that

The further design and fabrication of forage chopper should be followed up with modifications to achieve greater results i.e. in-cooperation of adjustable blade so as to achieve different cutting length of materials for different ages of the livestock.Secondly, the chopper should be introduced to the local livestock farmers. Finnaly for further designing of the forage chopper, one of the most important factors related to cutting energy is the blade considered to be the most favorable for optimum energy cutting and blades having bevel angles ranging from 20^{o} to 30^{0} will also give the optimum energy requirement.

REFERENCES

1. Kaul, R.N and Egbo, C.O (1985): Introduction to Agricultural mechanization,first Edition (London and Basingstoke). Pp 116 -127. Macmillan publishers

2. Crowder, L.V and Chheda, H.R (1982): Tropical Grassland Husbandry, Published in the (USA) PP 311 - 315

3. Claude Culpin (1981): Farm machinary, Tenth Edition (Great Britain) PP 180 -183. Granada Publishers.

4. Anthony Youdeowei, F.O.C Gedinma, and Ochpa C.O (1988), introduction to Tropical Agriculture. (Hong Kong) PP 205 - 206.Macmillan publishers.

5. Hall, A.S, Holowenko, Laughlin, H.G (1982): Theory and problems of machine design, Schaum's outline series PP 138 - 142

6. Data Design, PSG College of Technology: Combatry 641064 India, 1982.

7. Yumnam Jekendra and Pratap Singh (1991): Energetics of forage chopping, Agricultural mechanization in Asia, Africa and Latin America volume 22 No. 1 (Udapur, India), PP 59 - 63.

8. Ige M.T and Finner M.F (1997). Forage Harvestor knife response to cutting force. Agricultural mechanization in Asia, Africa and Latin America, volume 28 No1 PP 43 - 46.

9. BOLYUBOV S: (1989), Exercises in machine drawing third Edition, Mir- Publishers (Moscow) PP 170 - 122