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DESIGN AND CONSTRUCTION OF GINGER SLICING MACHINE USING LOCALLY SOURCED MATERIALS

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ABSTRACT

The need for the design and construction of ginger slicing machine arose when manual slicing with kitchen knives is injurious and cause health hazards. Ginger spice crop will be reduced to a thickness of about 2 millimeters thereby reducing thickness and enabling fast drying on the sun or other dryers for further processing. The designed machine consist basically of an electric motor that provide the operation power and a drive shaft that bear a rotary disc with blades that effect the slicing action. The driver shaft rotates on two ball bearing and is connected to the electric motor by a pulley and v-belt synthesis and analysis were made before the prototype machine was constructed. The design analysis show that a drive shaft with 20mm diameter and an electric motor of one horse power running at 750 revolutions per minute is required for the construction of the prototype. Also in the design consideration a V-belt drive of size A-35 is recommended for the machine. The design of the component parts of the machine was based on strength and rigidity, the entire component was assembled by welding and screwing with bolts.

INTRODUCTION

Ginger (Zingiber officinale Roscoe) belongs to the plant family of Zingler raceae. It is an erect herbaceous plant, which produces underground tuberous stems or rhizomes characterised by its strong essence. Though a perennial plant, it is cultivated vegetative as an annual crop in tropical regions to yield the fleshy underground rhizomes. It is one of the oldest and most important of all the spices and condiments. It has been under cultivation for millennial in many parts of the worlds. Its importance as a spice is underscored by the fact that it is now grown on commercial scale in many countries of the world. A slicing (splitting) machine is device (machine) that is used to cut a solid into smaller sizes (slice) as to fit into what it is to be used for. Slicing machines are different types according to their uses. There are some which are used for slicing different food items such as bread, meat, vegetables, spice etc. and some for other solid materials.

The Ginger slicing machine is a machine designed to slice the ginger spice into smaller sizes, without affecting the nutrition value of it, so as to preserve it. Further processed products of ginger are used for products such as ginger drinks, chocolate pastries and biscuits etc.
Ginger has medical value. It is employed for treatment of asthma, shortness of breath, ear ache and diarrhoea (Cobley and steel 1995).

Homeopathic practitioner recommends it for several disorders. Ginger export earned Nigeria considerable foreign exchange in 1970s. export earnings decline in 1970s due to number of factor, which include difficulty in processing and storing the produce. This leads to needs for the design and development of a machine that can process ginger by slicing without compromising it quality.

In Nigeria, the splitting and processing of ginger rhizomes is still done on a small scale. The farmers split harvest ginger rhizomes manually with local knives using family members or hired labour.

This method is slow and labour – intensive as about 32kg of ginger rhizomes could be split by a labour per day. The economics of splitting ginger manually offer little prospects of making large-scale production of ginger splits. The slitting of ginger rhizomes has to be done properly so as to prevent lost of the vital nutrients. The imported machines do not seem to be acceptable to Nigerian farmers due to prohibitive initial cost and the type of slices produce. So demand is not available, farmers still resorts to using the manual method of splitting ginger using knives.

Ginger is a native to South Eastern Asia (Parry, 1969), a region whose cuisines still features this wonderfully spicy herb. Ginger was mentioned in ancient Chinese, Indian and middle Eastern literatures, and has long been priced for its aromatic, culinary and medical properties. Improvement of ginger spread around ancient Rome, Europe in Mediterranean, Spain, West India, Mexico and South America in the 16th century while the Portuguese introduced it to west Africa with the same period.

Ginger is cultivated extensively in India, Nigeria, Jamaica, Sierra-Loene, Indonesia, China, and Australia, with India producing about 50% of the world's production (Ali et al, 1991).

Cultivation of ginger in Nigeria started seriously around 1927, when the colonial government carried out an investigation to find a crop that would generate internal trade and income for the populace of the present Southern part of Kaduna State to enable them pay taxes. Today ginger is commonly grown in this area, comprising of Kafanchan, Kagoro, Kachia, Zonkwa, Jaba and kubacha among others and has remained the most important ginger growing area in the country. It is today referred to as the traditional home of ginger production in Nigeria, and has placed Nigeria on the world map as one of the major producers of ginger. Umudike has established that good quality rhizomes could be grown in the southern part of the country, further confirming Nigeria as a potential producer of the crop. There are no available data on the volume of ginger produced in Nigeria. This has been difficult due to the land tenure system of farming being practiced in the country. However, the average ginger from size individual farmers has been reported as 0.26ha, about half an acre, (Ahmed et al,2004) and that a farmer could have more than one plot of small size at different locations. In nearly eight years of ginger production in Nigeria, farmers have relied almost exclusively on two major varieties, the yellow ginger ''Tafin Giwa" known for its spicy and pungent flavour, and the black ginger ''Yatsun biri"" widely cultivated for extraction of its essential oils. The yellow variety is mostly grown in Nigeria because it has the highest demand in the Nigerian market.

MATERIAL SELECTION / DESIGN ANALYSIS

MATERIAL SELECTION

In the course of designing any machine member, the selection of materials and manufacturing process by which the part are to be constructed should carefully be considered. For this reason, the person doing the design should be familiar with such independent factors as the adaptability of the material and the design details involved in the processes. Since the selection of material involves a large number of factors.

Some of the factor considered in selecting the materials for the construction of ginger slicing machine were based on:

(1) Physical properties
(2) Mechanical properties
(3) Economic properties

PHYSICAL PROPERTIES

Some of the properties of the materials considered under physical properties include:

i. MACHINABILITY

This is the ability of the materials used to be easily machined using various machine operation, very expensive material which can be easily machined is more economical in selection than a low priced material which may be difficult to machine.

ii. WEIGHT

Here, the weight of the materials to be used should be as low as possible except in design where weight is of great importance.

iii. FRICTION AND WEAR

Under this consideration the material are selected so that the effect of rapid friction and wear are reduced. Also the parts must be easily lubricated to reduce friction and wear as much as possible.

iv . NOISE

The materials to be used must be such that the noise in the moving member will not be so much. Here also, lubrication is important to reduce noise.

MECHANICAL PROPERTIES

The properties of the material considered here are:

i. STRENGTH

This is a property of a mechanical element. The strength of an element depends upon the choice of treatment and processing of the material. Ultimate strength is necessary to prevent failure of the member by rapture. Moreover to guard against permanent deformation of the member, consideration is given to the elastic limit in design.

ii. RIGIDITY

This is of importance in member whose deflection is limited by service requirement. Here considerations were given to clearance and alignment. Rigidity depends upon the modules of elasticity. It may be emphasized here that a member made of cast iron will be more rigid than a member of equal load carrying ability, made of steel, since the larger size required for the cast iron member will more or less compensate for its lower modules of elasticity.

ECONOMIC PROPERTIES

The factor considered under economic properties include:

i. AVAILABILITY OF MATERIALS

The choice of a material can be affected by its non-availability. For this reason, the availability of the material has to be given serious consideration that is to say that the material to be used must be readily available in the local market.

ii. COST

In selecting a machine member, cost of the material has to be considered. The cost of the material to be used is a function of the mechanism. However, cost should not be compromised if a material has a property, which is a must in a machine member, but with a high cost.

iii. AESTHETICS

The members selected under this property should be such that they will have high aesthetic value i.e. they should be beautiful in look.

iv. TOXICITY: -

Ginger is a food material, therefore our machine is a food handling machine, so in accordance with the national food and drug administration control (NAFDAC) regulation, the parts of the machine in contact with the ginger during processing (slicing action) must be rust and corrosion free. Stainless steel have such properties hence we considered stainless steel material for the

construction of the inlet hopper' outlet hopper cutting disc and cutting blade because of the fact that stainless steel though expensive will prevent contamination of the ginger produce.
Other parts of the machine like the framework and bodywork will be better done by mild steel material which is less expensive.

DESIGN ANALYSIS

DETERMINATION OF THE POWER REQUIREMENT OF THE SLICER

In determining the power required by the ginger-slicing machine, it is assumed that:
The machine will slice 500g of ginger in 20 seconds. The velocity at discharge or outlet is $1/5^{th}$speed of the rotating cutting disc.
Discharge is equal to volume flow rate V. Volume flow rate is defined as the product of area of the lower base and velocity of flow at the outlet i.e.
V = AxV ………………………………………………………………………… (1)
For continuity of flow,
Discharge Q = $VA_iV_i = A_0V_0$ ……………………………………………………… (2)
where i and 0 denotes inlet and outlet respectively.
Specifying A_{01} area of outlet point to be $0.0006m^2$ then
$V_o = Q/A_0$ ………………………………………………………………………… (3)
Discharge Q = V = Capacity of the ginger slicing machine in m^3
V = Vs/t
Where Vs is the volume of the hopper = 0.0041 $7m^3$
T is time of slicing per batch = 20 seconds
V = 0.00417/20 = $2.085 \times 10^{-4} m^3/s$
from equation (3)
Velocity = $V_0 = V/A_0 = Q/A_0$ …………………………………………………… (4)
Substituting
$V_0 = 2.085 \times 10^{-4} / 6 \times 10^{-4} = 0.348 m/s$
We recall that the velocity of the cutting disc
Vc = 5Vo ………………………………………………………………………… (5)
Vc = 5 x 0.348m/s = 1.75m/s
Angular speed of the cutting disc given by
$Wc = V_c/r_c$………………………………………………………………………… (6)
Where r_c = radius of the disc = 80mm = 0.08m
Substituting
$Wc = \frac{1.75}{0.08} = 21.875$ radian/sec
Converting to revolution per minute
$\frac{21{,}875 \times 60}{2 \times 3.142} = 708.86$rpm
The centrifugal force produced or experienced by the cutting disc is given by
$F_c = Mrw^2$ ………………………………………………………………………… (7)
Where M = mass of cutting disc = 6kg
r = radius of cutting disc = 0.08m
W = angular speed of cutting disc
= 21.875 radian/sec
Substituting
$F_c = 6 \times 0.08 \times (21.875)^2$ $F_c = 229.688N$
The power required to drive the cutting disc is defined as
$P_c = F_cV_c$ ………………………………………………………………………… (8)

Substituting the values of F_c and V_c
P_c=229.688x 1.75
P_c = 401.954 watts
Power required to drive cutting disc can also be defined as:
P_c = torque developed by the disc X angular speed of the disc
i.e $P_c = T_cW_c$……………………………………………………………………….(9)
T_c = F_c x r_c = 229.688 x 0.08
T = 18.375 Nm
Therefore,
P_c = 18.375 x 21.875
P_c = 401. 954 watts
Converting to horse power, we know that 1hp = 745 watts

$$\frac{401.954}{754}\ 0.54\text{hp}$$

Assuming that there are no losses both from the belt drive and that frictional resistance power supplied by motor is equal to power required by the cutting disc.
i.e
$P_m = P_c = P_s$ ……………………………………………………………………… (10)
Where
P_m = Motor power , P_c= disc power. P_s = shaft power
Then $T_mW_m = T_cW_c = T_sW_s$ …………………………………………………………… (11a)
$W_c = W_c$
$\frac{T_cW_c}{W_c}$ ………………………………………………………………………………(11b)
Substituting $T_s = \frac{401.954}{21.875}$
T_s = 18.375Nm
Also T = force on the pulley of the disc shaft x radius of the pulley of the disc shaft.
i.e. $T_s = F_sr_s$
radius of the shaft = 50mm = 0.50m
$F_s = T_s/ r_s$ = 18.375/ 0.05
F_s= 367.50N
In like manner the pitch line velocity assuming no slip on the drive is defined as:
$V= r_mW_m=r_sW_s$ …………………………………………………………… (12)
Angular speed of electric motor Wm is given as
$W_m = r_sW_s/r_m$ ………………………………………………………………. (13)
Where r_m = radius of electric motor pulley 0.015m
W_s = 21875 rad/s
Substituting
$W_m = \frac{0.050 \text{ x } 21.875}{0.015}$
W_m = 72.92 rad/sec
In revolution per minute
$W_m = \frac{72.92 \text{ x } 60}{2\times3.142}$= 696.213 rpm
Also from equation (the torque provided by the motor is
$T_mT_cW_c/W_m$
Substituting,
$T_m = \frac{T_cW_c}{W_m}$
Tm $= \frac{18.375\text{x}21.875}{72.92}$

$T_m = 5.55N_m$

The power of the electric motor is deduced as follows:

$P_m = T_m W_m$…………………………………………………………. (14)

Where:

P_m = Power of motor

T_m = Torque of motor

W_m = Angular velocity of motor

Substituting

P_m = 5.55 x 72.92 watts = 401.789 watts

Converting to horse power

401.789/745 = 0.539 horse power (hp)

Then in order not to have deficiency of power an electric motor of 0.75 horse power running at 750rpm was chosen for our construction.

DETERMINATION OF THE BELT LENGTH

The pitch length of belt is defined as

$L_p = 2_c + 1.57\ (D + d) + \frac{(D-d)^2}{4_c}$ ……………………………… (14)

Where

C = center to center distance = 250mm = 0.25m

D = Diameter of the disc shaft pulley = 0.10m

d = Diameter of the motor pulley = 0.030m

Substituting

$L_p = 2 \times 0.25 + 1.57\ (0.10 + 0.30) + \frac{(0.10 + 0.30)^2}{4\ x\ 0.25}$

L_p= 0.50 + 0.2041 + 0.0049

L_p = 0.709m = 709mm

The choice of V—Belt was made because of the following reasons (Black, 1955):

(1) The drive of V-belt is positive because of the slip is negligible when compared with other belt drives because of wedge action.

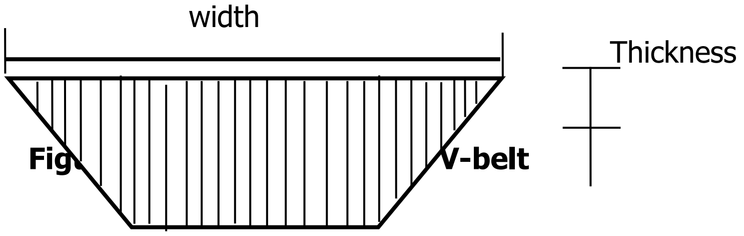
(2) V-belt permits high speed reduction even up to ratio of seven to one; 7:1

(3) V-belt drive can operate in any position even when the belt is vertical.

(4) They have short center distance which results in compact construction. They can also be shielded with guard easily.

(5)The force of friction between the surface of the belt and the pulley is high due to wedge action. This wedge action permits a smaller area of contact, increases the pulley capacity of the belt and consequently results in increase in the power transmitting capacity.

(6)Flat-belts are hinged while B-belts are endless resulting in smooth and quiet operation, even at high operating speed.



BELT SELECTION	**WIDTH, W(mm)**	**THICKNESS, T(mm)**	**MINIMUM PITCH DIAMETER OF PULLEY (mm)**
A	13	8	125
B	17	11	200
C	22	14	300
D	32	19	500
E	38	23	630

Table 3.1 Dimension of Standard Cross Section

BELT SELECTION	**A**	**B**	**C**	**D**	**E**
DIFERENCE BETWEEN PITCH AND INSIDE LENGTH (mm)	36	43	56	79	92

Table 3.2 Conversion of Inside length to pitch length

In selecting the types and section of the Vee belt for the ginger slicing machine, the normal inside length of the belt (mm) was determined first and foremost. The nominal inside length is defined as:

$L_1 – L_p$ - (Difference between pitch length and inside length) .... (15)

The dimensions of the pulley are as follows:
Width of pulley, w = 12mm
Thickness of pulley, t = 8mm

The pulley dimension thus shows from table 3.1 that the required belt selection is A
Also from table 3.2 the difference between pitch and inside length (mm) for belt selection A is 36
Thus from equation (15)
$L_1 = L_p$- (Diff, between pitch length and inside length)
Substituting
L_1 = 709mm — 36mm = 673mm
Therefore the belt required is designated as A: 673

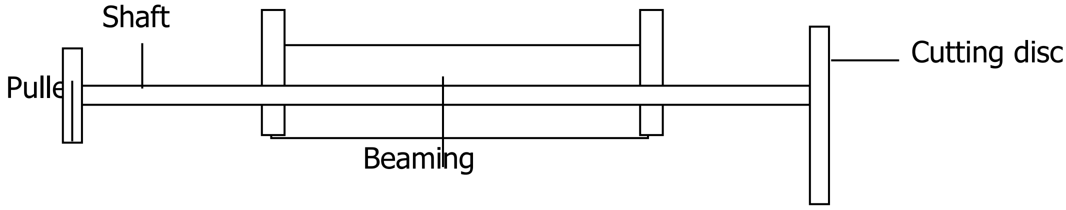


Figure 3.2. Schematic diagram of forces acting on disc and shaft

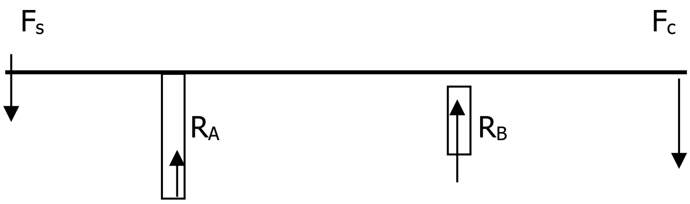


Figure 3.3 Line diagram of the shaft
Where: F_s = force or tension on the disc shaft = 367.5N
F_c = force or tension on the cutting disc = 229.688N

DETERMINATION OF FORCES AND REACTIONS

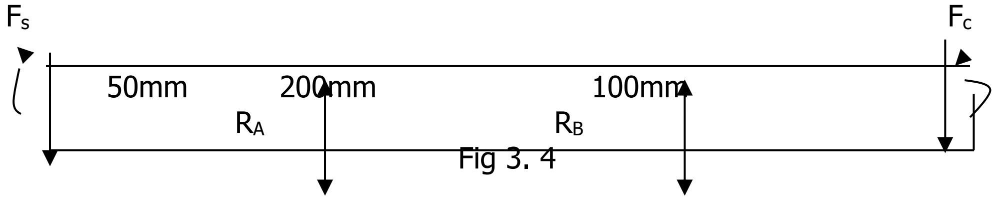


Fig 3. 4

Taking moments about B, $\sum MB = 0$
$100f_c+200R_A - (50+200)F_s = 0$
$100f_c + 200R_A — 250F_s = 0$
$0.10f_c + 0.20R_A — 0.25F_c = 0$ (converting to metres)
Substituting the value of f_c& f_s above
$0.10 \times 229.688 + 0.20R_A —0.25 \times 367.50$
$22.9688 + 0.2OR_A — 91.875 = 0$
$0.20R_A = 91.895—22.9688$
$0.2OR_A = 68.9062$
$R_A = \frac{68.9062}{0.20}$
$R_A = 344.531N$
Taking moments about point A $\sum MA = 0$
$50f_s + 200R_B - (100+200)f_c = 0$
$50f_s + 200R_B — 300f_c = 0$
$0.050 + 0.2OR_B — 0.30f_c = 0$ (converting to metres)
Substituting the values of f_s and f_c
$0.050 \times 367.50 + 0.20R_B - 0.30 \times 229,688 = 0$
$0.20R_B = 68.7064 - 18.375$
$0.20R_B = 50.5314$
$R_B = \frac{50.5314}{0.20}$
$R_B = 252. 657N$

CONTROL
Total upward forces = total downward forces
$R_A + R_B- F_s- F_c$
$R_A + R_B- F_s - f_c = 0$
Substituting for values of R_A, R_B, F_s, F_c
$344.531 + 252.657 - 367.50 - 229.688 = 0$
$597.188 - 597.188 = 0$
$0=0$

DETERMINATION OF MAXMUM BENDING MOMENT ON THE SHAFT

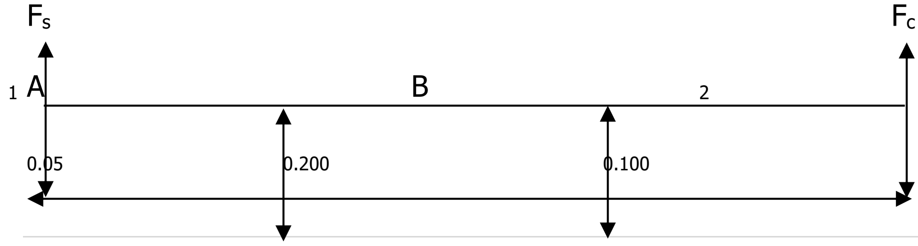


Fig 3.5

Section

$(1 - A^R)\ MR_1 = F_sR_1$

$(0 \leq X_1 \leq 0.0050)$

$x = 0\ M_1 = -\ 367.50 \times 0$

$M_1 = 0$

$X = 0.05ml$

$MA = -\ 367.50 \times 0.050$

$M_A = -\ 18.375Nm$

(A^LB^R)

$Mx_2 = f_s\ (0.050 + X_2) + R_A\ X_2$

$0 \leq X_2 \leq 0.0200$

$X = M_A = -\ 367.50\ (0.050 + 0) + 344.531 \times 0$

$M_A = -\ 18.375Nm$

$X = 0.200m$

$M_B = -\ 376.50\ (0.050 + 0.0200) + 344.531 \times 0.200$

$M_B = -\ 91.675 + 68.9062$

$M_B = -\ 22.969Nm$

$(B^1 - 2) = Mx_3 = -\ F_s\ (0.250 + x_3) + R_A\ (0.200 + x_3)\ R_bx3$

$(0 \leq x_3 \leq 0.100)$

$x = 0\ M_B = -\ 367.50\ (0.250 + 0) + 344.531\ (0.200 + 0)\ 252.657 \times 0$

$M_b = -91.895 + 68.9062 + 0$

$M_b = -\ 22.969Nm$

$X = 0.100m$

$M_2 = -\ 367.50\ (0.250 + 0.100)\ 344.531\ (0.200 + 0.100) + 252.657 \times 0.100$

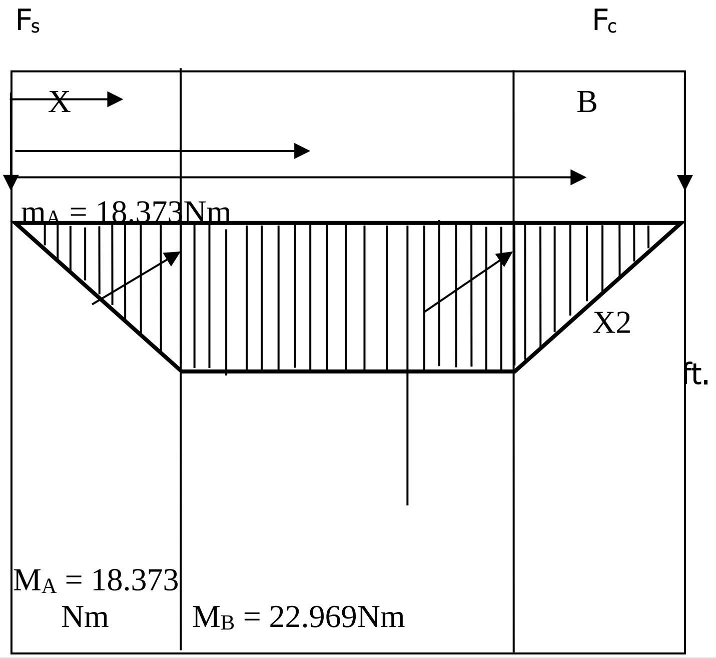
252.657×0.100

$M_2 = -\ 367.50 \times 0.350 + 344.531 \times (0.300) + 252.657 \times 0.100$

$M_2 = -\ 128.625 + 103.3593 + 25.2657$

$M_2 = -\ 128.625 + 128.625$

$M_2 = 0$



From the analysis, it is observed that point B is most critical and has the maximum bending moment i.e. M_b M_{max} = 22.969Nm.
According to the American Society of Mechanical Engineers (ASME) code, which takes into account the shock and fatigue influence on the shaft, the maximum shear stress is defined as
Tmas = $\frac{16}{\pi d^3}\sqrt{(\text{KbMb})^2 + (\text{KtMt})^2}$
where K = combined shock and fatigue
Vt = combined shock and fatigue factor applied to tensional moment.

	Vb	Vt
(i) Load gradually applied	1.5	1.0
(ii) Load suddenly applied (Minor shock)	1.5 - 2.0	1.0 -1.5
(iii) Load suddenly applied (Heavy shock)	2.0 - 3.0	1.5 - 3.0

Table3.3 Value of V and V for rotating shafts

From table 3.3 V_b = 1.5 and V_t 1.0
The shaft s made of plain carbon steel of grade 40CB (i.e 40% carbon and 8% manganese) with ultimate tensile strength.
∂ut = 5130N/mm^2
Yield strength in tension ∂ut = 380N According to ASME code, the permissible share stress
T∂ for shaft without key way is taken as 30% of the yield strength in tension or 18% of the ultimate tensile strength of the material which ever is minimum i.e
T∂ = 0.30 (∂yt which ever is maximum
T∂ = 0.18 ∂ut
T∂ = 0.30 x 380 = 115N/mm^2
T∂ = 0.18 x 580 = 104.4N/mm^2
The minimum of these two values is 104.4N/mms and there is no keyway on the shaft.
T∂ = 0.75 x 104.4 = 78.3N/mm^2
Where 0.75 is the permissible shear stress in the shaft due to absence of keyway.
Γ_{max} = 78.30N/mm^2
M_t = torque on the shaft pulley = Γ_s
M_t = Γ_s = 18.395Nm = 18,395Nmm
M_b = 22.969Nm = 22,969Nmm
$d^3 = \frac{16}{\pi \Gamma max}\sqrt{(\text{KbMb})^2 + (\text{KtMt})^2}$
Substituting
$d^3 = \frac{16}{3.142\ (78.30)}\sqrt{(1.5 \text{ x } 22{,}969)^2 + (1.0 \text{ x } 18{,}375)^2}$
d^3 = 0.06504v x $\sqrt{1.189 \text{ x } 10^9 + 337.64^6}$
d^3 = 0.06504 x $\sqrt{1.5246\ x\ 10^9}$
d^3 = 0.06504 x 39046.647 , d = 13.643mm

TESTING, RESULTS AND DISCUSSION OF RESULT

TESTING

The test carried out on this product after construction shows that its performance is satisfactory. The test was carried out to check for the efficiency of the machine and the average time of slicing

RESULTS AND DISCUSSION OF RESULT

The test was carried out for five consecutive number of times, with the same mass of ginger as shown in the table below:

No of test	Sliced time (mins)	Quantity by weight (kg)
1.	2.50	5kg
2	3.50	5kg
3	3.00	5kg
4	2.55	5kg
5	4.00	5kg

Table 4.1 Test result

Time different experienced is as a result of the different shape of the ginger rhizomes.

Average time of slice $= \frac{\sum_{n-1}^{s} time}{n}$

$$= \frac{2.50 + 3.50 + 3.00 + 2.55 + 4.00}{5}$$

$= \frac{16.35}{5}$ $= 3.27$mins

THEORETICAL EFFICIENCY

Theoretical efficiency was calculated as $= \frac{Output\ power}{inpu\ power}\ x\ \frac{100}{1}$

Where output power of the cutting disc, input power is the power of the electric motion

$\frac{Pc}{Pm}\ x\ \frac{100}{1}$

P_c = 401.954watts (0. 54hp) P_m = 745watts (1 hp)

Efficiency of machine (η_m) = $\frac{401.954}{745}\ x\ \frac{100}{1}$, = 54%

BILL OF ENGINEERING MEASUREMENT AND EVALUATION (BEME)

The bill of engineering measurement and evaluation is sum of all cost incurred directly and indirectly in the construction of the project work.

S/N	PARTS	TYPE	QTY	UNIT COST (N)	TOTAL COST (N)
1	Electric motor	1 horse power	1	25,000	25,000
2	Shaft	φ 25mm	1	2,000	2,000
3	Machine Housing	Mild Steel Plate	1	4,500	4,500
4	Cutting Disc	3mm thick HSS			
		A35	1	5,000	5,000
5	V- Belt	φ 25mm	1		
6	Bearing	Stainless Steel	2	200	200
7	Cutting Blade	1’’ Square Pipe	2	1000	2000
8	Frame	2mm thick galvanise	2 length	500	1000
9	Cutting Disc Housing	plate	1	1200	2,400
					1,500
10	Machine Hooper	Stainless steel	2 sheet	1,500	3,000
11	Bolts	10,13,15 bolts	10	1,500	500
12	Screw		20		400
13	Base (Angle Iron)	25mm/25mm	2 length		3,000
	Roller Balls		4	50	8,000
14	Shaft Pulley		1	20	2,000
15	Paint	φ 180mm	2 cups		1000
16	Electric Motor Pulley		1	1,500	1,500
17	Contingency	φ 40mm			
				2,000	5,000
18				2,000	
				500	
				1,500	
	TOTAL				68,000

CONCLUSION

The fabrication of the slicing machine was stated with drawing of isometric view of the assembled machine. The component of the machine were identified and listed down with their dimensions, Feasibility studies were carried out on the machine components to ascertain the material and manufacturing processes required, after being convinced that the material and manufacturing processes would be met. The costing for each component was undertaken. The research was found to be economically viable.

The critical parts on the machine were identified and analysed. This was to ensure that those parts do not fail while in service.

The aim of the research, which is the design and construction of a slicing machine for ginger, has been achieved.

This was achieved by carefully reaching a compromise between practicality, cost, anaesthetic and size. The machine has been tested and found to be working effectively.

RECOMMENDATION

The research aim was achieved. However I wish to recommend that further design of the slicing chamber should accommodate a range of sizes of rhizomes also include the rate of feed of rhizomes into the slicing chamber as this will improve the performance on the already constructed machine. Also improvement in cutting power of the blade should be made as it will increase the efficiency of the machine.

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