Control Theory and Informatics
ISSN 2224-5774 (Paper) ISSN 2225-0492 (Online)
Vol.5, No.4, 2015

Design of Dehulling Machine for Rubber Seed Processing

E.A. Fagbemi[1], A.F. Iyayi[1], P.O. Ayeke[1], P.C. Chimekwene[1], P.O. Akpaka[1], B. Omonigho[2]
[1]Research Operation Department, [2]Work and Services
Rubber Research Institute of Nigeria, Benin City, Edo State, Nigeria.

Abstract
The designed Dehulling Machine is a machine used to removes shells from rubber seeds and as well separates the foreign materials from the rubber seed kernels. The Dehulling Machine for rubber seed processing is powered by Electric Motor, the Electric Motor drives the Shaft for dehulling operation and the blower/Fan Shaft, the Total Power required is 70KW. The Transmission System consists of arrangement of driven and driving Pulleys, Belt, and Shafts with Bearings. The diammeter of the driven and driving pulleys for the dehulling operation is 70 mm and 330 mm respectively and V-belt of 1.2 m long. The blower has driven and driving pulley diammeter of 63 mm and 130 mm respectively and V-belt of 761 mm long. The Dehulling Mechanisms include: Dehulling Shaft that accommodates the Dehulling Stone of diammeter 300 mm and thickness 80 mm. The Shaft is supported by bearing and the driven by driving pulley mounted on the eletric motor. The chaffs and the kernels collector is designed such that the kernels(heavier) fall freely while the chaffs and other foreign materials are blown off. The blower has fan duty of 1 m^3/s and made of the blades Support (length = 20 mm, breath = 10 mm, thickness = 10 mm, no = 12), Blade (length =100 mm, breath = 60 mm, thickness = 0.5 mm, no of blade = 6) and Blower Cylinder. The main frame is made of mild-steel and it accommodates all other members of the machine.
Keywords: Dehulling, machine, shells, rubber, seed, chaffs.

Introduction

Natural rubber is an economic tree crop in Nigeria and has diversity of uses which include provision of raw materials for agro-based industries, foreign exchange earning and offers employment to a sizeable segment of the Nigerian farming rural population [Abolagba et al, 2003]. The usage of rubber is related to its property. The predominant property of solid rubber is its elastic behaviour or deformation by compression or tension. The tyre industry is the major consumer of natural rubber. It is well suited for the manufacture of tyre especially radial, heavy duty and high-speed tyres because of its dynamic qualities such as good tear strength and low heat build up. Beyond the use of rubber for manufacture of tyres, rubber is used for the manufacture of specific products such as flexible oil resistance pipelines for offshore oil fields, inner tubes of tyres, footwear, bridge pad and building foundation in Earthquake prone areas. The latex concentrate is used for the production of carpet underlay, adhesives, foam, balloons, condoms, and medical accessories such as gloves and catheters. Rubber wood is used for furnitu.re, particleboards and fuel [Fasina, 1998; Giroh et al, 2007].

The rubber seed weight is between 3.5-6.0 g, it is ovoid in shape with the ventral surface slightly flattened. The average sizes of rubber seed is 15.2 mm longitudinally and 2.0 mm transversely. The seed coat (husk) is hard and shiny, brown or grey to brown with numerous darker mottles or streaks on the dorsal surfaces, but few or none on the ventral side [Webster, 1984]. The average weight of the dried seed is about 4.5 g, the kernel of the rubber seed is roughly half the weight of the total seed [Aigbodion et al, 2005]. Rubber plant grows for about 4 – 5 years before it starts to flower. In Nigeria flowering is once between February and March, while in Malaysia flowering is twice a year between March and April and between August and September [Olapade and Salawu, 1985]. Rubber fruit drops naturally when matured and dehisces to release seeds which are then picked by hand from the plantation floors for use as seedlings which are later grafted with scions as improved planting materials or for processing into rubber seed oil. Rubber seed oil and cake are extracted from the rubber seed after processing. The oil is a semi drying oil that contain 29% saturated, 23% oleic, 32.5% linoleic and 22.5% linolenic, the oil is used in production of putty, hair shampoo and also used as industrial oil (raw materials) to replace linseed oil. The rubber seed is also used in the manufacture of putty and alkyds resins, which find application in the paint and leather industry. Furthermore, rubber seed cake extracted from rubber seeds is valuable in livestock feeds [Fasina, 1998]. The cake contains tolerable quantities of cyanogeni glucoride and can be used as livestock concentrate after drying and toasting [Uzi et al, 1985]. Nigeria has a total of about 247,100 hectares of land under rubber cultivation and it is estimated to yield a total of 43,000 tonnes of rubber seeds which if properly harnessed will add value to the downstream sector of the rubber industry in the areas employment generation for seed collection and processing. Research has shown that these seeds are useful in the manufacture of valuable consumers' goods as mentioned. It is however regrettable the crude methods of seed processing is devised by users and the urgent need for the fabrication of dehulling machine to avoid colossal loss in the processing process.

In rubber seed processing, the seeds and the kernels are crushed and processed together for extraction of rubber seed oil and cake. The research has been shown that more oil is recovered when only the kernels are processed. In this study the prospect of the use of dehulling machine is to remove the seed coat/outer shell of seeds (nuts, grains etc). The designed machine aids the rubber seed oil recovery by processing only the kernels and also saves time and energy as it dehusks and as well separates the shell from the kernel which has been done by hand picking before.

Machine Conception

The dehulling machine in view is to dehusk and separates the rubber seeds at an appreciable efficiency, lower power consumption with relatively low cost. The machine components and system mechanism consist of the following:

Feeding hopper

This serves as the inlet of the machine, it is trapezoid in shape, and accommodates the whole seeds from which the kernels is to be removed.

Shaft

Shaft is a transmission element for dehulling operation as well as the blowing operation, the first shaft is for dehulling operation that rotates the dehulling stone and the second shaft carries the fan blade of the dehuller blower.

Blowing/Cleaning Unit (fan)

This cleans/separates the dehulled rubber seed kernels by removing the shells and other foreign materials by blowing stream of air across the mass of dehulled seeds and other plant materials. The considerations for effective design of the blowing unit are to determine the appropriate volume of air and the discharge rate.

Main Frame

The main frame is the main body of the machine on which the other members are rested.

Pulley and Transmission Belt

The pulley and belt are transmission system through which shafts is linked/coupled to the electric motor.

Foreign Materials/ Chaffs Outlets

Foreign materials and chaffs are blown through the foreign materials/chaffs outlets. The outlet is inclined to allow the seed to slide back directly below the dehulling unit housing, while the foreign materials and chaffs are blown off. The blown off chaffs are collected at the outlets of inclined tray and the kernels are collected at the bottom outlets.

Dehulling Chamber/Dehulling Stone Housing

This is where the dehulling operation takes place and it accommodates the dehulling stone.

Operation of the Machine

The rubber seeds to be dehulled are feed into the hopper; the dehulling point is located between the dehulling stone and the housing. Due to the pressure exerted by the rotating dehulling stone, the rubber seed kernels are separated from the seed and collected at the bottom along with the shells. The shells or husks are separated from the kernels by means of blower. The cleaned kernels are therefore collected at the bottom outlets.

The efficiency of the operation of the dehulling machine depends on: physical properties of the rubber seed e.g. size, shape, hardness, e.t.c., the feed rate of the charge, the dehulling speed and effectiveness of the dehulling surface in the dehulling chamber and the volume of effective air to blow the chaffs and other consideration, which include the moisture content.

Material Selection

Belt a and pulley

The selection of v-belt is based upon obtaining a long and free life. The selection is also hinged on its efficiency. In general, efficiency of v-belt ranges from 70 % - 90 %. Therefore, this type of belt is chosen with the following dimensions.

$w = 20mm = 0.02m$, $h = 11mm = 0.011m$, $the\ pitch\ width(p) = 17mm = 0.017$.

The required speed for v-belt is 4000rpm. If the belt runs faster than 5000rpm or much slower than 1000rpm trouble may be encountered [Joseph et al, 1983]. Also the minimum recommended pitch diameter (D_p) $=125mm$

a. *First Set of Pulley*

The first set of pulley is the electric motor and fan (blower) pulleys

[$N_1 = 1000rpm \rightarrow selected,\ \ N_2 = 2050rpm$ [1]

$Assumption = d_1 = 130mm$, $d_2 = \frac{(N_1 d_1)}{N_2}$, $d_2 = 63mm$]

b. *Second Set of Pulley*

This set of pulley is for electric motor and shelling/dehulling stone pulley.

[$d_3 = N_4 d_4$, $N_3 = N_1 = 1000rpm$, $d_3 = 70mm(assumed)$, $d_4 = \frac{(N_1 d_3)}{N_3}$
$N_4 = 210rpm$. [Duraism and Manian, 1990]
The pulley of steel material is selected due to its strength. The density of mild steel$= 7840\ kg/m^3$ [Khurmi and Gupta, 2004]

Shafts

Due to the strength, toughness, reliability on resistance to shock and repeated loading, steel material is selected for the shaft to accommodate the loads that would be impacted on it. The parameters to be considered on shaft design calculation include; maximum allowable stress for shaft (σ), maximum shear stress (τ), density of steel (ρ), combine shock and fatigue factor as applied to torsion (k_t), combine shock and fatigue factor as applied to bending (k_b) [Khurmi and Gupta, 2004].

Dehulling Stone

Dehulling stone is made from metal sheet, parameter considered in selecting dehulling stone include; density (ρ), ultimate tensile strength [Khurmi and Gupta, 2008].
The thickness of the metal sheet=$2m$, the diameter of dehulling stone=$300mm$, allowances between the dehulling stone and narking surface$= 21mm$ wrt average size of rubber seed.

Fan

[*Cylinder diameter*$= 30mm$ = *0.03m, Cylinder length*$= 120mm = 0.12m$]

Blade Support

Length $= 20mm = 0.02m,\ Breath = 10mm = 0.01m,\ Thickness = 10mm = 0.01m$
$Number\ of\ Support = 12$

Blade

$Length = 100mm = .1m\ \ Breath = 60mm = 0.06m\ ,Thickness = 0.5mm = 0.0005m,$
$Number\ of\ Blades =$
6, $Fan\ Duty = 1m^3/s$
The assumed values are selected for better construction to meet up with the objectives of the project.

Design Calculation

Belt Design

Length of the belt

$L_1 = \frac{\pi}{2}(d_2 + d_1) + 2\ x + \frac{(d_2 - d_1)^2}{4x}$ [Khurmi and Gupta, 2004]

Where $x =$ *centre of the sheaves* $= \frac{1}{2}(d_2 + d_1) + d_1$ [8]

a. *First Set of Pulley ;(Blower and Motor Pulley)*
   [$d_1 = 130mm = 0.14m,\ d_2 = 63mm = 0.06m, x = 0.2265m,$ *];* $L_1 = 0.7611m$
b. *Second Set of Pulleys: (dehulling pulley and the motor pulley)*
   [$d_4 = 0.333m,\ d_3 = 0.07m,\ x = 0.27m$ *]*
   $L_2 = 1.2m$

Tension in the Belt

$\frac{T_1}{T_2} = e^{\alpha\mu}$, [$T_1 = tension\ in\ the\ tight\ side(N)$ [3],
$T_2 =\ tension\ in\ the\ slack\ side(N)\alpha = wrap\ angle\ on\ the\ smaller\ pulley,\ \mu =$
$coefficient\ of\ friction.$
]

α_1 β_1

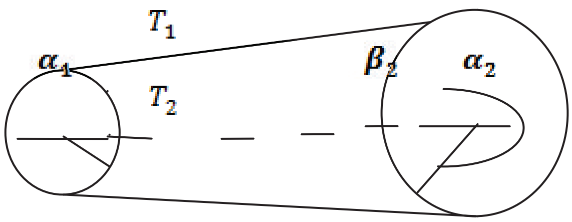


Diagram. 1

$[\alpha_1 = (180 - 2\beta); 180 - 2\sin^{-1}(\frac{R-r}{c}),\ \alpha_2 = (180 - 2\beta); 180 - 2\sin^{-1}(\frac{R-r}{c})]$

a. First Set of Pulleys

$[R = 65mm,\ r = 31.5mm,\ c = 226.5mm]$

$\beta = \sin^{-1}\frac{(R-r)}{c},\ \beta = 8.51^0, \propto = 162.98^0$

Power in the Belt is given by:

$p = \frac{(T_2 - T_1)}{1000}\ v = 0.5kw$ [12]

Belt Speed

$v = \frac{\pi d_1 N}{60} = 6.8\,{}^{m}/_{s}.$

Therefore; $T_1 - T_2 = \frac{(1000\ P)}{V}\ = 73.42N$

Torque Developed is given by:

$T_r = (T_1 - T_2)\frac{d_2}{2}\ = 2.31Nm$

b. Second Set Pulleys

$sin\ \beta = \frac{(R-r)}{x}$, $[R = 166.5mm, r = 35mm,\ x = 271.5mm,]$

$\beta = 28.97^0,\ \alpha = 122.06^0$

Tension in the both Sets of Pulley

First Set of Pulleys

$[\ \alpha\ in\ radian = 162.98 \times \frac{\pi}{180} = 2.84rad,]$

$\frac{T_1}{T_2} = e^{0.52\times 2.83},\ T_1 = T_2 \times 4.4,$

$P = \frac{(T_1 - T_2)V}{1000},$

$T_2 = \frac{P\times 1000}{3.4\times V}, = 21.63N\ and\ T_1 = 95.172N.$

Torque is given by:

$T_R = M_t = (T_1 - T_2)\frac{d_3}{2}$ [10]

$= 12.24Nm$

Second Set of pulleys

[$\alpha\ in\ radian = 122.06 \times \frac{\pi}{180} = 2.13rad,$ *]*

$\frac{T_1}{T_2} = e^{\alpha\mu} = e^{0.52\times 2.13},\ P = \frac{(T_1 - T_2)V}{1000}$

$T_1 = T_2 \times 3.03,\ T_2 = \frac{P\times 1000}{2.03\times V} = 14.13N$

$T_1 = 42.82N$

For Transmission Shafts, maximum permissible working stress in tension and compression (σ) is $112Mpa$ and maximum permissible shear stress (τ) is $56Mpa$ [Khurmi and Gupta, 2008].

The Dynamic Loads on the Shaft

Pulley

Cross volume (v_c) of pulley$= \frac{\pi w d_4^2}{4} = 1.74 \times\ 10^{-3}m^3$ [9]

Volume of the groove on the pulley(v_g)

$=$ belt cross sectional area $\times$ diameter

$= d_4 \times w \times h \times \pi\ = 2.30 \times 10^{-4}m^3$

Net volume of pulley: v_{net}

$= v_c - v_g = 15.1 \times 10^{-4}m^3$

Force exerted by the Pulley(F_p)

= weight of the pulley acting on the shaft

$= density(\rho) \times volume(v_{net}) \times g$
$= 116.13N$

Dehulling Stone

Volume of Dehulling Stone $= \pi r^2 l$ [9]

[$r = dehulling\ stone\ radius = 0.15m,\ l = \quad dehulling\ stone\ thickness = \quad 0.08m\ volume = 0.0057m^3$]

Weight of the Stone$= \rho \times vol \times g = \quad 434.97N$

Weight of the Rubber Seeds

The average weight of rubber seed (dried) is about 4.5g [13].

The Capacity of the Designed Hopper

$\frac{(ab+b^2 \tan\theta)c}{2} = \frac{((150\times250)+250^2 \tan 29)150}{2} = 8.2 \times 10^{-3}m^3$

$\frac{b}{e} = \cos\theta,\ e = \frac{250}{\cos\theta} = 0.286m$.

Gravimetric Capacity of the Hopper

The gravimetric capacity of the hopper is an estimate from the weight of the seeds that will be resting in the hopper.

Density (ρ) $= \frac{mass}{volume}$

mass$= volume \times density$ *(Density of Rubber Seed=* $548.8g/m^3$*)*

Gravitational Capacity$= mass = volumetric\ capacity \times density\ of\ rubber\ seed.$

Volume of Rubber Seed $= volume\ that\ will\ occupy\ the\ hopper$

$= volume\ of\ the\ hopper = 8.2 \times 10^{-3}m^3.$ [$m = 4.5g\ (dried\ seed)$] [10]

Mass $= volume \times density = 8.2 \times 10^{-3} \times \rho_r$

Total Weight of Rubber Seed in the Hopper

$= ma \quad = (4.5 \times 9.81)N = \quad 44.15N$ [Khurmi and Gupta, 2004]

Rupture Force

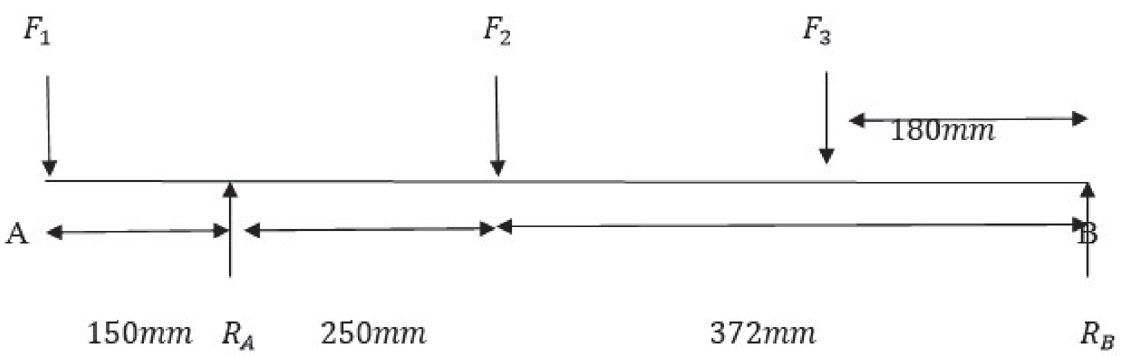
Rupture force refers to the hardness of the rubber seed shell, tested and found to be $0.61N$ [http/polymerweb.com].

Total Weight on the Dehulling Shaft:

$= 44.15 + 434.97 + 116.13 + 0.61$
$= 595.86N$

General Force Representations

Vertical load consideration



[$F_2 = 116.13N,\ F_2 = 434.97N,\ F_3 = 44.76N$]

Taking moment about B

$R_A = 417.23N$

Total upward forces = total downward force

$R_B = 178.63N$

Table 1: Shear Force and the Bending Moment for Vertical Loading Consideration.

S/N	FORCES(N)	POINT(m)	SHEAR FORCE (N)	BENDING MOMENT (Nm)
1	116.13	0	-116.13	0
2	434.17	400 from A	301.1	-17.42
3	44.76	180 from B	-133.8	57.86
4	417.2	150 from A	-178.63	32.16
5	178.65	0	0	0

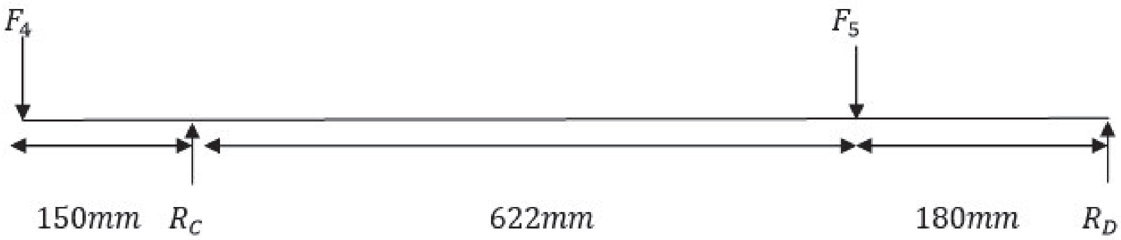
Source: *Data Analysis*

Horizontal Loading Consideration

Horizotal loading is produced due to the pull (tension) of the belt on the pulley against the shaft and force against the rupture force of the seeds [Gary et al, 1984]

Tension $= T_1 + T_2 = F_4 = 116.802N \ (calculated)$

$F_5 = force\ against\ the\ rupture\ force = 44.76N$



Taking Moment About D:

$R_C = 148.69N$

Downward Forces = Upward Forces:

$R_D = 12.87N$

Table 2: shear force and the bending moment for Horizontal Loading Consideration

S/N	FORCES (N)	POINT(m)	SHEAR FORCE (N)	BENDING MOMENT (Nm)
1	116.802	150 from C	-116.80	0
2	44.67	180 from D	31.89	-17.-52
3	148.61	150 from C	-12.87	2.32
4	12.87	0	0	0

Source: Data analysis

Max. Vertical Bending Moment $M_V = 57.86Nm$

Max. Horizontal Bending Moment $M_H = -17.52Nm$

Max. Bending Moment $M_b = [M_V^2 + M_H^2]^{\frac{1}{2}} = 60.45Nm$

Shaft Diameter

$$d^3 = \frac{16}{\pi s_s} \sqrt[2]{[(K_b M_b)^2 + (K_t M_t)^2]}$$

[$K_t = 1.75\ selected$, $K_b = 1.45 = selected$, $S_s =$ *Shear Stress (constant)* $= 45MPa$ [Khurmi and Gupta, 2004]

Diameter (d) of dehulling Shaft: $d = 21.5mm$

d of $\mathbf{30}mm$ is selected for safety, factor of safety $= \frac{30}{21.5} = 1.4$

Fan Design

Centrifugal fan type is selected for this design work because it is relatively inexpensive and self cleaning [Khurmi and Gupta, 2004].

Fan Shaft Design

Weights acting on the fan shaft are: weight of cylinder holding the blade support, weight of the blade support, weight of the pulley and weight of the blade

Weight of the Pulley

Gross Volume of Pulley $(gv_v) = \frac{\pi d_3^2 w}{4} = 7.6979 \times 10^{-5} m^3$

Volume of Groove on the Pulley (v_g)

=belt cross sectional area$\times \pi\pi d_3 = \frac{1}{2}(w+p)h\pi d_3$

$= 4.47 \times 10^{-5} m^3, p = 0.07m, w = 0.02m, h = 0.011m$

Net vol. of pulley $= (7.698 - 4.47) \times 10^{-3} = 3.23 \times 10^{-5} m^3$

Weight of pulley = density$\times$volume$\times$ $g = 2.48N$

Weight of Cylinder (w_c)

Volume of cylinder $= \pi r^2 l = 8.48 \times 10^{-3} m^3 \; (r = 0.015m, l = 0.12m)$

$w_c = vol.\times density \times 9.81 = 6.52N$

Weight of Blade Support (w_s)

$w_c = length \times breath \times thickness \times density \times 9.81 \times no\ of\ blade\ supports$

$= 0.02 \times 0.01 \times 0.01 \times 7840 \times 9.81 \times 12 = 1.85N$

Weight of Blades (w_b)

$w_b = length \times breath \times thickness \times density \times 9.81 \times no\ of\ blades$

$= 0.1 \times 0.06 \times 0.0005 \times 6 \times 7840 \times 9.81 = 1.380N$

Total Weight on the Fan Shaft (W_T)

$W_T = \mathrm{w_p + w_c + w_s + w_b} = 12.23\mathrm{N}.$

Diammeter of Fan Shaft selected is 30mm [Osmorme, 1997]

Power Required

Total power required$=$ power to drive the stone $+$ power to drive the fan (Blower) [Khurmi and Gupta, 20048]

$F_D = F_F + F_R, \; (P_D = F_D V = F_D \omega); \omega = 26.18^{rad}/_{sec}$]

$F_R = \frac{w}{a}\omega^2 = F_R = 30.4KN.$

$F_C = m\omega^2 = 30.4\ KN \quad (m = 4.944\ k_{g,})$

$F_F = \mu.(F_C + 0.61) = 14.5\ KN$

(($\mu = 0.477\ (selected)$)

$F_D = F_F - F_R = 15.9KN$

$P_D = F_D V = F_D \omega r.$ ($\omega = 26.18 \frac{rad.}{sec.}, r = radius\ of\ pulley = 166.5mm$)

$P_D = 69.30KW$

For the Blower;

power$= \frac{(P_S \times Q)}{0.75}$ [6]

$Q =$ Fan duty ($\frac{m^3}{sec} = 1m^3/sec$), $P_S =$ static pressure$= 500pa$

$P = \frac{(1\times 500)}{0.75} = 666.6W$

Total power required

$P_D + P$

$= 69.30 + 0.6666 = 70KW\ (94hP)$

$$\underline{\text{Blower (rpm)}} = motor\ rpm \times \frac{sheaves\ diameter\ of\ the\ motor}{sheaves\ diameter\ of\ the\ fan} = 3{,}095rpm$$

Conclusion

From the outcome of the design, the dehulling machine for rubber seed processing is used to remove shells from the rubber seed and as well separates chaffs/shells and other foreign materials from the kernels.

The machine is designed such that, it can be easily fabricated and maintained with simplicity of operation.

The machine can be conveniently used by natural rubber farmers to aid/enhances value of natural rubber products in economic development. The rubber seeds kernels are removed manually by beating before, the introduction of this dehulling machine saves time, energy and cost of production.

Therefore, the components are strong, the materials are readily available and well selected, and the designed works is best for fabrication method of production of the model.

REFERENCES

Abolagba, E. O, Aigbekaen, E.O and Omokhafe, K.O. 2003, Farm Gate Marketing of Natural Rubber in the South East Rubber Growing zone of Nigeria.*Nigeria Journal of Agriculture and Rural Development* 6.40- 48

Fasina, A.B. 1998, Investment Opportunities in Rubber industry in Nigeria. A paper presented at the (IRRDB) meting held at Abuja. 18p.

Giroh, D.Y., Ephraim, I.J., F.O. Igbinosun and Ogwuche, P. 2007, A quantitative analysis of adoption of natural rubber production technologies among farmers in Southern Nigeria. *Journal of Sustainable Tropical Agricultural Research* 21. 11 – 18.

Webster 1984

Aigbodion. A.I, Bakare. I.O, Okieimen. F.E and Akinlabi. A.K, 2005, Preliminary Investigations in the Synthesis and Characterization of Maleinized Rubber Seed Oil. ChemTech Journal Vol.1, A Publication of Chemical Societies of Nigeria Edo State Chapter, Nigeria, pp 1-9

Olapade, E.P. and Salawu, R.A. 1985, Influence of Flowering and Fruiting Patterns on Natural Rubber Seed Production. Proceeding of a National Conference on Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood. Pp-72.

Uzu, F.O, Ihenyen, G.A, and Imoebe, S.O. 1985, Processing, Analysis and Utilization of Rubber Seed Oil and Cake. Proceeding of a National Conference on Industrial Utilization of Natural Rubber (Hevea brasiliensis) Seed, Latex and Wood. Pp-19.

Joseph Edward Shigley and Larry D. Mitchell, 1983. Mechanical Engineering Design. Mc Graw-Hill, inc. Japan.

Duraismy V.M and Manian R., 1990, Design, Development and Evaluation of Castor Bean Sheller, Agricultural Mechanization in Asia, Africa, and Latin America. Pp 42-45.

R.S. khurmi and J.K Gupta, 2004, Theory of Machine, Eurasia Publishing House (PVT) LTD, Ramnagar, New Delhi-110055.

R.S. khurmi and J.K Gupta, 2008, Machine Design, Eurasia Publishing House (PVT) LTD, Ramnagar, New Delhi.

Gary. K.D, T. Lester and C. Paul, 1984, Design of Agricultural Machinery. John Wiley and Sons inc. Toronto Pp 259

Http/polymer web .com

Osmorme, W.C, 1997, Fans. Pergamon Press Inc. Maxwell House: fair view park, Edward, New York 10523, U.S.A.

Nomenclature

$h =$ Belt height (m).

$w = belt\ width\ (m)$.

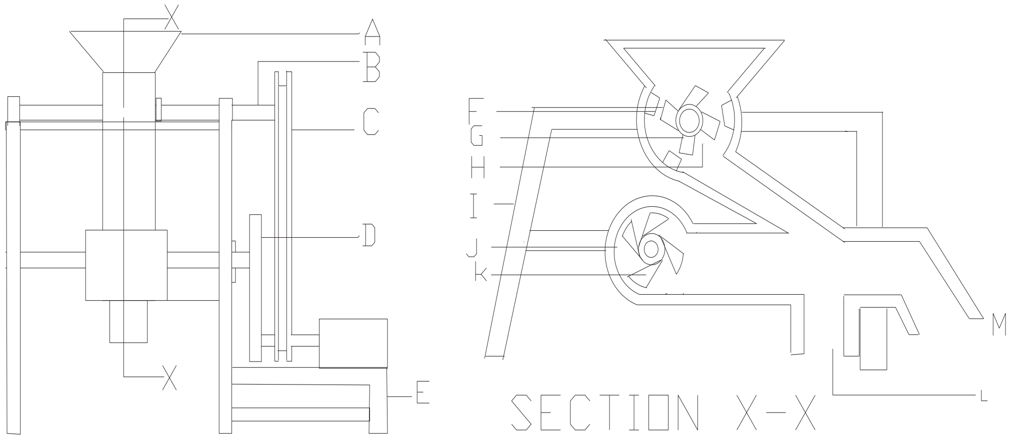
$P = groove\ pitch\ width$.

$d_1 = pitch\ diammeter\ of\ driving\ pulley\ for\ fan$.

$d_2 = pitch\ diammeter\ of\ driven\ pulley\ for\ fan.$

$N_1 = speed\ in\ revolution\ per\ minute.$

$d_3 = pitch\ diammeter\ of\ the\ driving\ pulley\ for\ dehulling\ stone.$



DEHULLING MACHINE FOR RUBBER SEED PROCESSING.

$d_4 = pitch\ diamemmeter\ of\ the\ driven\ pulley\ for\ dehulling\ stone.$

$x =$Centre of the sheaves

$L_1 = lenght\ of\ the\ blower\ belt\ (m)$

$L_2 = lenght\ of\ the\ dehulling\ stone\ belt\ (m)$

$T_1 = tension\ in\ the\ tight\ side\ (N),$

$T_2 = tension\ in\ the\ slack\ side\ (N)$

$\alpha = wrap\ angle\ on\ the\ smaller\ pulley,$

$\mu = coefficient\ of\ friction.]$

$p = power\ in\ the\ belt\ (W)$

$T_r = belt\ torque\ (Nm),$

$v = belt\ speed\ ({}^{m}/_{s})$

M = Chaffs and Foreign Material Outlet

L = Kernels Outlet
K = Fan Blade
J = The Blower/Fan
I = Machine Frame/Stand

H = Dehulling Chamber
G = Dehulling Stone
F = Dehulling Surface
E = Motor Stand
D = Transmission Belt (Blowing Operation)
C = Transmission Belt (Dehulling Operation)
B = Dehulling Shaft
A = The Hopper