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Design and Fabrication of Tamarind Cover and Seed Separation Machine

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Abstract— ***Tamarind is a very useful kitchen product and available in abundant form in rural area. It is again an important ingredient in Ayurvedic medicines as well as in daily needs throughout India. All these needs are fulfilled by tamarind pulp, which become available after separation of seed and cover from tamarind. The traditional method of preparation of this pulp is a hand process that becomes tedious and lengthy task to separate out the cover and seed from Tamarind. In addition, this operation needs huge manpower requirements. On the other hand more than sixty percent of the Indian population lives in villages and agriculture is the main domain of their resource. Preparation of tamarind pulp is one of the joint household enterprises in most of the villages in Zarkhand and Uttar Pradesh. Hence, the automation of this process is a need of these enterprises. The complete process of formulation of tamarind pulp i.e. right from collection of tamarind to convert it to final form are performed manually. It consumes lot of time and man force investments. To increase the productivity of these enterprises automation of this process will play a crucial role. The focus of this paper is on design and fabrication of a machine, which will separate cover and seed from tamarind. It comprises of three sub-units carrying processes of cover braking, cover separation and seed removal respectively. The selection of design of these process units and their validation from Mechanical Engineering Design point of view is detailed in this paper.***

Index Terms**—Tamarind Structure, Design, Separator, Cutter.**

I. INTRODUCTION

Automation is the need of today. Industries worldwide are growing rapidly through automation. Most of the Indian population lives in villages and agriculture is the main source of earning. Along with farming, the people in rural India earn through various co-supported activities. Tamarind trees are very common to them and supply of pulp of tamarind to various food processing, medicine producing industries can increase their earnings. Thus this automation not only will develop entrepreneurs but also contributes to green automation industrialization. In Zarkhand and Uttar Pradesh forest around the village is very dark and the people find the huge amount of tamarind trees around them. Thus they manually separate cover and seed from the tamarind and supply it to various industries and stores. All this process requires lot of time and manpower which can be reduced by atomization of the process. No machine was found which can be directly used to separate the cover and seed from the tamarind. Even various food processors were studied but not found suitable for this process. Hence it was decided to go for design and fabrication of such a machine which can perform this task.

To atomize the process of cover and seed separation one should go through the manual process pulp extraction. The manual process is as follows.

- The radish brown tamarind pods are first dried in sun so that the cover become brittle
- Now on a flat surface, it is hammered with some soft material to break the cover.
- The cover is separated from the tamarind by wind.
- Seed is removed through hand process.

The selection of the design for the above mentioned process is very crucial for the high quality production of tamarind pulp.

II. SELECTION OF DESIGN OF TAMARIND COVER AND SEED SEPARATOR

The process of removal of cover and seed from tamarind pods is divided in four parts.

a)Breaking of cover of tamarind
b) Separation of cover from tamarind
c)Removal of seed from tamarind pods
d) Separation of seed from pods

To select material and design for the above mentions process characteristics of the material being handled i.e. of tamarind must be taken into consideration.

Characteristics of Tamarind:

The features of tamarind are illustrated as below

- It is 3-8 inches long and Radish brown in color.
- When ripped, shell become brittle and easily gets broken.
- Pod contains 6-12 large, flat, glossy, brown seed embedded in pulp.

1. Selection of Design of Tamarind cover breaker (TCB):

The TCB is to be used for breaking the cover of tamarind from its pods such that it will just get removed from the pod and will not stick to the pulp. Various machines used for agriculture products processing were studied like,

- Rubber roller husker[1]
- Ground nut stripper [3]

Out of these machines Ground nut stripper was found more close to the required system. In this mechanism strippers are provided on circular plates. And this is used to remove dry mud-from the grounds nuts.

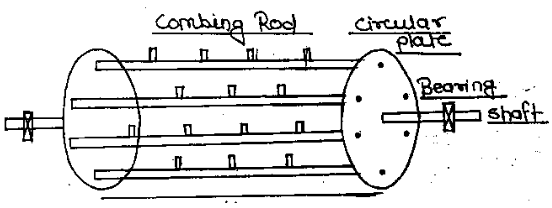

Fig .1. Ground nut stripper

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This mechanism can't be used directly for the removal of cover of tamarind. So some modifications are suggested in this mechanism.

Modifications Suggested:

This Mechanism is very similar to it. Only a cylindrical cover is provided to the stripper and is made somewhat inclined. At the upper end hopper is provided and from lower end the material is collected.

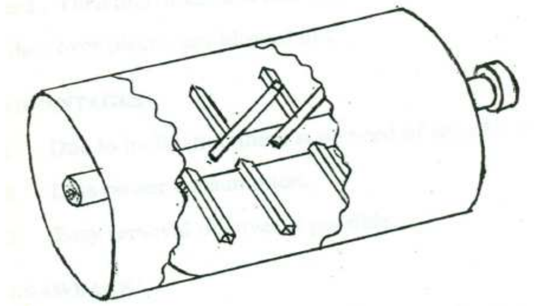

Fig. 2. Modified stripper (TCB)

Advantages:

- Due to inclination there is no need of separate conveyer.
- Less power consumption.
- Easy removal of cover is possible.

2. Section of Design of Tamarind cover separator(TCS):

The TCS has to perform a function of separation of the cover from pod. To select the design again some of the machines were studied like

- Paddy separator
- Suction blower
- Centrifugal blower
- Exhaust fan

Out of these Exhaust fan was found more suitable to satisfy the needs.

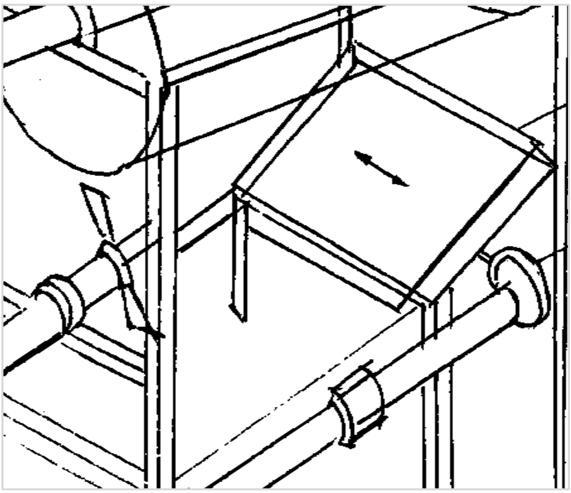

Fig. 3. Separator design (TCS)

When the cover and pods will fall down from the TCB the vibrator will vibrate to bring the covers and pods down and exhaust fan will blow off the covers and hence will get separated.

3. Selection of design of Tamarind Seed Remover (TSR):

For design selection of TSR following types of machine systems were studied**.**

- Burr grinder
- Auger
- House hold mixer

Out these systems the household mixer mechanism is found more suitable. It is found that the blade of the mixer finely cuts the pods of the tamarind. But still the seed remains to be separated from the pods. Hence with some modifications Toothed Blade Cutter is selected. The modifications are

- Cutter blade is having a toothed structure on its edge and hook shape at the end so that it will cut and separate seed from tamarind respectively.
- The cutter has cylindrical covering and both circular ends are open.
- The blades are so placed on the central shaft such that it will follow a helical path as shown in fig 4.

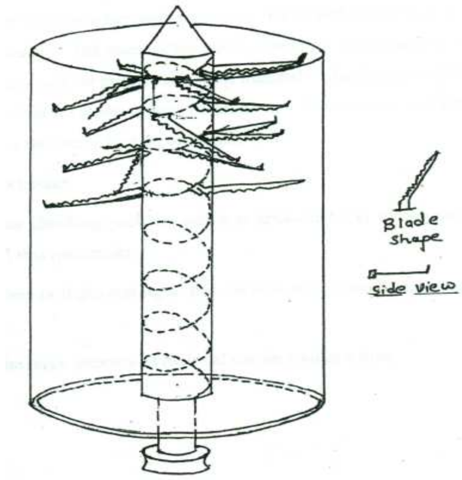

Fig .4.Toothed blade cutter (TSR)

Due to centrifugal force the cut material will hammer on cylindrical surface and seed will be removed. The blades are bent in a horizontal plane so that it will cut the tamarind material efficiently.

III. Experimentation And Trials

Previous database or calculations were found unavailable for knowing or calculating the force required to remove the cover of Tamarind. Hence an experiment has to be conducted. To know the force required, different weights of same cross sectional area were allowed to strike on 150 gm Tamarind from different heights. The experimental database is tabulated as below.

Energy required for cover removal:

From above experimentation energy required for removing the cover of 150 gm Tamarind by 300gm weight

= weight x height

= 300 X 10-3x 9.81 X 300 X 10-3

= 0.8829 J

Hence, Energy required for removing the cover of 1000 gm Tamarind= 5.886 J

Assumptions made to find the above mentioned energy are,

a. 1Kg of material is in the drum for an instant of time.

b. Weight of wooden blade will be 2 Kg.

c. Total weight of 8 discs will be 1 Kg.

d. Length of blower blade will be 200 mm.

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e. Weight of vibrator and connecting rod combine will be 3 kg.

f. Material in vertical drum will be 1 kg.

g. Weight of blade and mounting on the vertical shaft will be 2 kg.

Table 1.Weight checking for breaking the cover of Tamarind

S.N.	Weight	Height	Result
1	100gm	300mm	Coved removed in small extent
		600mm	Cover removed well
		900mm	Cover sticks on tamarind pulp
2	300gm	300mm	Cover removed well
		600mm	Cover removed but it get mix with pulp badly
		900mm	Cover removed but seed was damaged.

IV. REQUIRED MOTOR POWER

As assumed, there will be 1 Kg of material in the drum for an instant of time. Let weight of wooden blade (total) is 2 kg & the total weight of 8 discs is 1 kg. Therefore the total weight on the shaft is 4Kg.

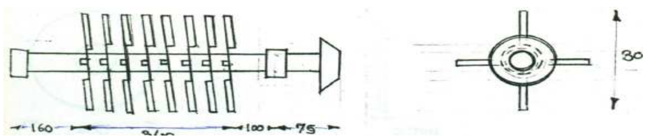

Fig .5.Tamarind Cover breaker Shaft

a) Power required for TCB Unit ***(All Dimensions in mm)***

P1 =2πNT1 /60

TI=m x g x D/2

Where m-4 kg

D = dia of drum = 300mm

T1 = 4 x 9.81 x 300/2

T1= 5.886 Nm

P1 = (2π x 400 x 5.886) /60

P1 = 226.558 W= 0.53HP.

b) *Power required for the blower* ***(All Dimensions in mm)***

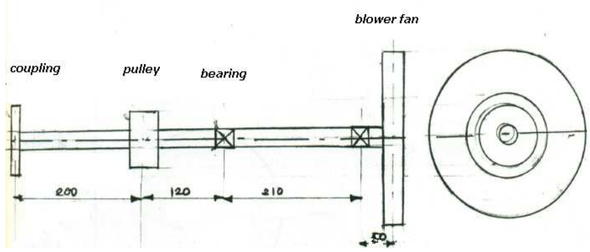

Fig 6.Blower shaft for the cover separation

T2 = 20 x Rl2

=20 x 0.1

T2 = 2Nm

Power Required P2 = 2π x N x T2/60

= (2π x 1440 x 2)/60

=310.59W

P2 = 0.4 HP

c) Power required for vibrator ***(All Dimensions in mm)***

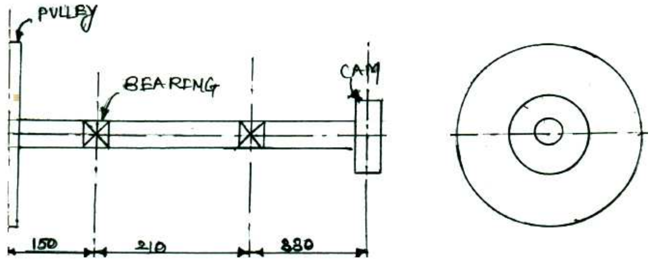

Fig .7. Shaft with cam connected to Vibrator

The weight of the pan and connecting rod may be assumed to be 3 kg and there will be l kg material on the pan. Now the vibration stroke equal to 60 mm. Therefore Torque required to drive the vibrator will be

T3= mg x 60/2

T3=4 x 9.81 x 60/2

T3=1.17 Nm

Thus, Power required is

P3 = 2πNT3/60

= 2π x 240 x 1.177/60.

=29.58 W

=0.0396 HP ≈ 0.04HP

b) Power required for cutter Unit

As assumed, the material in the drum is 1 kg. Weight of blades &mounting is 2kg. Therefore total weight on the shaft is 3 kg.

Torque required for shaft = mg x D/2

= 3 x 9.81 x 150/2

=2.207Nm

Power required for shaft

P4=2πNT4/60

=2π x 2.207x 750 1 60

=173.357 W

P4 = 0.232HP

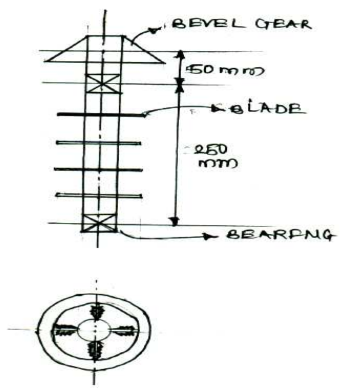

Fig .8. Shaft of seed separator unit

Hence, Total Power Required

= Power required for all the four units

= 0.53 + 0.4 + 0.04 + 0.232

= 1.202 HP

V. VALIDATION OF DIMENSIONS OF VARIOUS PROCESS UNITS IN TERMS OF MECHANICAL ENGINEERING DESIGN

The design analysis involves the use of design data book Also the analysis is too long to show completely in this paper.

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The design of one of the process unit is shown in detail as a sample.

I. Design of cover Removal Unit

a. Design of V-belt (between drum Shaft and motor shaft)

N1= Speed of Drum shaft = 400 rpm
N2 = Speed of motor = 1440 rpm
PR= 0.746 KW
From T-XV-2,
Pd = PR x K1
K= Load factor for electric motor line shaft = 1.10
Pd = 0.746 x 1.10
Pd = 0.820 KW
From T-XV-8,
From Design Data Book for 0.746 kW we can use A-type belt and recommended pulley diameter is 75 mm
Recommended Width of belt (W) = 13 mm
Centrifugal tension factor = 2.52
Peripheral velocity for A-type belt will be
Vp = πDINI / 1000
= π x 75 x1440 / 1000
Vp = 340 m/min
From table T XV-10,
Recommended Range for Vp 300 to 1500 m/min with diameter D2 = 75 mm
N1D1 =N2D2
400 x D1 = 1440 x 75
D1 = 1440 x 75/400
D1 = 270mm
Power Rating per Belt
= (Fw - Fc) $(e^{\mu e/Sin\alpha/2} - 1 / e^{\mu e/Sin\alpha/2})$ * Vp
From T-XV-I0
μ = Coefficint of friction = 0.3
C = DI+D2= 270 + 75 = 345 mm
H = Angle of lap
From T-XV-l,
e = π- (D2-Dl) /c
e = π - (270-75) /345 = 2.75 rad
From T-XV-9,
Fw = Working load = W2 = 132 = 169 N
Fe = Centrifugal tension = Kc x (Vp/5)2
Kc = Centrifugal tension factor = 2.52
Fe = 2.52(340/60 x 5)2
Fe = 3.236 N
From T-XVll.
a = Cone angle = 38°
P = (169-3.236)* $e^{0.3x2.57/Sin (38/2)}$ _1 / $e^{0.3x2.57/Sin (38/2)}$
From X 5.67,
P = 85l.86 W
No of Belt = $^{Pd}/_{Power/Belt}$
= 820/851.86
No of Belt = 0.96 =1
Length of Belt
L = π /2 (D1+D2)+2C+(D2-D1) 2/4C
= π/2(75+270)+2 x 354+(270-75)2/4 x 345
L= 1259mm
L = 1.26 m
From T-XVI,
Tension in belt
T 1/T2=$e^{\mu e/Sin\alpha/2}$
= $e^{0.3 x 2.57/ sin (38/2)}$
= 10.67
TI-T2 = Pd / Vp= 820 x 60 / 340
Tl - T2 = 140.S8N
Tl = 10.67T2
10.67T2 - T2= 140.S8
T2 = IS N
Tl= 166.62 N

b. Design of pulley P1 (pulley on drum shaft)

From TXVI-ll
Width of the pulley
L= (n-l) e + 2f
For A- type
n=1
e=15
f=9 to 12 = 10 (assume)
L= (1-1) * IS+2 * 10
L=20mm
b= 3.3 mm
h=8.7mm
From T-XI -07
Type of construction = Arm construction for diameter above 150 mm
No. of arm = 4
No. of set = 1
Rim Thickness = $0.25\sqrt{D} + 1.5$
t = 0.25√ 270 + 1.5 = 5.67 ≈ 6mm

c. Design of Bevel Gear

Here θ = 20^0 = α
No of teeth = 30 (assumed)
TXVI-20,
Pitch angle
tan γ = sin θ / tg / tp+cos θ
= *sin20/30/30+cos20*
γ = 10^0
Diameters of gear are same
i.e. D1=D2
Now D1=T1m=D2
Where M = Module of gear

i. Tangential tooth load

ft = pd/vp
Vp = Pitch line velocity = πDN/60000
= π mtg * 400/60000
= π m*3*400/60000
Vp = 0.628m, m/sec
= 631/m (1)

ii. Beam Strength

From T XVI - 15
FB = so*cv'*b*y*m (l-blL)
From T XVI - 10
Selecting SAE1030, so = 140 mpa
cv'=0.5 for N<1000 rpm
From XVI-20
Now cone distance = L = 0.5 $(D1^2+D2^2)^{1/2}$
= 0.5 $(t1^2+t2^2)^{1/2}$
=0.5 $(30^2+30^2)^{1/2}$
=21.21m < 30m

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Face width = 7*m for L < 30* m
Now assuming 20° full depth
From TXVI-5
Y=0.485- 2.87/tf
tf= t /cos γ
for acute angle gear
tan γ= sinθ/(tp/tg+cosθ)
= sin20/(l +cos20)
=0.176
$y = \tan^{-1} (0.1\ 76) = 10^0$
tf = *t/cosγ* = 30/cos 10=30.46
Y= 0.485 - 2.87/30.46
Y = 0.39
FB = 140 x 0.5 x 7m x 0.39 x m(1-7m/21.2l)
=128.03m2 (2)
Now equating eq.1 and 2
$631/m=128.03m^2$
m= 1.708 mm
From TXVI -7 , Selecting standard module
m=2mm.
D 1 = D2 = 30 x 2 = 60 mm
Thus, Ft = 319 N, FB = 512.l2N & V_P =1.2566 m/s
As FB > Ft , The design is ok .

iii. Dynamic load

$FD = ft + 21\ vp\ (ceb + ft)\ I\ (21vp+ (ceb+ft)^{1/2})$
Assuming 20^0 full depth, c = 11800.
e = 0.05 from fig 16.1in data book
FD = 1904.92 N

iv. Limiting wear load

$Fw = DP * Q * kb\ I\ \cos\gamma_p$
Q = 2tg / (tg+tp) = 2x30.46/30.46+30.46 = 1
Fw = 60 x 1x 14 x K I cos 10
Fw = 852.96 KN
Now Fw=FD
60 x 1 x 14 x K I cos10 = 1904.92
K=2.233
From the value of K = 2.401
BHN for gear = 350
BHN for pinion = 450
Fw = 60 x l x 14 x 2.401/ cos 10
Fw = 2047.95N
As Fw >FD Hence design is OK.

C. Design of Shaft (SO1)

Total weight of disc = 1 kg
Weight of wooden strip = 112kg
Weight of bolt = 112kg
UDL = 2 kg = 2x9.81=19.62N
Weight of gear = 2.0x9.81 = 19.62N
Distance between bearing = 600 mm
Taking moment about A
€MA= 0
19.62x675 - RB x600 + 19.38 x330 = 0
Thus, RB=32.73 N
€ FY=O
RA - 19.62 + 32.73-19.38 = 0
RA=6.27N
Shear force calculation
S.F. at A = 6.27 N
S.F. at C = 6.27 N
S.F. at D = -13.11 N
SF at LHS of D = -13.1lN, S.F. at RHS of D = 19.62 N
S.F. at C = 0 N
Bending Moment (B.M.):
M at A=O N mm
M at B = 6.27 x160 = 1003.2 N mm
M at C = 6.27 x500 - 19.38 x 340/2 = -159.6 N mm
M at D = 6.27 x 600-19.38 x 270 = -1470.6 N mm
M at E=O N mm
$Te = (M^2+T^2)^{½}$
$= (1470^2 + 5886^2)^{½}$
= 6066.78 N mm

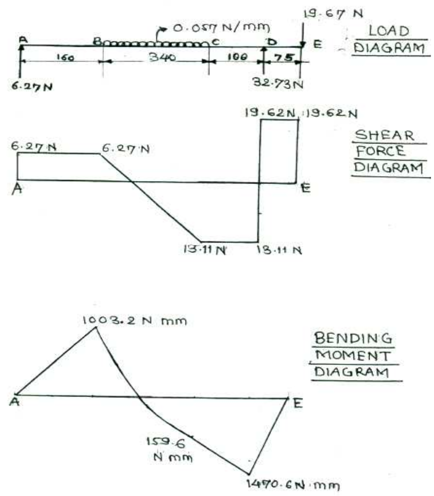

Fig .9. Shear force and bending moment diagram for shaft S01

Assuming the shaft material SAE 1030
From Table T-II-7
Yield Stress Sys = 154 & factor of Safety F.S. = 2.3
Shear Stress, Fs= Sys *1*F.S. = *154/2.5* = 61.6 Mpa.
$Te =\pi/16 \times fs \times d^3$
$6066.78 = \pi/16 \times 61.6 \times d^3$
d=7.94mm
For rotating shaft, gradually applied load & heavy shocks, from table T - XI-3, Kb = 2.5
d = 7.94x 2.5
d= 19.88 mm
Std. d=20mm
$Te = 1/2\ (M+(M^2+T^2)^{½})$
$=1/2(1470 + (1470^2+5886^2)^{½})$
Te = 3768.4 N mm
$\pi / 32 \times fs \times d^3 = 3768.4$
π /32 x 61.6 x d 3 = 3768.4
d= 8.34mm
d= 8.34 x 2.5 = 21 mm
From Table T - XI-4 std. d=22 mm

d. Design of Shaft (S02)

Wt. of pulley = 2 kg
Tension Tl = 15 N
T2 = 160.05 N
Load on pulley = (2 x 9.81) + 15 + 160.05
= 194.67 N
Load on Gear = 2 x 9.81 = 19.62 N
Taking moment about A
-19.62 x 20- RB x 150 + 194.67 x 170 = 0

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RB = 218.01 N
€Fy= 0
RA - 19.62 +RB - 194.67 = 0
RA - 19.62 + 218.01 - 194.67 = 0
Hence, RA = -3.72 N
Shear force calculation
S.F. at C = -19.62 N
SF at A LHS = - 19.62 N
SF at A RHS = -19.62-3.72 = -23.34 N
SF at B LHS = -23.34 N
SF at B RHS = -23.34 +218.01 = 194.6 N
SF at D LHS = 194.6 N
SF at D RHS = 0 N
Bending Moment:
B.M. at C =O
B.M. at A=-19.62x20=-392.4 N mm
B.M. at B= -19.62 x 170 + RA x 150
= -19.62xI70+(-3.72) x 150 = -3893.4 N mm
B.M. at D = -(19.62 x 190) – (372 x 170) + (218.01 x 20)
= 0 N mm
$Te = 1/2 (M+(M^2+T^2)^{½})$
$= 1/2 (3894.4+(3894.4^2+5886^2)^{½})$
Te = 7057 .16 N nun
$Te = π / 16 x Fs x d^3$
$7057.16 = π / 16 x 61.6 x d^3$
d= 8.35 mm
From table T - XI-3
kb = 2.5
d = 8.35 x 2.5 =21 mm

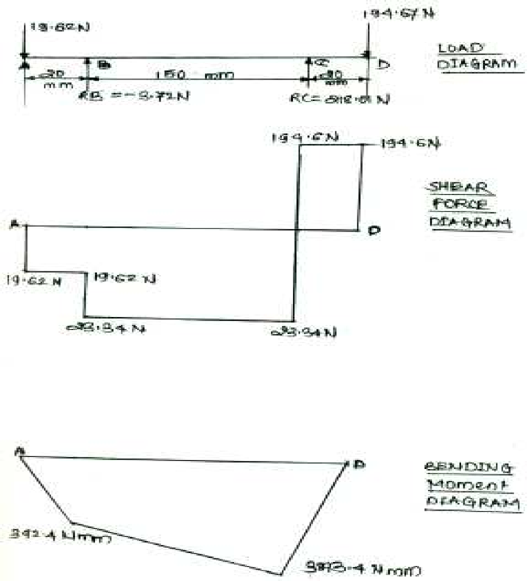

Fig.10. Shear force and bending moment diagram for shaft S02

$Te = 1/2 (M+(M^2+T^2)^{½})$
$= 1/2 (3893.4 + (3893.4^2+5886^2)^{½})$
Te = 5475.28 N mm
$Te = π / 16 x Fs x d^3$
5475.28 = II /32 x 61.6 x d3
d = 9.680 nun = 10 nun
Assuming bending stress 2.5
= 10 x 2.5 = 25 nun
Standard diameter of d = 25 mm.

The fig 11 shows the approximate model of the machine with various machine parts. The detailing of these machine parts will fall in full length paper.

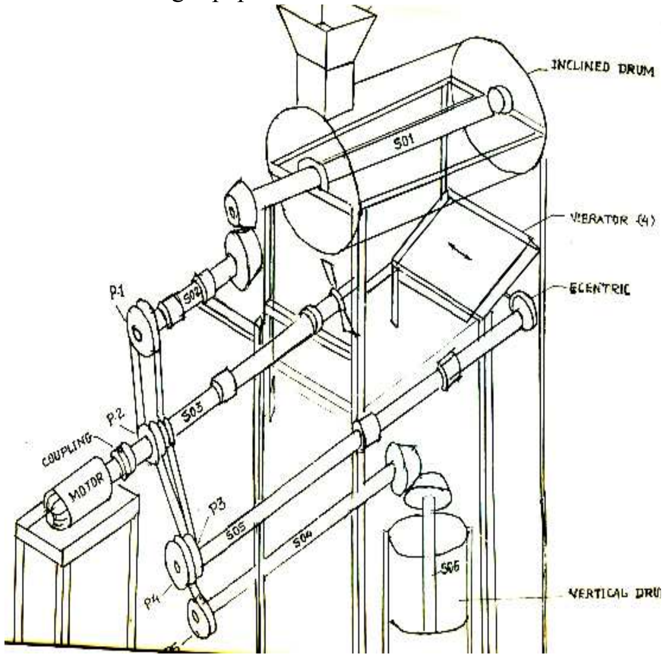

Fig .11. Approximate model of the machine

VI. FABRICATION OF THE MACHINE PARTS

Basic principles of fabrication given below are kept in mind and followed while fabricating machine elements.

1. Sharp edges should be avoided
2. Each joint should be tight so that hazards will be avoided
3. Cost should be as low as possible.
4. The parts must be removable so as to repair and replace the parts whenever required.
5. Space or holes must be provided for oil lubrication wherever needed.

The machine parts are fabricated by various types of manufacturing processes and machine tools in workshop. Main component that are fabricated in workshop as follows -

1) Body Frame
2) Cover Removal unit
3) Vibrator
4) Seed removal unit

The above mentioned units comprises of many number of sub-units. Hence it is very difficult to show the fabrication details of the each and every process unit. For the sake of information one of the main components of machine is given in detail.

1. Body Frame

The front view of the machine is shown in the fig 12. The machine consists of

- six machine shafts of variable lengths
- two bevel gear pairs
- three V-belt drives and
- An eccentric cam.

The machine shafts are machined on the lathe machine. The bevel gear pairs are manufactured on milling machine. The eccentric cam of the vibrator is also machined on Lathe

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machine. The cost involved in fabrication of the machine will fall in the full length paper.

Table 2.Details of the fabrication of Frame of the machine

S.N.	Operation	Process Used	Machine Tool
1	Cut the angle of 50x50x5 mm of length 1400mm and 300 mm	Cutting	Gas Welding Torch
2	Construct the frame of 1400mmx300mm from angles	Welding	Arc Welding Machine
3	Cut the angle of 25x25x5mm of length 100mm (02 NO.)	Cutting	Hacksaw Blade
4	Weld the above angle at one end to base frame in vertical position	Welding	Arc Welding Machine
5	Cut the angle of 25x25x5 mm of length 1210 mm (02 NO)	Cutting	Power Hacksaw
6	Weld these angles at a distance of 550 mm to one end of base frame	Welding	Arc Welding Machine
7	Cut the angle of 35x35x5 mm of length 1210 (02 NO)	Cutting	Gas Welding Torch
8	Weld these angles vertically to the base frame at a distance of 550mm to one end of the base frame	Welding	Arc Welding Machine

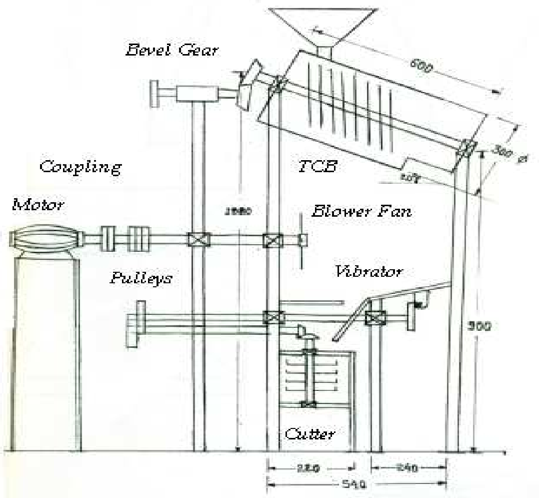

Fig 11. Front View of the machine

VII. Result Analysis

The machine is designed for removing the cover of 10 kg tamarind pods per hour and the machine giving very good result for the same. It is also possible to remove cover of more than 10 kg tamarind pods per hour. After conducting the trial, 90% cover is getting removed with two blades per disc on the shaft of TCB. A provision of four blades per disc on the shaft of TCB is also made available. It is possible to remove 100% cover by increasing the number of blades on the disc or by changing dimensions of blade. Seed removal is found only 20-25%. In the present situation cutter shaft is placed vertically downward below the blower. Hence semi-processed tamarind pods are passed away directly through the seed removing drum without coming in contact of cutting blades. The distance between the cutting blades could be decreased by increasing the number of blades per unit run of the shaft. This would cut the pods and after collision on the wall of the drum seed would get removed.

VIII. Conclusion

The fabricated machine is designed for removing the 10kg Tamarind pods cover and seed per hour. The results of the trials are satisfactory for cover removal process. But there is further scope in development of same model for seed removal process. The modifications suggested above can be made so that the machine would show the result for tamarind seed separation very efficiently.

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