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DESIGN CONSIDERATION & MODELING OF GROUNDNUT SHELLER MACHINE

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Abstract:
Basically the groundnut is grown by small scale farmers in developing countries like India. The average kernel price is approximately double the price of pod. Lack of groundnut processing machines, especially groundnut Sheller, is a major problem of groundnut production, especially in country like India. A research work for design, modeling and performance evaluation of groundnut Sheller consisting of fed hopper with a flow rate control device, shelling unit, separating unit and power system. The performance and output of the machine was evaluated in terms of throughput capacity, shelling efficiency, mechanical damage and material efficiency. Regression models that can be used to express the relationship existing in between the Sheller performance indices, moisture in pod and feed rate were establish. This paper describes about the design of various components or parts of groundnut Sheller machine. Hence in this design of various parts are necessary and design of various parts because of which the design quality of those parts will get improved. This project involves processes like design, modeling and analysis of different components etc.

Keywords: Groundnut, Sheller machine, efficiency, Design consideration, calculations and design procedure

I. INTRODUCTION

The sole purpose of this paper is to understand the fundamental knowledge of design and mechanism of machine. The design is an environment friendly and uses simple mechanical properties such as shelling system, blowering mechanism and automatic separating system etc. For this, some crushing force is needed to crush the groundnut. The design is done so that the knowledge and understanding of designing, mechanism and forces are increased. This project consists of designing and modeling of an groundnut Sheller machine considering various important and useful parameters. In this project, designing & development of a groundnut Sheller machine to crush or shell groundnut so the farmers can gain maximum profit by selling groundnut directly into the market. As well as the study of analysis is very important in order to carry out this project to ensure that what are the forces acts on different components. This project involves the designing and modeling of different parts of the shelling machine considering different parameters. This project is mainly about creating a new concept of groundnut shelling (crushing) that would make easier to bring anywhere and easier to crush groundnut. After the design will get completed, it is transformed for the analysis of different components of the machine.

II. DESIGN PROCEDURE

The basic aim is to give the complete design of the groundnut Sheller machine. In this, the detail explanations and some more parameters related to the project are included. With references from various sources such as journal, design data book, thesis and literature review has been carried out to collect information related to this project.

A. Design consideration

- Maximum Force required for crushing of groundnut
- Required shelling speed (velocity ratio)
- Standard or basic size of groundnut
- Material of different machine components

B. Design calculations

Determination of crushing power by analytical

By, according to KICK'S RELATION

Power required to shell the groundnut

H = KK x Fc x In(L1/L2)

Where,

H - Power

L1 - Length of shelled groundnut = 3.54 x 10-2 m L2 - length of unshelled groundnut = 1.48 x 10-2 m

KK - kick's constant = 1.2 Fc - crushing strength = 500 N/m2

C. Design Of V-Belt

Design Power (P_d) = $P_R \times k_L$

Where, P_R = rated power

Load Factor, K_L = 1.10

Selection of belt on the basis of design power. Nominal width, w

Nominal thickness, t

Recommended Diameter, D

Centrifugal tension factor, K_C

Bending stress factor, K_b

Peripheral Velocity, $V_p = \frac{\pi D_1 N_1}{60}$

D_1 = Diameter of smaller pulley i.e. electric motor shaft pulley,

N_1 = Speed of electric motor shaft pulley.

If this velocity i.e. V_P is in range then, Ok.

Now, assuming Velocity Ratio, VR to calculate speed of driven pulley.

N_1/N_2 = VR

By using velocity ratio with neglecting slip,

$$\frac{N_2}{N_1} = \frac{D_1}{D_2}$$

D_2 = Diameter of larger pulley

Centre to centre distance for V-belt,

C = ($D_1 + D_2$) **OR** C = D_2

Angle of lap or contact on smaller pulley, $\theta_1 = \pi - \frac{D_2 - D_1}{C}$

Angle of lap or contact on larger pulley, $\theta_2 = \pi + \frac{D_2 - D_1}{C}$

Since the smaller value of 'θ' for the pulley will governs the design.

Belt Tension Ratio,

$\frac{F_1}{F_2} = e^{\mu\theta \, cosec\alpha/2}$

α = Groove angle = 34^0

μ = Coefficient of friction = 0.3

F_1 = Tension in tight side

F_1 = Tension in slack side

Belt Tension, $(F_1 - F_2) = \frac{P_d}{V_P}$

Power Rating Per Belt = $(F_W - F_C) \frac{e^{\mu\theta}/\sin\frac{\alpha}{2} - 1}{e^{\mu\theta}/\sin\frac{\alpha}{2}} \times V_P$

Working Load, F_W

Centrifugal Tension, $F_C = K_C \times (\frac{V_P}{5})^2$

No. of Strands = $\frac{P_d}{Power/Belt}$

Length of the Belt,

$$L = \frac{\pi}{2} \times (D_1 + D_2) + 2C + \frac{(D_1 - D_2)^2}{4C}$$

Bending Load, $F_b = \frac{K_b}{D}$

K_b = Bending stress factor,

D = Diameter of pulley i.e. smaller or large.

Initial Tension, $2\sqrt{F_i} = \sqrt{F_1} + \sqrt{F_2}$

Fatigue Life of Belt, $F = F_i + F_C + F_{bmax}$

D. Design of Shaft

Design Torque, $T_d = \frac{60 \times P \times K_L}{2\pi N}$

Load Factor, K_L = 1.75 (For Line Shaft)

Selecting material of shaft SAE 1030,

S_{ut} = 527 MPa S_{yt} = 296 MPa

$\tau_{max} \leq 0.30\, S_{yt} \tau_{max} \leq 0.18\, S_{ut}$

Considering F.O.S. = 2

For ductile material with dynamic heavy shocks for machines like forging, shearing and punching etc.

$\tau_{max} \leq 0.30\, S_{yt} = 0.30 \times \frac{296}{2} = 44.4\ N/mm^2$

$\tau_{max} \leq 0.18\ S_u = 0.18 \times \frac{527}{2} = 47.43\ N/mm^2$

Considering minimum of it i.e. $\tau_{max} = 44.4\ N/mm^2$.

Consider Shaft-2 under loading

W_{P4} = Weight of pulley.

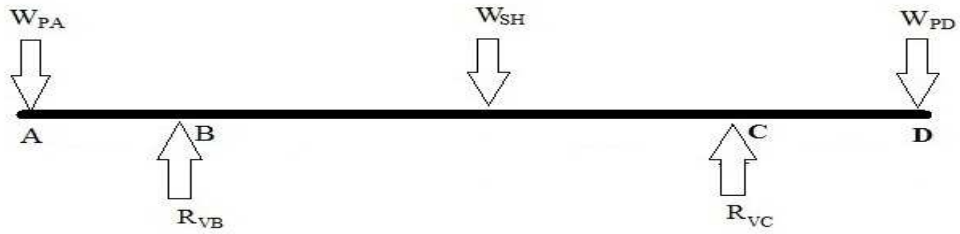


Fig.:- Vertical Shear Force Diagram

Resolving all the force vertically, $R_{AV} + R_{BV} = W_{PA} + W_{SH} + W_{PD}$

Taking moment about 'A

R_{BV} = Vertical Reaction at B R_{CV} = Vertical Reaction at C

As we know that bending moment at A and D will be Zero. ∴ $M_{AV} = M_{DV} = 0$

M_{AV} and M_{DV} are the vertical bending moments at point A and D respectively.

B. M. At C = $R_{AV} \times 90$

Resolving all the forces horizontally,

$R_{AH} + R_{BH} = F_3 + F_4$

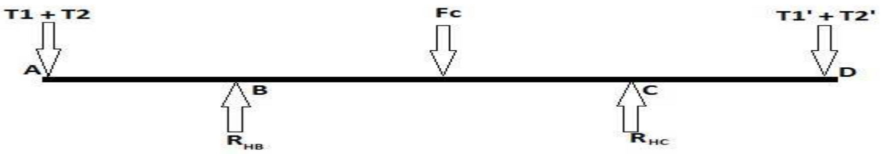


Fig.:- Horizontal Shear Force Diagram

Taking moment about 'A'

$(F_3 + F_4) \times 90 = R_{BH}$

We know that B.M. at A and B will be zero.

∴ $M_{AH} = M_{BH} = 0$

M_{AH} and M_{BH} are the horizontal bending moments at point A and B respectively.

B.M. at C, $M_{CH} = R_{AH}$

Resultant Bending Moment,

$$M_C = \sqrt{(M_{CV})^2 + (M_{CH})^2}$$

Now, for diameter of shaft,

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{(K_b M)^2 + (K_t T_d)^2}$$

Now, Recommended value for K_b and K_t

For rotating shaft,Suddenly applied load (Heavy shocks) K_b = 2 to 3 = 2.5K_t = 1.5 to 3 = 2.3 τ_{max} = 44.4 N/mm^2
Consider Shaft – 1 under loading
W_{P2} = Weight of pulley-2,
W_{P3} = Weight of pulley-3.

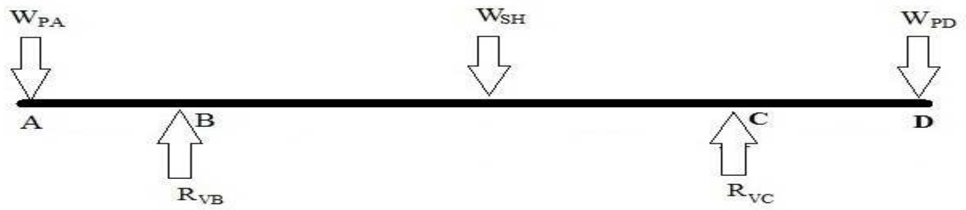


Fig.:- Vertical Shear Force Diagram'

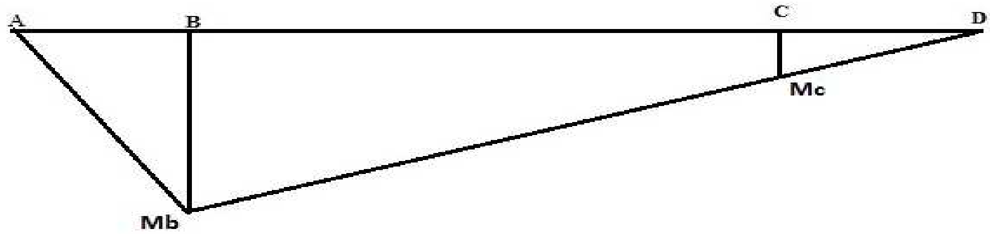


Fig.:- Vertical Bending Movement Diagram

Resolving all the forces vertically,

$$R_{AV} + R_{BV} = W_{P2} + W_{P3}$$

Taking moment about 'A'

$$W_{P3} + W_{P2} = R_{BV}$$

R_{BV} = Vertical Reaction at B
R_{AV} = Vertical Reaction at A

We know that B.M. at A and B is zero ∴ $M_{AV} = M_{BV} = 0$
M_{AV} and M_{BV} are the vertical bending moments at point A and B respectively.
B.M. at C, $M_{CV} = R_{AV} \times 35$
B.M. at D, $M_{DV} = R_{BV} \times 60$
Resolving all the force horizontally,
$R_{AH} + R_{BH} = (F_1 + F_2) + (F_3 + F_4)$

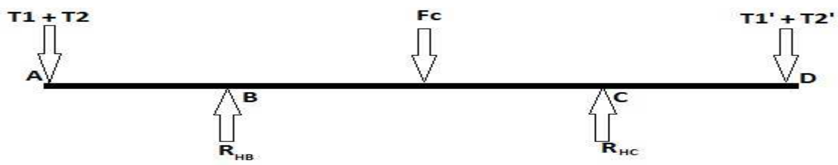


Fig.:- Horizontal Shear Force Diagram

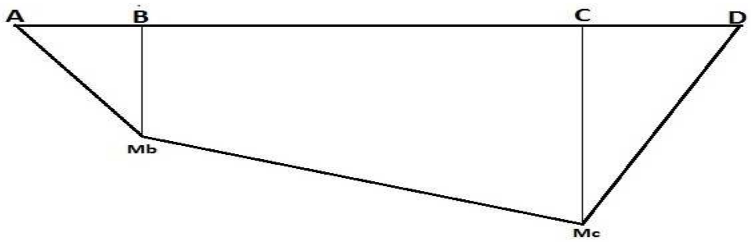


Fig.:- Horizontal Bending Movement Diagram

Taking moment about 'A'

$R_{BH} \times 180 = (F_1 + F_2) \times 120 + (F_3 + F_4)$

R_{BH} = Horizontal Reaction at B

R_{AH} = Horizontal Reaction at A.

We know that B.M. at A and B is zero,

$$\therefore M_{AH} = M_{BH} = 0$$

M_{AH} and M_{BH} are the horizontal bending moments at point A and B respectively.

B.M. at C, $M_{CH} = R_{AH}$

B.M. at D, $M_{DH} = R_{BH}$

Resultant Bending Moment,

$$M_C = \sqrt{(M_{CV})^2 + (M_{CH})^2}$$

$$M_D = \sqrt{(M_{DV})^2 + (M_{DH})^2}$$

Now, diameter of shaft,

$$\tau_{max} = \frac{16}{\pi d^3}\sqrt{(K_b M)^2 + (K_t T_d)^2}$$

For rotating shaft Suddenly applied load (Heavy shocks)K_b = 2 to 3 = 2.5K_t = 1.5 to 3 = 2.3 τ_{max} = 44.4 N/mm^2

E. Design of Pulley

L_P = 11 mm;

b = 3.3 mm;

h = 8.7 mm

e = 15 $\pm$ 0.3;

f = 9-12 = 10.5;

α= 34^o;

Min. Pitch Diameter, D_P = 75 mm

Types of construction – Web construction for pulley diameter below 150 mm

Types of construction – Arm construction for pulley diameter above 150 mm i.e. for bigger pulleys.

No. Of Arms = 4

No. Of Sets = 1

Rim thickness, t = 0.375 $\sqrt{D}$ + 3 (Heavy Duty Pulley)D = Diameter of pulley

Width of Pulley, W = (n - 1) e + 2f

Where 'n' is no. of belts = 1.

Hub Proportions

Hub diameter, $D_h = 1.5\, d_s + 25$ mm

d_s = Diameter of shaft = 18 mm
Length of Hub, $L_h = 1.5\, d_s$

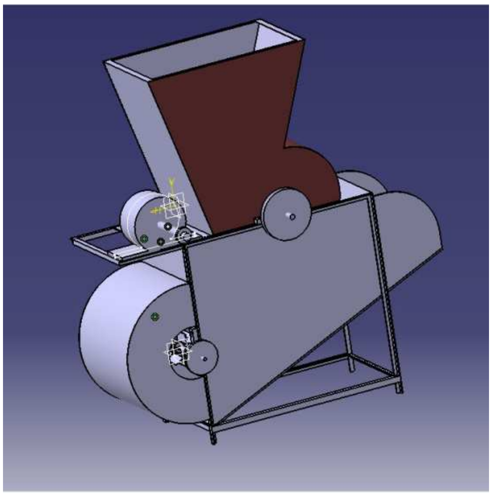
Moment on each Arm, $M = \frac{(F_1 - F_2)(D - D_h)}{n}$

n = no. of arms
D_h = Hub diameter

III. MODELLING

Mechanical Components in machine.

- Hopper
- Semicircular net (sieve)
- Roll shaft (main shaft)
- Fan shaft
- Bearing
- Foundation frame
- Pulley (4Nos.)
- Belt(2Nos.)
- Fan cover



MODELING OF MACHINE

IV. CONCLUSION

The above design procedure is been adopted for the design and modeling of Groundnut Sheller machine which will make the product durable for long time and also make it efficient also helps to understand the concept of design. With help of this design we can create model of an automatic groundnut Sheller machine to simply achieve high volume of profit as well as to reduce the human efforts and fatigue. After all process has been done, shelling operation may help us to understand the designing, modeling that involved in this project.

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