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Design Consideration of Corn Sheller Machine

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Abstract

Corn is grown on small scale farmers in developing countries like India. The average kernel price is approximately twice the price of maize. Lack of Corn processing machines, especially Corn Sheller, is a major problem of Corn production, especially in our country India. A research-work for design, fabricate, and performance evaluation of a Corn Sheller consisting of feed hopper, shelling unit, separating unit and power system. The performance of the machine was evaluated in terms of throughput capacity, shelling efficiency, material efficiency and mechanical damage. Regression models that could be used to express the relationship existing between the Sheller performance indices, pod moisture content and feed rate were establish. This paper describes about the design of various components of Corn Sheller machine. Hence in this design of various parts are necessary, and design of various parts due to which the design quality of those parts will be improved. Overall, this project involves processes like design, fabrication and assembling of different components etc.
Keywords: Corn, Sheller Machine, Efficiency, Design Consideration, Calculations, Design Procedure

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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 mechanism properties such as shelling system, and automation separating system etc. In this, some threshing force is needed to thresh the Corn. The design is so done that the knowledge of designing, mechanism and forces are increased. This project consists of designing and fabrication of an automatic Corn Sheller machine considering various important parameters. In this project, designing & development of a machine to shell Corn so the farmers can gain high profit by selling Corn direct in market. As well as the study of manufacturing was very important in order to carry out this project to ensure that what are needs to do. This project involves the process of designing the different parts of this shelling machine considering forces and ergonomic factor for people to use. This project is mainly about generating a new concept of Corn shell (thresh) that would make easier to bring anywhere and easier to thresh Corn. After the design has completed, it was transformed to its real product where the design is used for guideline.

II. DESIGN PROCEDURE

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

A. Design Consideration

- Maximum Force required to crush Corn
- Considered shelling speed (velocity ratio)
- Standard size of Corn
- Material of machine components

B. Design Calculations

Determination of crushing power by analytical
By, according to KICK'S RELATION
Power required to shell the Corn
$H = K_k x\ Fc\ x\ \ln(L2/L1)$
Where,
H - Power
L1 - Length of shelled Corn = 1.48×10^{-2} m
L2 - length of unshelled Corn = 20×10^{-2} m
KK - kick's constant = 1.2

Fc - crushing strength = 200 N/m^2

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,

$$V_p = \frac{\pi D_1 N_1}{60} V_p = \frac{\pi D_1 N_1}{60}$$

D_1 = Diameter of smaller pulley i.e. electric motor shaft pulley,
N_1 = Speed of electric motor shaft pulley.

$$V_p = \frac{\pi \times 75 \times 1440}{60 \times 1000}$$

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,

$$\theta_1 = \pi - \frac{D_2 - D_1}{C} \theta_1 = \pi - \frac{D_2 - D_1}{C}$$

Angle of lap or contact on larger pulley,

$$\theta_2 = \pi + \frac{D_2 - D_1}{C} \theta_2 = \pi + \frac{D_2 - D_1}{C}$$

Since the smaller value of $'\theta'\theta,$ for the pulley will governs the design.
Belt Tension Ratio,

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

$\alpha\alpha$ = Groove angle = 34^0

$\mu =$
Coefficient of friction $= 0.3$

μ= Coefficient of friction = 0.3
F_1 = Tension in tight side
F_1 = Tension in slack side

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

$$\frac{e^{\mu\theta}/\sin\frac{\alpha}{2} - 1}{e^{\mu\theta}/\sin\frac{\alpha}{2}} \times V_p \frac{e^{\mu\theta}/\sin\frac{\alpha}{2} - 1}{e^{\mu\theta}/\sin\frac{\alpha}{2}} \times V_p$$

Power Rating Per Belt = $(F_W - F_C)$
Working Load, F_W

Centrifugal Tension, $F_C = K_C \times\times (\frac{V_P}{5})\frac{V_P}{5})_2$

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

Length of the Belt,

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

Bending Load, $F_b = \frac{K_b K_b}{D \quad D}$
K_b = Bending stress factor,
D = Diameter of pulley i.e. smaller or large.
Initial Tension, $2\sqrt{F_i}\sqrt{F_i} = \sqrt{F_1} + \sqrt{F_2}\sqrt{F_1} + \sqrt{F_2}$
Fatigue Life of Belt, $F = F_i + F_C + F_{bmax}$

D. Design of Shaft

Design Torque, $T_d = \frac{60 \times P \times K_L 60 \times P \times K_L}{2\pi N \quad 2\pi N}$
Load Factor, $K_L = 1.75$ (For Line Shaft)
Selecting material of shaft SAE 1030,

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

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

Considering F.O.S. = 2
For ductile material with dynamic heavy shocks for machines like forging, shearing and punching etc.

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

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

Considering minimum of it i.e. $\tau_{max}\ \tau_{max} = 44.4\ N/mm^2$.
Consider Shaft-2 under loading
W_{P4} = Weight of pulley.

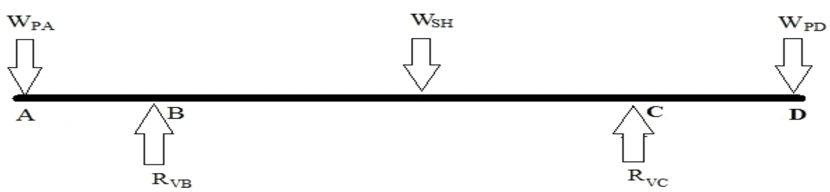

Fig. 1: Vertical Shear Force Diagram

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. $\therefore$ $M_{AV} = M_{DV} = 0$
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,

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

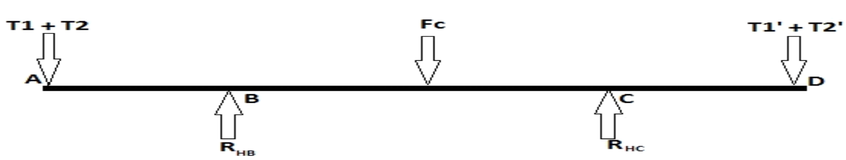

Fig. 2: Horizontal Shear Force Diagram

Taking moment about 'A'

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

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

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

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

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

Resultant Bending Moment,

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

Now, for diameter of shaft,

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

Now, Recommended value for K_b and K_t

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

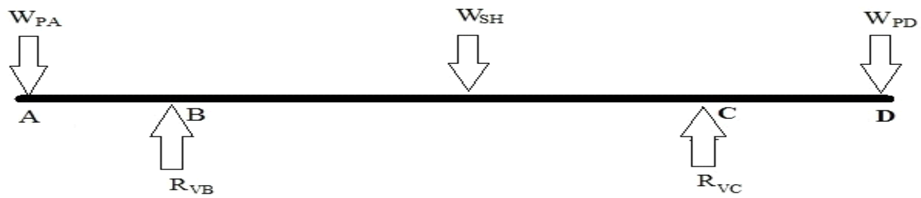

Fig. 3: Vertical Shear Force Diagram'

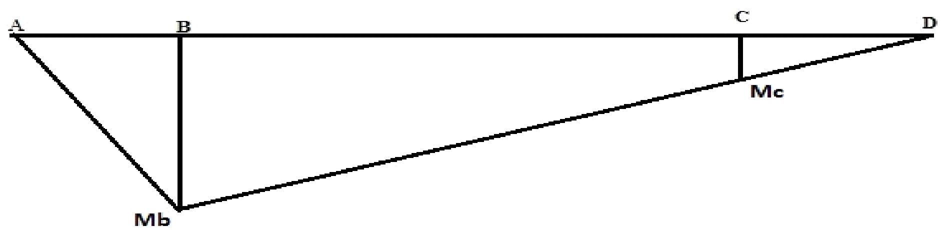

Fig. 4: Vertical Bending Movement Diagram

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,
$R_{AH} + R_{BH} = (F_1 + F_2) + (F_3 + F_4)$

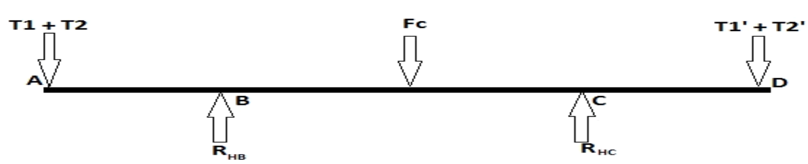

Fig. 5: Horizontal Shear Force Diagram

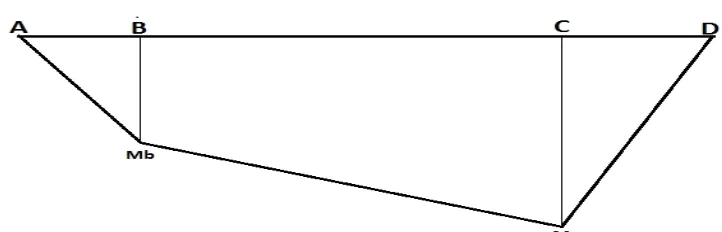

Fig. 6: Horizontal Bending Movement Diagram

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,

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

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

$$\text{B.M. at C, } M_{CH} = R_{AH}$$
$$\text{B.M. at D, } M_{DH} = R_{BH}$$

Resultant Bending Moment,

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

Now, diameter of shaft,

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

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

E. Design of Pulley

L_P = 11 mm;
b = 3.3 mm;
h = 8.7 mm
e = 15 $\pm\pm$ 0.3;
f = 9-12 = 10.5;
$\alpha\alpha = 34^{\circ\circ}$;
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 $\sqrt{D}\sqrt{D}$ + 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, $M = \frac{(F_1 - F_2)(D - D_h)}{n}\frac{(F_1 - F_2)(D - D_h)}{n}$
n = no. of arms
D_h = Hub diameter

F. Fabrication

Mechanical Components
- Hopper
- Semicircular net (sieve)
- Roll shaft (main shaft)
- Bearing
- Foundation frame
- Pulley (2Nos.)
- Belt(1Nos.)

III. CONCLUSION

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

REFERENCES

[1] Y.V. Mahatale and V.P. Pathak, " Physiological evaluation of different manually operated Corn shelling methods"
[2] Ilori T. A., Raji A. O and O. Kilanko, " Modelling some ergonomic parameters with machine parameter using hand powered Corn Sheller"
[3] B. ASHWIN KUMAR AND SHAIK HANEEFA BEGUM, "Design, development and performance evaluation of a hand operated Maize Sheller"
[4] Pratima Pandey, Jwala Bajrachrya and S Pokhare "Influence of corn seed processing with a locally produced sheller on seed quality and their damage"
[5] Design for a pedal driven power unit by David Weightman,Lanchester polytechnic, United Kingdom
[6] 6 www.shellermechanism.com
[7] Gite, L.P. and Yadav, B.G. 1989. Anthropometric survey for agricultural machinery design, An Indian case study. Applied Ergonomics. 20: 191-196
[8] Kumar, V.J.F. and Parvathi, S. (1998). Ergonomic studies on manually operate maize Sheller, Agricultural. Engineering Journal, 7(1): 37-45.
[9] Oriaku E.C, Agulanna C.N, Nwannewuihe H.U, Onwukwe M.C and Adiele, I.D "Design and Performance Evaluation of a Corn De-Cobbing and Separating Machine" Volume-03, Issue-06, pp-127-136
[10] Shiwalkar B.D.,''Design data for machine elements'', 2010 Denett & Company
[11] Rattan S.S, ''Theory of machine'', edition 2012, S.Chand Publication
[12] Bhandari V.B., ''Design of machine elements''.3rd edition,2010 the Tata McGraw Hill Education Private Limited
[13] J. R. Immer, Material handling, McGraw Hill book company pvt. Ltd., Dec 1953
[14] R. S. Khurmi" and "J. K. Gupta", Theory of machine by, S Chand and co ltd, 14 edition, Aug. 1, 2005
[15] Hajra Chaudhari S.K. and A.K., Workshop technology, Arnold Publication, 1956

