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Design & Fabrication of a Motorized Maize Shelling Machine

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Abstract—*The processing of agricultural product into quality forms not only prolongs the useful life of these products but also increases the net profit farmers make from such products. In this work, emphasis was placed on demand led design which involved understanding the need of the farmer and designing an appropriate system that meets that need. Many farmers grow maize but could not afford the cost of acquiring some of the imported threshing machines because of their cost. Such people resort to manual means of threshing which results into low efficiency, high level of wastage and exerting of much labour. This machine was constructed to shell maize and separate the cob from the grains.*

1. INTRODUCTION

Maize, the American Indian word for corn, means literally that which sustains life. It is, after wheat and rice, the most important cereal grain in the world, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and, more recently, fuel [1] In Africa, maize has become a staple food crop that is known to the poorest family. It is used in various forms to alleviate hunger, and such forms include pap or ogi, maize flour, and etc. It is because of the importance place of maize that its processing and preservation to an op-timed condition must be analyzed. In Asia, maize production is over 200 billion kilograms a year and it is expected that the total maize production in developing countries will eventually overtake production in industrialized countries. (J.N. Nwakaire et al., 2011)There have been large variations in the production of maize in India since independence. However on the other side the running cost and the initial cost of existing thresher are so high that poor person who has the less then the acreage farms cannot afford it. Instead of two people only one person can do the work and acquire good quantity of production without any difficulty. The production cost is also less for this machine. These machines have good production rate but production rate but production rate depends upon availability of electricity

Due to the frequent load shading the production rate have been decreased. This demand power will be useful in to ascertain the dimension of various components associated with the machine by obtaining design dimensions of components' fabrication will be done at last trials will be taken to ascertain viability and production capacity

In India, Corn is emerging as the third most important crop after rice and wheat, and it has significance as a source of a large number of industrial products besides its use as human food and animal feed Corn is also a versatile crop, allowing it to grow across a range of agro-ecological zones. In our country, most of land use for agricultural purpose which produces semi-finished products. Corn also is one of the agricultural semi-finished goods. Every part of Corn has economic value as the grain, leaves, main crop stalk, tassel and cob can all be used to produce a large variety of food and non-food products. In India Corn is grown in all the seasons, i.e., kharif, Rabi and summer. After harvesting with sickle and plucking of cob manually, dehusking of cob is done by hand to remove its outer sheath and further grain is obtained by shelling the cob traditionally, i.e. by beating the dehusked cobs with sticks or with fingers or sickle, etc. This activity is mostly done by farmer women. In our country, most of the farmers shell corn by mainly three methods namely shelling cob grain by hand; hand operated corn Sheller and beating by stick method were carried for removing corn kernel from the cob. The Corn shelling was designed and built to improve the standards of living of people living in villages of developing countries. There are several electrical operated Corn shelling machines for mass shelling. Mostly farmers used to take their unshelled Corns to such industries were they get their final product that is shelled Corn and then they used to sell this product to the market. This incurred the cost of transportation between farms to machine industry increase the cost of product. Most of contractor used to give less cost for unshelled Corn and they got the profit of shelled Corns.

The problems are similar and manifold. Part of the solution to these problems lies in the evolution of an Intermediate Technology i.e. Low capital, labor-intensive, locally based. This concept of a technology more appropriate to the needs of developing countries can be applied equally well to agricultural mechanization. The problems of underdevelopment are particularly acute in the rural areas of countries, where the poorest people live and where agricultural underproduction and migration has most effect. This synopsis on the design and fabrication of motorize operated Corn shelling machine that will remove corn from corn kernel.

2. LITERATURE SURVEY

Maize shelling a post-harvest operation is the removal of maize seeds from the cob. This operation can be carried out in the field or at the storage environment. Maize shelling therefore is an important step towards the processing of maize to its various finished products like flour. The different methods of maize shelling can be categorized based on various mechanization technology used. These includes: hand-tool-technology, and engine power technology.Maize production in Nigeria is of great importance with the increase in population and use of maize grain, the market demand for maize grain also increased. However, maize shelling in developing and under-developed nations has been and remains a serious problem to its processing as it is tedious and often require considerable labour hours (Abdullah et al, 1979).

2.1. Y.V. Mahatale and V.P. Pathak "Physiological Evaluation of Different Manually A. Operated Corn Shelling Methods"

Corn is the Third largest cereal produced in the world with a trend of rising production in India. The normal area for Corn in India was 77.27 lakh hectares with production about 150.91 lakh tones in the year 2007. Rajasthan has the largest area 10.62 lakh hectares under cultivation among all states with total production of 21 lakh tones. Four method of Corn shelling namely shelling cob grain by hand, octagonal Corn Sheller, hand operated Corn Sheller and beating by stick method were carried for removing Corn kernel from the cob. For ergonomically evaluation ten male agricultural subjects of 25-35 yr. age group were randomly selected for study. Present traditional method of shelling Corn has proved to be inefficient, laborious, time consuming and low output. The energy expenditure rate was highest for beating by stick method (3.84 kcal/min) and lowest for octagonal Corn Sheller (1.52 kcal/min). Traditionally Corn is threshed by shelling cob grain by hand and beating the cob by stick. At present Corn shelling has been improved by the use of tubular Corn Sheller and hand operated Sheller. The energy expenditure rate was highest for beating by stick method (3.84 kcal/min) and lowest for octagonal Corn Sheller (1.52 kcal/min). Energy expenditure rate for shelling cob grain by hand and octagonal Corn shelling operation could be scaled in "Very light" category of work load. Whereas the hand operated Corn Sheller and beating by stick method could be scaled as in "Light" category of work load. For Corn shelling operations octagonal Corn Sheller and hand operated Corn shelling are superior to shelling cob grain by hand and beating by stick Method.

2.2. Ashwin Kumar and Shaik Haneefa Begum "Design, Development and Performance Evaluation of a Hand Operated Maize Sheller"

The author conducted a research on design, development and evaluation of hand operated Corn Sheller in College of Agricultural Engineering during the year 2012-2013.The traditional shelling methods are rubbing the Corn cobs against each another, rubbing on bricks or stone and by using iron cylinder consisting of wire mesh inside. These methods are time consuming involves drudgery. In view of this, the study was undertaken to design, development and evaluation of hand operated Corn Sheller. The Corn Sheller consisted of a cylinder and a concave. The cylinder made up of high carbon steel of size diameter 21 cm. The cylinder length 86 cm, having beaters which rotates along the cylinder and separates grains from the cobs. While the concave was fabricated using 5 mm size mild steel rods. The length of concave was 91 cm with slotted opening size of 30.3cm×2.5cm. It was observed by the author that for hand operated Corn Sheller at a moisture content of 12% w.b. and at a feed rate of 130kg/h, the shelling efficiency, unshelled percentage and visible damage was found to be 99.56%, 0.44% and 1.07%, respectively

2.3 Pratima Panday, Jwala Bajrachrya and Pokharel" Influence of Corn Seed Processing with a Locally Produced Sheller on Seed Quality and Their Damage"

The author says that corn is one of the most important staple crops in the world. It is also the second important food crop in Nepal, that more than 45% of the population in mid-hill and high-hills considers maize meal to be their survival food. Community Based Seed Production (CBSP) is a sustainable agricultural phenomenon implied in hill and high-hills of Nepal under the Hill Maize Research Program in collaboration with Nepal Agricultural Research Council (NARC); CIMMYT, Nepal; Directorate of Crop Development (CDD), with the objective to produce quality seeds of maize at local level and to increase the use of improved quality seeds and eventually increase the crop production. Maize kernels are in general shelled from the cob manually using hands. Manual shelling of maize is labor intensive and typically takes weeks and months for shelling the manual harvest. The mechanized alternatives to shelling maize by hand are available but they are often unaffordable for subsistence farmers. Wooden corn Sheller is a simple but traditional device made locally for shelling the maize kernels and distributed to CBSP farmers group. All data observed and analyzed in the present study reveals the corn Sheller is equally efficient and saved the time, labors and other resources. The corn Sheller could be used for maize processing and conditioning.

3. PROJECT OBJECTIVES

- The main aim of this project is to overcome the traditional method.
- Motor selection - to choose proper electric motor for this application based on torque speed and power.
- To reduce the power using belt drive and pulley system to form uniform shelling and threshing operation.
- To construct a structure to fit all accessories to it with proper moving attachments.
- Design of shelling shaft.
- Retraction of shells from corn hubs.
- To design threshing shaft.
- To design separation zone for corn shells and seeds.
- To increase the efficiency.
- To reduce the hard work.
- To reduced time to shell the CORN.

To develop a low cost machine which can be used by farmer to convert their semi-finished (CORN) into finished product (Corn) it satisfies the need of village people to earn more money.

4. PROJECT METHODOLOGY

- To construct working drawing of assembly by computer aided design procedure.
- To select optimum motion for threshing and shelling operation.
- To design a frame to sustain all these accessories and all loads developed by it.
- To design shaft for shelling operation to run shelling operation smoothly.
- To design belt drive and pulley system for threshing and shelling operation.
- Design of shaft for threshing operation.
- To perform test on corn having different moisture contain from 20% to 75%.

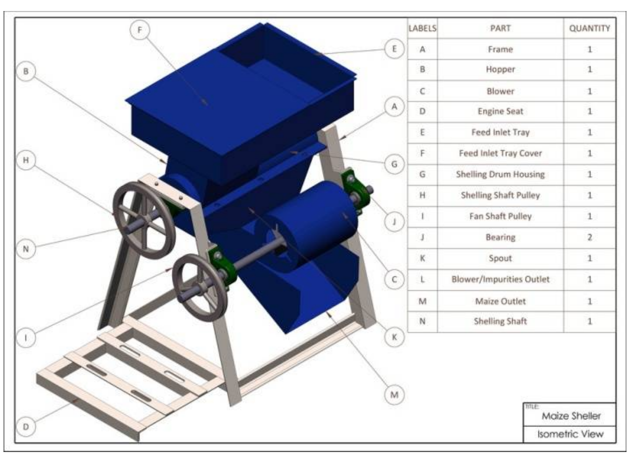

Figure 1 Maize Sheller Machine Cad model

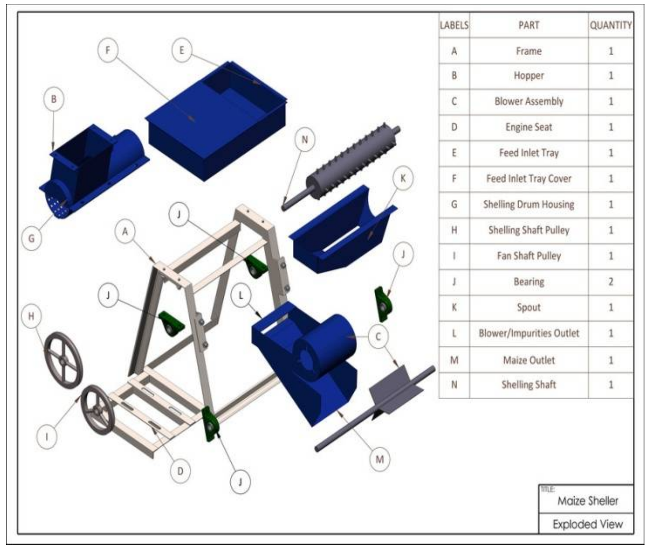

Figure 2 Maize Sheller Machine D-Assembly

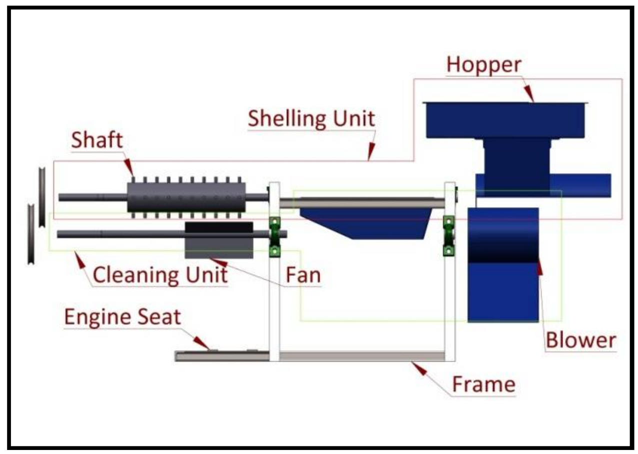

Figure 3 Maize Sheller Machine Unit

4.1 Belt, Pulley and Shaft Design for Shelling Operation:

A solid Shaft made up of mild steel 40C8 having yield strength as 380 Mpa was choose. This shaft was coupled to electric motor rotating at 1440 rpm. The following design parameters are:

1. Permissible Shear Stress (Ʈ):-

When the external force acting on the component tends to slide the adjacent planes with respect to each other, the resulting stresses in these planes are called shear stress.

τ = Syt/ F.S. = 0.5 (Syt) / F.S. = 0.5 (380) /1.5

= 126.66 N/mm^2

2. Torsional Moment (Mt):-

M_t = 60 ×106 (KW) / 2ΠN. = 60 × 10^6 (1.492) /2Π (710) = 20066.97 N-mm.

3. Bending Moment:-

For Pulley (1)

D = 130.

Calculation of P_1 and P_2.

$M_t = (P_1 - P_2) \times (D/2)$.

$20066.97 = (P_1 - P_2) \times 65$

$(P_1 - P_2) = 308.72$

$P_1 / P_2 = e^{0.3\pi}. = 2.566$

$P_1 = 2.566 \times P_2$

Put value

$2.566P_2 - P_2 = 308.72$

$P_2 = 197.14N$

$P_1 = 2.566 \times 197.14 = 505.86$ N

Let, $R_1 + R_2 = 703$

Taking moment at R_1,

$R_2 * 800 = 703 * 1000$

$\therefore R_2 = 878.75$ N

From equation

$R_1 = 175.75$ N

Now, bending moment is given by,

$M_b = (878.5*200) + (175.75 * 1000)$

=351.45 N-m

4. Shaft Diameter on Strength Basis:

Transmission shafts are subjected to axial tensile force, bending moment or torsional moment or their combinations.

Most of the transmission shafts are subjected to combined bending and torsional moments.

We know,

$d^3 = \{[16 / (\tau \times \pi)] \times (Mb^2 + T_2^2)^{0.5} \}$

$= \{[16 / (126.66 \times \pi)] \times (351450^2 + 15830^2)^{0.5} \}$

$d = 24.18 \approx 25$ mm

5. Length of belt:-

$L = 2c + (\pi/2) (D + d) + (D - d)^2/(4c)$

$L = 2*600 + (\pi/2) (130 + 63) + (130 - 63)^2/ (4*600)$

L=1505.03mm

From std. table

L = 1600mm

Corrected center distance:-

$L = 2c + (\pi/2) (D + d) + (D - d)^2/(4c)$

$1600 = 2c + (\pi/2) (130 + 63) + (130 - 63)^2/ (4c)$

C = 645mm

4.2 Belt, Pulley and Shaft Design for Threshing Operation

Speed (N) = 600 rpm

P = 0.746 KW, Syt = 380N/mm^2

ϴ = Angle of wrap

$P1/ P2 = e^{\mu\theta}$

P1/ P2 = 2.566

1. Permissible Stress (Ʈ):-Shear

Ʈ = 0.5 (Syt) / F.S = 0.5 (380) /1.5. = 126.66 N/mm2

2. **Torsional Moment (Mt):-**

Mt = 60 × 106 (KW) / 2ΠN= 60 × 106 (1.492) /2Π (600)

= 23745.92 N-mm.

3**. Bending Moment:**

For Pulley, D = 125mm

Calculation of P_1 and P_2.

$Mt = (P_1 - P_2) \times (D/2)$.

$18996 = (P_1 - P_2) \times 62.5$

$(P_1 - P_2) = 303.936$

$P_1 / P_2 = e^{0.24\pi}$

$P_1 / P_2 = 2.566$

$P_1 = 2.566 \times P_2$

Put value

$2.125P_2 - P_2 = 368.15$

$P_2 = 194.08$ N

$P_1 = 2.566 \times P2$.

$P_1 = 2.566 (194.08)$

$P_1 = 498.02N$

Let, $R_1 + R_2 = 692.1$

Taking moment at R_1,

$R_2 * 850 = 692.1 * 1000$

$\therefore R_2 = 814.23N$

$R_1 = 122.13$ N

Now, bending moment is given by,

$M_b = (814.23*150) + (122.13 * 1000)$

=244.264 N-m

4. Shaft Diameter on Strength Basis:

$d^3 = \{[16 / (\tau\times\pi)] \times (Mb^2 + T_2^2)^{0.5} \}$

$\{[16 / (126.66\times\pi)] \times (244264.5^2 + 18996^2)^{0.5} \}$

$d = 24.18 \approx 25$ mm

Length of belt:-

$L = 2c + (\pi/2) (D + d) + (D - d)^2/(4c)$

L = 1297.23mm

From std. table

L = 1250mm

Corrected center distance:-

$L = 2c + (\pi/2) (D + d) + (D - d)^2/(4c)$

$1250= 2c + (\pi/2) (125 + 63) + (125 - 63)^2/ (4c)$

C=476mm

Frame: The frame was made up of mild steel. The overall dimensions of frame were 80.5 cm length, 60 cm width and 136.5 cm height. The Sheller unit was fixed to this framework. The frame has a bottom set, stand, and flywheel

Cylinder: It is made up of high carbon steel of 21 cm diameter. The length of cylinder was 86 cm having adjustable metal pegs/ spikes which are placed at a spacing of 9 cm in equally spaced in four rows which rotate along the cylinder and separate grains from the cobs.

Hooper: The hopper was fabricated in trapezoidal shape, using mild steel of 18 gauge thickness and dimensions of 28 cm length, 18 cm width and 39 cm height. It is placed on the outer casing for feeding the maize cobs.

Outer Cover: It was made up of 16 gauge mild steel sheet and was bent to semicircular shape of diameter 43.3 cm and was rigidly fixed to give protection to the cylinder and to avoid grains spilling out. It has a provision for attaching to hopper. A flange was attached to it along the length to facilitate cleaning of inner cylinder

Design of Pulley:

Length of belt between driving shaft and driven shaft

d=diameter of driving pulley=50.8mm

D=diameter of driven pulley=304.8mm

C=central distance between driving & driven pulley=500mm

Length of belt $L= (r1+r2) +2X+ (r2-r1)^2/2$

$L=л (25.4+152.4) +2 \times 500 + (152.4-25.4)^2/2$

L=1591.07 mm.

Selection of Motor:

A two phase motor of 0.25 hp running at 1450 rpm is chosen based on the load conditions. The motor is prime drive in the machine it converts electrical power into mechanical power. It gives rotary motion to mechanism. The motor design is a very important design aspect in machine design practice.

To calculate the power

$P = (2\pi NT / 60)$

$(0.25 \times 746) = (2\pi \times 1450 \times T / 60)$

$T = (186.5 \times 60 \times 1000 /2\pi \times 1450)$

$T = (186.5 \times 60 \times 1000 /2\pi \times 1450)$

T = 1228.23 N-mm

Design of Angles:

Due to the load of plate, job and filing force, the angle-link may buckle in two planes at right angle to each other. For buckling in the vertical plane (i.e.in the plane of the links), the links are considered As hinged at the middles and for buckling in a plane perpendicular to the vertical plane, it is considered as fixed at the middle and the both the ends.

Here,

The maximum load due to above factors = 50 kg (including friction)

F= 50kg = 50 x 9.81 = 490.5 N.

We know that the load on each link, $F_1 = 490.5/4 = 122.625$ N.

Assuming a factor of safety as 3,

The links must be designed for a buckling load of Wcr = 122.625 x 3 = 367.875 N

Let t_1= Thickness of the link

b_1= width of the link so, cross sectional area of the link = A = $t_1 \times b_1$

Assuming the width of the link is three times the thickness of the link, i.e.$b_1 = 3 \times t_1$

Therefore

$A= t_1 \times 3 t_1 = 3 t_1^2$

And moment of inertia of the cross section of the link,

$I = 1/12\, t_1 b_1^3 = 2.25\, t1^4$

We know that $I = AK^2$, where k = radius of gyration.

$K^2 = I/A = 2.25\, t_1^4 / 3\, t_1^2 = 0.75\, t_1^2$

Since for the buckling of the link in the vertical plane, the ends are considered as hinged,

Therefore, the equivalent length of the link L = l = 600 mm.

And Rankin's constant, a = 1/ 7500 Now using the relation,

Here stress-f = 100 N / mm^2

$$367.875 = \frac{100 \times 3 \times t_1^2}{1 + (1 / 7500)(6002/0.75t_1^2)}$$

$300 t_1^4 – 367.875 t_1^2 –64 \times 367.875 = 0$

$t_1^2 = 26.20$

$t_1 = 5.1$ mm

$b_1 = 3 \times t_1 = 3 \times 5.1 = 15.35$ mm.

But the standard angle available of 35x 35 x 5 mm. Hence considering the safety aspect it has been selected. This can bear the impact loading. Hence the design is safe [5, 6].

Design of Bearing: Depending upon the nature of contact the antifriction bearing has been chosen**.**

Design of Hopper: Hopper design is based on a common criterion for it to function. The criterion is called the "Angle of repose". Angle of repose is the maximum slope at which a heap of any loose or fragmented bulk material will stand without sliding. It can also be called the angle of friction of rest (Eugene and Theodore, 1986). This type of hopper is a gravity discharge one and the recommended angle of inclination of hopper for agricultural materials is 80 or more, higher than the angle of repose (Micheal and Ojha, 1987).

The angle of repose of maize is 270 (Richey, 1982). This hopper has a shape of a truncated prism.

B= Width of hopper top= 280 mm (chosen)

L = Length of hopper top = 285 mm (chosen)

b = Width of hopper bottom = 130 mm (chosen)

l= Length of hopper bottom = 160 mm (chosen)

h= Vertical height of hopper = 220 mm (chosen)

y = Slant height of hopper

Ø= Angle of inclination of hopper

x = √ 752 - 62.52

x = 41.46mm

Therefore, from the right angled triangle

$$\text{Tan } Ø = \frac{220}{41.46}$$

Tan Ø = 5.306

Ø = 79.30^0

Hence, since the angle of inclination of hopper, O is greater than the angle of repose of maize plus 80; the hopper will do the required job.

The Volume of Hopper

The volume of hopper can be calculated using equation below:

$$Vn = \frac{(Vct-Vcb)}{2} – Vcb$$

Where

Vct = Volume of cuboid having the hopper top, has its length and breadth

Vcb= Volume of cuboid having the hopper, bottom has its length and breadth

Note: The height of cuboid for calculating Vct and Vcb is the vertical height of the hopper (220 mm).

Therefore,

Vct = 285 x 280 x 220

= 17556000 mm^3

Vct = 0.017556m^3

Vcb = 160 x 130 x 220

= 4576000 mm^3

Vcb = 0.004576 m^3

Therefore,

Volume of hopper =

$$Vh= \frac{(0.017556 -0.004576)}{2} – 0.004576$$

= 0.004202m^3

Determination of Number of Spikes on the Shelling Cylinder:

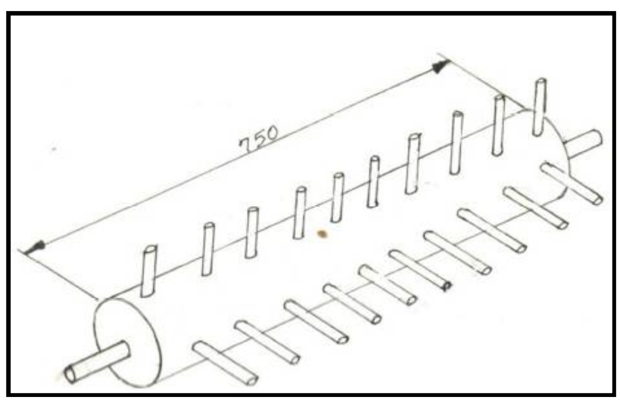

Figure 4: No. of Spikes on the Shelling Cylinder

The number of spikes on the shelling cylinder is given by

$$Np= \frac{Lc}{Ssr} \times \frac{\pi d}{SSc}$$

Where, N_p = Number of spikes on shelling cylinder

L_c = Length of shelling cylinder = 645 mm

S_{sr} = Spike spacing on row = 50 mm

S_{sc} = Spike spacing on circle = 80 mm

d = Diameter of shelling cylinder = 92 mm

Therefore $N_p = \frac{645}{5} \times \frac{\pi 92}{80}$ mm

= (12.90) x (3.6128)

= 46.6

= 47

The total number of spikes on the shelling cylinder,

$N_p = 47$

Calculation of The Overall Height:

Lengths AC and EG are calculated by using the Pythagorean Theorem,

$AC^2 = AB^2 + BC^2$.

Also, $AC = (AB^2 + BC^2)^{1/2}$,

And $OC = (AB^2 + BC^2)^{1/2}/2$,

$EG^2 = EH^2 + HG^2$,

$EG = (EH^2 + HG^2)^{1/2}$

And $MG = [(EH^2 + HG^2)/2]^{1/2}$

From the principle of similar triangles, for triangles PMG and POC:

PM/MG = PO/OC, or PM = PO x MG/OC.

Then the volume of the hopper is given by:

V_{hopper} = [(area of base) x height]/3

= [(AB x BC) x h – (EH x HG) x x]/3,

Where:

h = overall height;

x = height of the truncated top

5. CONCLUSION AND FUTURE WORK PLAN:-

Conclusion:

Having tested the performance of the fabricated machine, it could be concluded that the shelling efficiency, cleaning efficiency, grain recovery efficiency, Sheller performance index, total grain losses and output capacity are 87.08%, 95.89%, 95.48%, 91.55%, 2.96% and 623.99kg/hr. respectively at 13% moisture contents of maize and at 886rpm shelling speed The best moisture content of maize for shelling according to this evaluation is 13% dry basis and the best shelling speed is 886rpm.

Using improved power operated Sheller. It was found that shelling efficiency and capacity of the Sheller were 98.51 per cent and 402.01 kg/h, respectively. By considering all factors such as percentage of whole kernels, efficiency, unshelled kernels and capacity, it was found that shelling process of maize having 13 per cent moisture content, fed at cylinder speed of 350 rpm gave better results but there was considerable damage as compared to slow speed of operation.

Self-reliance is the major drive of development and vibrant economy. This machine has been fabricated with the use of locally available materials. The machine is simple, less bulky and effective with its self-cleaning ability. Grains loss and mechanical visible damage have been very minimal. Performance test has revealed that the efficiency of the machine is 99.2%. The machine threshes 200kg of maize within an hour. The machine can either be powered by an electric motor or engine (diesel or petrol). The electric motor seat provides adjustment so that the V-belt can be fixed easily. There is no doubt that the machine will ease the long term scourge of youth unemployment in our land.

FUTURE WORK PLAN:

The process of maize shelling can be automated by using motors to for reducing human interaction with the process. The operated maize Sheller produces noise during operation. To avoid this, improvements can be made in the design. To increase the productivity, the design can be modified in such a way that more than one cob can be inserted at a time. The machine has a great future scope in any industry and for farmers due to its ease of use, moderate cost and simple design.

The main the advantage lies in its low operating costs. Savings resulting from the use of this device will make it pay for itself within the short period of time.

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