Design and Fabrication of Sunflower Seed Extracting Machine

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***Abstract* – The present project focuses on solving the problem faced by the farmers in separating the seeds from the sunflower. Farmers use the manual methods due to unavailability of suitable machinery for sunflower threshing. During manual sunflower production, the most time and labor-consuming operation is the threshing of sunflower by beating the sunflower heads with a stick, rubbing wear heads against a rough metal surface or power tiller treading machine. The aim of the project is to fabricate a machine which will separate the seeds from the sunflower. The main components required to fabricate the machine are Blades, Shaft, Pulley, Disk plates, Blower, Hopper, Tray, Sieves, Motor, V-Belt and Pillow Block Bearings. The sunflower threshing unit operates on the principle of axial flow movement of the material. The sunflower is threshed in a closed threshing unit by rotating blades where the seeds are separated from flower and husk of the flower is removed through blower. Finally the cleaned seeds are collected in a Tray.**

***Keywords* – Design and Fabrication, Sunflower, Seed Extractor etc.**

I. INTRODUCTION

The sunflower belongs to the genus Helianthus annus. "Helios" translates to sun in Greek and "annus" means the flower is an annual. The sunflower's name is believed to have originated from the connection of the plant to the sun, both in looks and behaviour. At a glance, the sunflower does indeed resemble the sun. Imagine a large circle with bright yellow fiery beams coming out all around it, just as a child would draw the sun in a picture. Certainly looks like a sunflower, doesn't it? Second, and most interesting, is the fact that the sunflower actually tracks the sun's position in the sky. This is called heliotropism and is explained below.[6][9]

The sunflower can produce vast quantities of oil per acre sown, since oilseed sunflower varieties are approximately 40 - 50% oil by weight. Sunflower seed yields can exceed 3000 pounds per acre, but more commonly, crops tend to average between 1200 - 2000 pounds per acre. Sunflower seed yields are less determined by dry spells than by pest pressures and the initial seed selection. [7]

Sunflower (Helianthus annuus L.) is one of the most important oil crops in the world and is ranked 5th in oil production in the world (FAO, 2009), but it is the most popular one in some countries such as Iran and Turkey. The price of sunflower seeds and oil depends on their production level. Thus, the production capacity of sunflower seeds highly affects the development of the processing industry. According to the FAO reports (2010), the world supply of sunflower seed oil for 2008- 2009 is estimated at 11.7 million tons (+18% compared with the previous marketing year) [10]

Present work, is formulated based on problems faced by the farmers in and around Erode in removing the seeds from sunflower. It takes a lot of time and requires a large man power labour for removing the seeds.Either farmers follow manual method of removing or they have to depend upon the industries which lend them large machines to remove the seeds. In the manual method they remove seeds by sliding the sunflower over a wire mesh or thrash it with a metal weld which is really problematic and involves a lot of labours which will land them in wastage of time and energy.Similarly in the second method they used to pay a sum of amount to the industries and have to get the seeds removed which is also going to be burden and loss for the farmers. Hence our project idea is going to be a great boon for farmers in terms of time as well as money.

The main objective of this paper is to Design and Fabricate SUNFLOWER SEED EXTRACTING MACHINE at a community scale.

1. A review of the currently existing sunflower seed extracting machine or in other words sunflower threshing machines in terms of their cost and performance characteristics.
2. A qualitative study of the types of materials and components suitable for the fabrication of the threshing machine and their availability in the market.
3. Modelling of the sunflower threshing machine by using CATIA V5 modelling software.
4. Fabrication of the seed extracting machine based on the design and modelling details.
5. Testing of the machine for its output and its operations at load and no load conditions.

II. DESIGN AND CALCULATIONS

Calculations were carried out in order to determine the dimensional and other mechanical properties such as Stress, Strain, and Torque etc. so as to withstand the effect of various loading on the machine. The following details furnish about the design of various parts those have been used in this machine. [8]

A. Design of Shaft

Design of shaft involves the determination of diameter in the case of solid shaft. Two criterions are generally used for this purpose they are

1. Strength criterion: Torsional strength is defined as the torque per unit maximum shear stress. Based on this, the maximum shear stress induced on the outer surface should not exceed the allowable value.
2. Rigidity criterion: Torsional rigidity is the torque required to produce a unit angle of twist in a specified length of the shaft. According to this criterion the diameter of the shaft is determined, based on the prescribed value of the limiting angle of twist θ.

i. According to torsional rigidity, the diameter of the solid shaft. [18][3][4][8]

$$D = \left(\frac{584 M_t L}{G\theta}\right)^{\frac{1}{4}} \text{--} (1)$$

Torque $M_t = 9550 \times 1000 \times \frac{N}{n}$ where M_t in N-mm

M_t = 9894.86 N-mm

$$\therefore \text{Diameter } D = \left(\frac{584 \times 9894.86 \times 1000}{(80\times10^3)\frac{\pi}{180}}\right)^{\frac{1}{4}} \quad D = 45.10 \text{ mm}$$

ii Diameter of the shaft subjected to Combined Bending and Torsion. According to maximum shear stress theory

$$D = \left[\frac{16}{\pi \tau_{ed}}\{(K_b.M_b)^2 + (K_t.M_t)^2\}^{\frac{1}{2}}\right]^{\frac{1}{3}} \text{------------------------} (2)$$

K_b = 1.5 K_t = 1.0 Constants for ASME codes (Shock and Endurance Factors)

Torque acting on shaft is given by

$$T = \frac{60 \times P}{2\pi N} \quad \text{--} \quad (3)$$

$$T = \frac{60 \times 746}{2\pi \times 720}$$

T = 9.826×10^3 N-mm

T = $(T_1-T_2)\times r$ -- (5)

$(T_1-T_2) = \frac{9.826\times10^3}{100}$

(T_1-T_2) = 98.26 N

Coefficient of friction,μ=0.3 angle of contact, θ=180˚

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$T_1 = 2.5663\ T_2$

T_2 = 62.735 N and T_1 = 160.990 N

Load due to pulley W_T,

$W_T = T_1+T_2$+dead weight

W_T = 62.735 + 160.99 + 4.905

W_T = 228.345 N

From Vertical Bending Moment Diagram(VBMD) we have

BM @ A = 0 N-mm

BM @ B = 475.13×10^3 N-mm

BM @ C = 237.5×10^3 N-mm

BM @ D = 0 N-mm

Therefore,

Maximum Bending moment $M_b = 475.13 \times 10^3$ N-mm

Maximum Torque M_t = 9894.86 N-mm D= 40mm

Diameter of the solid shaft subjected to combined bending and torsion, according to maximum shear stress theory

$$D = \left[\frac{16}{\pi\times176.5}\{(1.5\times475\times10^3)^2 + (1\times9894.86)^2\}^{\frac{1}{2}}\right]^{\frac{1}{3}} \quad (6)$$

Therefore the diameter of the shaft is 40 mm.

B. Design of Pulley and Motor Specifications

1 HP Single phase Induction Motor, Speed – 1440 rpm, 746 W, 230V, 6A, 50Hz

$$P = \frac{2\pi NT}{60} \text{---} (7)$$

$$T = \frac{60\times746}{2\pi\times1440}$$

T = 4.9471×10^3 N-mm

Since desired speed for threshing drum is 720 rpm we have

N_1 = 1440 rpm D_1 = 100 mm

N_2 = 720 rpm,

The speed ratio is given by

$\frac{N_1}{N_2} = \frac{D_2}{D_1}$ -- (8)

$\frac{1440}{720} = \frac{D_2}{100}$

$D_2 = 200$ mm

C . Design of V-Belt

V-Belts are wedge shaped with trapezoidal cross-section. They are endless belts moulded to shape and length. They will have nylon chords for load carrying and are covered with cotton fabric and moulded in rubber to have good friction co-efficient. They V-belts work in V-grooved pulleys generally known as sheaves. They are better suited for smaller centre distances and for transmitting medium to high powers. [18][3][4][8]

Speed of motor $n_1 = 1440$ rpm
Speed of threshing drum shaft $n_2 = 720$ rpm
Diameter of driver pulley $d_1 = 100$ mm
Diameter of driven pulley $d_2 = 200$ mm

i. Velocity $V = \frac{\pi.\mathrm{d1.n1}}{60000}$ ---------------------------------- (9)

$V = \frac{\pi\times100\times1440}{60000}$
V = 7.5398 m/s

ii. Equivalent pitch diameter of smaller pulley

$d_e = d_1 \cdot k_d$ $k_d = 1.31$ (small diameter factor- from DDHB)

$d_e = 131$ mm

iii. Belt cross-section

Based on d_e value from design data handbook the belt cross-section for $d_e > 125$ and <175 is B. for this cross section B, Power capacity is given by

$$kW = \left(1.08v^{-0.09} - \frac{69.68}{\mathrm{de}} - 1.78\times10^{-4}v^2\right)\times0.7355v$$

$$kW = \left(1.08\times7.5398^{-0.09} - \frac{69.68}{131} - 1.78\times\right.$$
10−4×7.53982×0.7355×7.539

kW = 1.8467 kW/belt

iv. Length of belt [18][3][4][8]

$$L = 2C + \frac{\pi}{2}(D+d) + \frac{(D-d)^2}{4C} \quad \text{--------------- (10)}$$

Assume average center distance C = 2D = 2×200

C = 400 mm

$L = (2\times400) + \frac{\pi}{2}(200+100) + \frac{(200-100)^2}{4\times400} =$
$1284.9876\ mm$
L = 1290 mm

v. Angle of contact [18][3][4][8]

$$\theta = 2\cos^{-1}\left(\frac{D-d}{2C}\right) \quad \text{----------------------------------- (11)}$$

$\theta = 2\cos^{-1}\left(\frac{200-100}{2\times400}\right)$
θ = 165˚

vi. Number of belts required

$$i = \frac{PK_s}{(kW)K_LK_a} \quad \text{------------------------------------- (12)}$$

From DDHB for cross-section B
$K_a = 1$, $K_L = 1.04$, $K_S = 1.54$

$i = \frac{0.746\times1.54}{(1.8467)\times1.04\times1} = 0.58$

i = 1 belt

Therefore, the V-belt required is of Cross-section B and number of belts required is 1

III. FABRICATION

Metal fabrication is the building of metal structures by cutting, bending, and assembling processes.

- Cutting is done by sawing, shearing, or chiselling (all with manual and powered variants) torching with hand held torches (such as oxy-fuel torches or plasma torches); and via numerical control (CNC) cutters (using a laser, mill bits, torch or water jets).
- Bending is done by hammering (manual or powered) or via press brakes and similar tools. Modern metal fabricators utilize press brakes to either coin or air-bend metal sheet into form. CNC-controlled back gauges utilize hard stops to position cut parts in order to place bend lines in the correct position. Off-line programming software now makes programming the CNC-controlled press brakes seamless and very efficient.
- Assembling (joining of the pieces) is done by welding, binding with adhesives, riveting, threaded fasteners, or even yet more bending in the form of a crimped seam. Structural steel and sheet metal are the usual starting

material for fabrication, along with the welding wire, flux, and fasteners that will join the cut pieces. [9][10]

A. Fabrication of Frame

Frame is the major support structure of the machine it withstands the load acting on the machine. All the components fabricated are assembled over the frame. The frame is made by using standard sections available i.e. the angle plates which are 50mm×50mm, 5mm thick and the angle is 90˚ between the adjacent plates. The angle plates are cut to the requirement and welded together for housing the machine components. The figure below shows the angle plate and frame fabricated for sunflower seed extracting machine using them. [9][10]

Fig. 1 Fabricated Frame

B. Step turning operation on solid shaft

As per the drawing the shaft of 40mm diameter and 1115mm length was chosen. The shaft is made of mild steel (C45). The raw shaft was purchased and step turned to the required dimensions in order to fit into the bearings and pulley. The shaft was turned using a conventional lathe machine to required tolerances. The figures below show the solid shaft and step turning operation on shaft. [9][10]

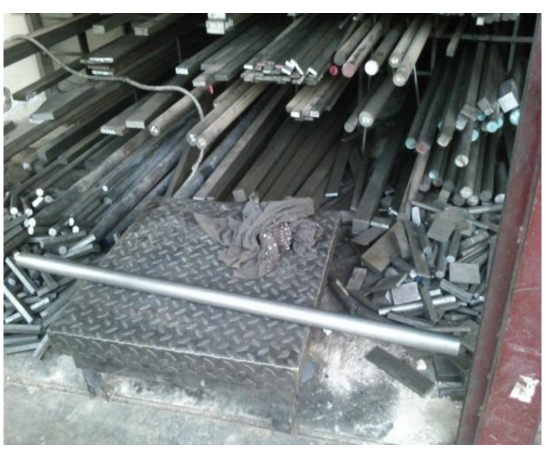

Fig. 2 Purchase of solid shaft of length 1120mm (Mild steel material)

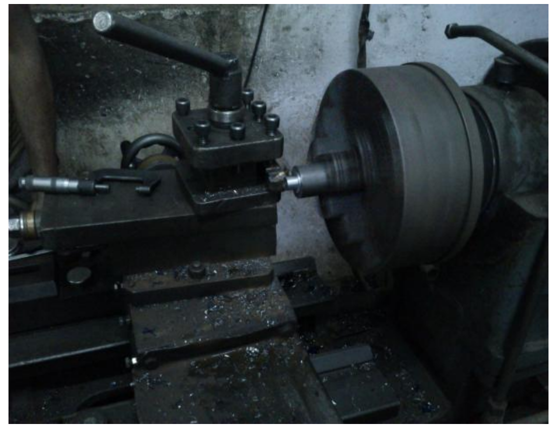

Fig. 3 Step turning operation on shaft

C. Fabrication of Threshing Rotor

Figure below shows the threshing rotor of the sunflower seed extracting machine. It is the most important part of the machine used to beat and thresh the sunflower. Here, we are using peg tooth with an open threshing rotor. 4 sets each of 12 teeth are welded on the each of the 4 strips which are placed at 90˚ around the circular plate as shown. The length of the each blade is 44mm and its thickness is 6mm. The blades are placed at a distance of 64mm along the length. [9][10]

Fig. 4 Fabrication of cutter strip with blades

Fig. 5 Fabrication of threshing Rotor

D. Fabrication of Threshing Drum Cover and Hopper

The threshing rotor needs to be covered with a cylindrical drum so as to thresh flowers within in this drum. The threshing drum cover houses the rotor with a clearance of 35mm. The threshing drum comprises of two semi-cylindrical sheets out of which one is perforated sheet. Both the sheets are welded together as shown in the figure. The side openings of the drum are covered by circular plates. Right end of the drum is covered by a circular plate with oval exit for the pulp of the flowers. Hopper is fabricated directly on to the drum as shown. The drum is of 920mm length and 280mm in diameter with a rectangle opening 100mm×150mm for hopper fabrication. [9][10]

Fig. 6 Fabrication of threshing drums Hopper

E. Fabrication of Helical Strips

The machine works on the principle of axial flow of material i.e. the flower is threshed inside the threshing Drum and moves helically along the length. Finally the pulp of the flower exits through an opening provided at the right end of the Drum. The circular strips are cut and bent helically and welded inside the drum. Three helical strips are placed in between every 4 blades. The figure below shows the helical arrangement made inside the threshing drum.

Fig. 7 Fabrication of Helical strips

F. Pulley Boring

Boring is a process of producing circular internal profiles on a hole made by drilling or another process. It uses single point cutting tool called a boring bar. In boring, the boring bar can be rotated, or the work part can be rotated.Lathe boring usually requires that the work piece be held in the chuck and rotated. As the work piece is rotated, a boring bar with an insert attached to the tip of the bar is fed into an existing hole. When the cutting tool engages the work piece, a chip is formed. Depending on the type of tool used, the material, and the feed rate, the chip may be continuous or segmented. The surface produced is called a bore.Large pulley of 8 inch diameter is bored to 30mm and small pulley of 4 inch diameter is bored to 24mm for proper fitting into shaft and motor. [9][10]

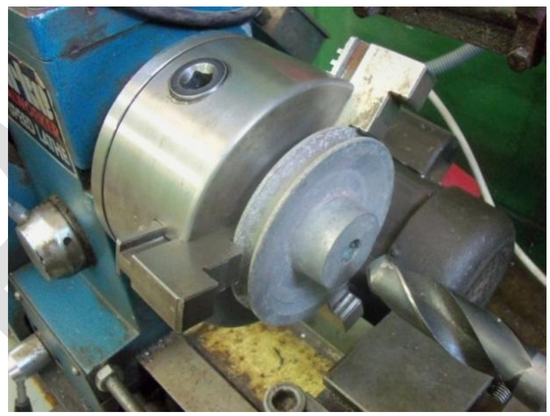

Fig. 8 Boring operation on both Pulleys

G. Power drive unit arrangement of Motor, Pulley, V-belt

The Power drive unit of the machine consists of 1HP single phase AC Induction motor which rotates at 1400 rpm. The pulleys are designed to transmit 700 rpm to the threshing rotor. The pulleys used are V-belt pulleys with a sheave present in them to accommodate V-belt. Two V-belt pulleys of 4 inch and 8 inch are used. V-belt of length 1290mm and width 29mm is used to transmit power from motor to the threshing rotor.

Fig. 9 Power drive unit arrangement

H. *Electrical connections (wiring and regulator)*

Motor being the running unit of the machine it needs single phase AC power source. Electrical wiring connection is provided from the source to the motor and the blower. Centrifugal Blower also needs AC power supply which is controlled through a regulator. The regulator controls the speed of the blower and the speed can be set to required rpm. [9][10]

Fig. 10 Electrical connections (wiring and regulator)

H. *Final Assembly of Machine*

All the components are fabricated and assembled together on the frame in their designed positions. The frame houses all the components like Motor, Centrifugal Blower, Bearings, Pulleys, Threshing Drum, Threshing Rotor, Collector sheet fabrication and wheels are provided to each 4 legs for easy convenience in moving the machine. The Motor, Centrifugal Blower and Bearings are mounted on to frame using thread fasting methods i.e. using Bolts and nuts. The collector sheet work, Threshing drum and wheels are welded to the frame. Finally the machine is painted and it is as shown below. [9][10]

Fig. 11 Final Assembly of Machine

Fig. 12 Angled View of the Machine

IV. RESULTS AND DISCUSSIONS

A. *Machine Productivity (Pth)*

To determine Productivity of the machine, following relationship was used, [18]

$$P_{th} = \frac{P_w}{t} \quad \text{--} \quad (13)$$

P_w = mass of total seeds in Kg
t = time consumed in threshing operation in hrs.

$$P_{th} = \frac{200}{1}$$

P_{th} = 200 Kg/hr

B. *Cleaning Efficiency*

To determine the cleaning efficiency, the following relationship was used. [18]

$$\eta_{cl} = \frac{M_s - M_a}{M_s} \times 100\ \% \quad \text{------------------------------------} \quad (14)$$

Where,
η_{cl} = Cleaning Efficiency, %
M_a = Mass of impurities = 72.73 gm
M_s = Total seed mass = 1000 gm

$$\eta_{cl} = \frac{1000 - 72.73}{1000} \times 100\ \%$$

η_{cl} = 92.72 %

C. *Seed Losses*

Losses could be determined for this machine according to the following equation [18]

$$\eta_{loss} = \frac{M_{sl}}{M_s} \times 100\ \% \quad \text{--} \quad (15)$$

Where,
η_{loss} = Seed Loss Efficiency,%
M_{sl}= Mass of separation losses = 37 × 0.0645 gm = 2.3865gm
M_s= Total seed mass = 1000 gm

$\eta_{loss} = \frac{2.3865}{1000} \times 100\ \%$ $\eta_{loss} = 0.238\ \%$

D. Threshing efficiency

The threshing efficiency was calculated from the following relation, [18]

$\eta_{th} = \frac{M_s - M_{th}}{M_s} \times 100\ \%$ ------------------------------------- (16)

Where,
η_{th}= Threshing Efficiency, %
M_{th}= Mass of Un-threshed seeds = 0 gm
M_s = Total seed mass = 1000 gm

Also by visual inspection number of seeds present in the threshed flower was NIL

$$\eta_{th} = \frac{1000 - 0}{1000} \times 100\ \%$$

η_{th} = 100 %

Considering seed losses during the operation the Threshing efficiency is 100 minus percent of seed losses, i.e.

η_{th} = (100 – 0.238) %

η_{th} = 99.76 %

E. Seed Damage

The mass of visible damage seeds was used to calculate seed damage percentage and it is as follows, [18]

$\eta_{sd} = \frac{M_{ds}}{M_s} \times 100$ --- (17)

Where
η_{sd} = Seed damage Efficiency, %
M_{ds} = Mass of visible damaged seeds = 16×0.0645gm = 1.032gm
M_s = Total seed mass = 1000 gm

$$\eta_{sd} = \frac{1.032}{1000} \times 100$$

η_{sd} = 0.1032 %

F. Specific Energy Consumption

To determine specific energy consumption the following relation was used and it is as follows, [18]

$\text{SEC} = \frac{\text{Consumed Power (kW)} \times \text{time (h)}}{\text{Productivity (Kg)}}$ -------------------------- (18)

$$= \frac{0.746 \times 1}{200}$$

SEC = 3.73×10^{-3} kW.h/Kg

$$SEC = \frac{3.73 \times 10^{-3}\ kW.h}{10^{-3}\ ton}$$

SEC = 3.73 kW.h/ton

V. DISCUSSIONS

1. The machine productivity was observed to be 200 Kg/hr for the flower feed rate of 500 Kg/hr.
2. By weighing the mass of output collected it was observed that out of 1000 gms of output seeds there was 72.73 gms of impurities (husk of the flower). Therefore the Cleaning efficiency of the machine is 92.72 %.
3. Seed losses is an important factor of the machine and the seed losses were found to be 0.238gms for 1000 gms of seed collected hence the seed losses is 0.238 % compared to previously existing machines which were 6.41, 8.18 and 9.64 %.
4. Threshing efficiency was determined by measuring the mass of un threshed seeds in the flower. It was found to be 100 %. However considering seed losses in the machine the overall threshing efficiency is about 99.76 %.
5. Seed damage was determined by visual inspection of the output from the machine. It was found to be 0.1032 %. When compared to existing machines which produces 0.336 and 0.346 % seed damage in this machine is less.
6. The threshing rotor runs at 700 rpm where the power consumption is 0.746 kW and specific energy requirement is 3.73×10^{-3}kW.h/Kg i.e. 3.73 kW.h/ton.

VI . CONCLUSIONS

1. The fabrication of sunflower seed extracting machine was successfully completed as per the design specifications.
2. It is easy to handle and operate. This project has been designed to perform the required task taking minimum time.
3. This project is economically feasible and we are under the impression that it can be further reduced, when produced on large scale.
4. The project is very useful for farmers and works with the threshing efficiency of 99.76%. Seed damage is almost NIL and seed loss is 0.238%.

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