Integrated Seed Decorticating and Oil Expelling machine for Simarouba seeds

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***Abstract*—The production of biodiesel from the seeds requires proper opening and separation of kernel from shell and removal of other impurities. Hence there is a need of proper and efficient machine to remove the shell from the kernel, which is called as decorticator and the machine used for extracting oil from these seeds are known as oil expellers. These two process i.e. oil expelling and decorticating are two separate entities and commercially available machines today have only one of these operations and hence mainly two different machines are needed in order to extract the oil from the seeds which after certain processes like trans-esterification gets converted to bio fuel. Commercially available machines are of the larger size and the capacity in range of few tons and litres. Hence only large Industries can afford to purchase these machines. Hence we came up with an idea of clubbing the two operations i.e. decorticating and oil expelling into single machine running on a single 1hp motor for Simarouba seeds, which is newest of its kind. We used the rasp bar to shear off the shells of simarouba seeds and two stages of mesh (sieve) so that the kernels and shells gets separated to the maximum extent. The separated kernels are allowed to move through a long pipe into the expeller in which the seeds gets crushed with the help of helical screw (worm) thus extracting the oil. The long pipe also acts as the buffer storage between the expeller and decorticator to match the output of the decorticator with the input of the oil expeller**

***IndexTerms*—Design, CADD Model, Decortication, Expelling etc.**

I. INTRODUCTION

In the last 10 years, biofuel has become a promising solution to the problems posed by fossil fuels. Biofuel development in India centres mainly around the cultivation and processing of Simarouba seeds which are very rich in oil (60%)[1]. Decorticators for various kinds of seeds are developed. Important among them are: Sunflower, Groundnut, Maize, Jatropha, Simarouba. The work by Mr.Ogunwoleentails the design and fabrication of a manually and electrically operated roasted groundnut decorticating machine.The decorticating machine is powered manually or by 0.161 HP,1500rpm electric motor. The decorticating unit comprises of rotating inner drum (150rpm) of length 550mm and a diameter of 60mm with brush like projections and a shaft of 68mm passing through its center. The groundnut seeds and the chaffs fall directly into the cleaning unit where an installed fan blow away the chaff and the seeds are collected directly through an opening below the decorticating unit[2].A small, continuous, hand-operated machine specially designed and constructed for decortications of Jatropha fruits has been done and evaluated for performance parameters. The performance parameters of the machine were evaluated at four different moisture content (7.97%, 10.53%, 13.09% and 15.65%) with the combinations of concave clearance (18mm, 21mm, 24mm and 27mm). The best set of conditions under which the decorticator can be operated is at fruit moisture content of 7.97% with concave clearance of 21 mm at which the machine efficiency of 90.96% can be obtained[3]. The next major process in biofuel production is oil expelling after seed decorticating. Aremu A. Kpresented the design of an oil expeller machine for kenaf. The designed machine has the capacity of 36.5 Kg/hr and capable to extracted oil efficiency up to 62.2%.The designed machine is provided with the best lubrication and easily maintained[4]. Deli Scarried out the research study effects of physical parameters in screw press machine. In this study Sativa seeds were studied using a KOMET Screw Oil Expeller.The study is carried out with different sizes of nozzle and at the different speed of the shaft also the different diameter of the shaft is taken into consideration for the study. The optimum conditions of parameters recorded 22.27 % oil yields with 8mm diameter and 19.05% with 11mm diameter of expeller shaft[5]. With the help of above literatures, our objectives were formed.

II. DESIGN CALCULATIONS

A. Tool shaft

Tool shaft is the shaft that carries the Decorticating tool and pulleys supported by Bearings. As shown in Fig.1, Tool shaft is considered as a beam in which Load due to pulleys act at C & D, Uniform distribution load being the Weight of a hollow decorticating tool and the whole Tool shaft is simply supported at A & B. Material of the shaft being Mild Steel.

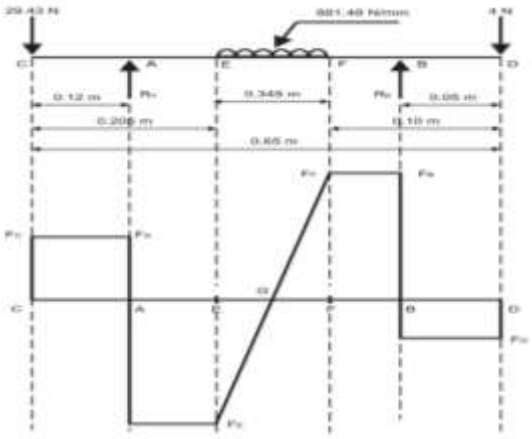

Fig. 1: Shear Force Diagram (SFD)

The diameter of a shaft d, is given by Eqn (1):

$$d = \left(\frac{16}{\pi\tau_{max}}\right)^{1/3} [(C_m M_b)^2 + (C_t T)^2]^{1/6} \text{ in m} \quad (1)$$

where,

τ_{max} is Maximum allowable shear stress permitted on the shaft in Nm^{-2}; M_b and T being the maximum bending moment and torque, respectively, on the shaft; C_m and C_t are the bending moment and torsional constants ($C_m = C_t = 1$).

From the SFD in Fig.1, it is inferred that the maximum bending moment (M_b) occurs at G.

Therefore,

$M_b = -(4\times0.278) + (160.21\times0.228) - (881.48\times0.178\times0.089)$

$M_b = 21.45\text{Nm}$

Maximum torque T, on the shaft is given by Eqn(2):

$$T = \frac{P\times60}{2\pi\times N} \text{ in Nm} \quad (2)$$

Where,

P is power in W; N is the rotational speed of the tool shaft in rpm.

Therefore, $T = \frac{1\times746\times60}{2\pi\times300} = 23.5$ Nm

Substituting in (1)

$$d = \left(\frac{16}{\pi\times58.3e6}\right)^{1/3} [(2\times21.5)^2 + (28.5)^2]^{1/6} \approx 18\text{mm}$$

Hence Standard safe Diameter is taken as d= 20mm and the same is used in our project.

B. Pulley

A larger pulley is used to transmit the rotating motion from the motor to the tool shaft. The velocity ratio of Belt drives is given by Eqn (3)

$$\frac{N1}{N2} = \frac{D2}{D1} \quad (3)$$

Where,

N_1 and N_2 are the rotating speed of the motor and pulley respectively; D_1 and D_2 being Diameter of motor and pulley respectively.

Therefore,

$D_2 = \left(\frac{1440}{300}\right) \times8\times10^{-2} = 38.4\times10^{-2}$m

Therefore diameter of pulley (large) is 38cm**.**

C. Length of belt

The belt used for power transmission is V- belt since it is more efficient for shorter distances. The length L, of the V- belt is given by the Eqn (4)

$$L = 2C + (D_1+D_2)\frac{\pi}{2} + \frac{(D_1+D_2)^2}{4C} \text{ in m} \quad (4)$$

Where,

C is the centre distance between the motor and pulley (60.5cm)

Therefore,

L= 196.97cm ≈ 198 cm

Length of V-belt is 198cm.

III. ANALYSIS

The tool shaft is subjected to analysis to determine the region at which maximum stress acts and to check whether the maximum stress developed is under safe limits. The software used for this purpose was Ansys.

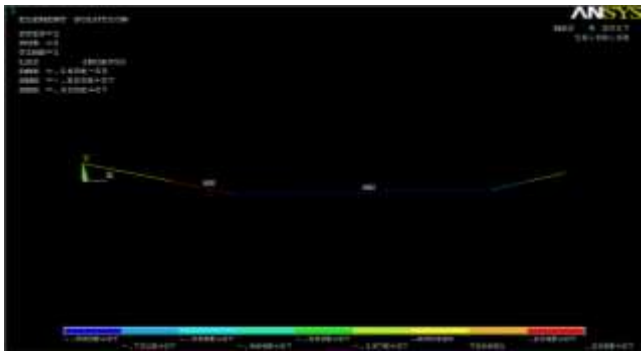

Fig .2: Stress acting on the tool shaft

Analysis of Tool shaft gave the following results:
Displacement=0.148mm;
Maximum stress induced= 3.38 MPa.
Since the obtained displacement magnitude is acceptable and as shown in the Fig.2, the Maximum induced stress is well below the allowable Yield strength (58.3MPa) of the tool shaft material, the design Diameter is Safe.

IV. CADD MODELLING

After obtaining the safe diameter of tool shaft, the tool shaft along with the mounted Decorticating tool is modelled using the software Solid Edge V19. As shown in the Fig.3, the Rasp bar Decorticating tool is mounted on the tool shaft. The shell of the seed gets sheared off due to the centrifugal action of the Decorticating tool.

Fig.3: CADD Model of Decorticating tool and tool shaft

Also keeping in the mind the ergonomic factor, the Frame of the machine, which houses all the components, was modelled and it is as shown in the Fig. 4.

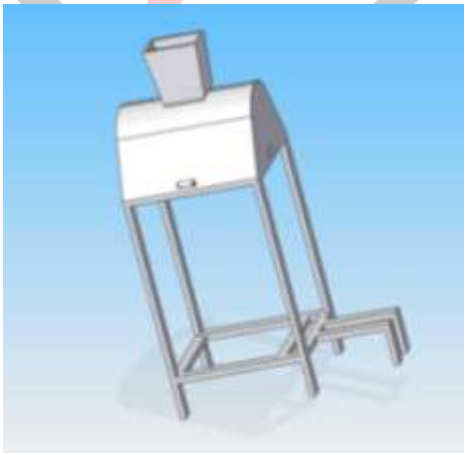

Fig.4: CADD Model of Machine Frame.

V. ACTUAL MACHINE

The Prototype of the machine was fabricated with reference to the objectives. The parts of the machine were made up of Mild Steel expect the pulleys which are made up of Cast Iron. The Actual machine is as shown in the Fig. 5.

Fig. 5: Actual Machine

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VI. OVERALL MACHINE SPECIFICATIONS

A. CAPACITY OF THE MACHINE

The capacity of the Machine C, is given by the Eqn (5)

$$C = \frac{Total\ mass\ of\ seeds\ input}{Time\ taken\ to\ Decorticate} \text{ in kg/hr} \quad (5)$$

$$= \frac{100}{1} = 100\text{kg/hr.}$$

Since there is a Buffer storage to match the output of the Decorticator to the input capacity of the oil expeller, the Capacity of the Decorticator itself is the Capacity of the Machine.

B. POWER CONSUMPTION OF THE MACHINE

The power consumption of the machine P, is given by theEqn (6)

$$P = motor\ power\ consumption \times Timeof\ \ run\ \ in\ kWhr \quad (6)$$

$$= 0.746 \times 1 = 0.746\text{kW-hr}$$

i.e. if machine runs for an hour then the power consumed by the machine is 0.746units.

VII. CONCLUSIONS

The literature survey gave us the understanding about the development of decorticators and oil expellers, through history and also about the existing machines in the market.The machine was designed and fabricated such that it can perform both decorticating and oil expelling processes which are the vital processes of Biofuel production. Arrangements and mechanisms were made such that both the processes run on a single motor of 1hp power. Instead of Regular willowers (blowers/fan), Vibrating sieve which was loaded eccentrically on the pulley, resulting in the vibratory motion, was used to separate the Kernels from the shells before letting it into the oil expeller. The long pipe with the angle of inclination 20^0 acts as a buffer storage between the Decorticator and oil expeller. The fabricated machine has the capacity of 100kg/hr with the power consumption of 0.746kW-hr when the machine runs for an hour.

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