International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

DESIGN AND MODIFICATION OF MECHANIZED STONE GRAIN GRINDER MACHINE

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Abstract – *Today in the world of Automation, almost in every sector including Transportation, communication, Manufacturing, Food processing, Health, Agriculture, Technological Innovation puts its steps. We are continuously modifying our old age principles in our new products. In this paper, a semi-automatic grain grinding machine has been developed based on the same principle used from many years in traditional Stone-Grain Grinder. In India, mainly in rural sides where proper technical skill is not there, People depends mainly on hand-power. Here a simple mechanism is used to grind and dehusk the food items like Vigna mungo etc. which can greatly reduce their physical labour in this grain grinding task without knowing much technical skill.*

Key Words: Stone-Grain Grinder, Quern, Grain, dehusk, Belt-Pulley

1. INTRODUCTION

Quern-stones are very rich traditional house-hold instruments, used for grinding many food items like separating lentil/Dal from Whole Beans, making wheat flour and other grains. From the Neolithic era (10,000–4,500 BC), the concept of stone grinders is being used for milling purpose [1]. Today the technology has been improved but the basic principle remains the same with few modifications. These stone grinders are used for many purposes like splitting the pulses, commonly known as Dal and then dehusking from those pieces. Traditional Stone Grain Grinder consists of two circular-shaped stones. The lower stone is mainly stationary and is called quern and upper hand rotating stone is called Muller or hand stone [2]. There are two holes of approx. 1'' diameter in the Muller in its centre and side portion used for pouring whole pulses and rotating respectively. The seeds or kernels are crushed by the crushing action of the rough inner surface of stones and lastly, crushed pulse grains along with husk came out from mating surface by means of centrifugal forces. Modern Dal Mill has arrived in today's market which can perform the same objectives. But rural people don't get full benefits of those as this big sized mill is impossible to install individually in own homes. In India, where 65 % is of the rural population [3], this problem is faced by villagers and the cost is also not suitable for one individual rural family.

1.1 Problems in Traditional Method

While operating stone grinder in the traditional way, the difficulties, rural people faced are as follows. These all are taken from customers' experiences.

- Due to the heavyweight of the stones, it takes many efforts from the users which sometimes become a problematic issue to the persons of old ages who operate this stone manually.
- Along with rotating stones by hands, pouring grinding items (e. g – whole cow beans etc.) into the hopper (the central hole) of Muller sometimes cause problems in its continuous rotation.
- It gives pain to the hand and shoulder after operating it manually for a few couples of hours (two to three hours), mainly to the users of old ages.

In this paper, mechanization of this entire process has been designed accordingly keeping those aforementioned problematic issues.

Fig -1: Traditional Stone-Grain Grinder

2. WORKING AND DESIGN SPECIFICATIONS

2.1 Study Objectives

- To design a low weight grinding machine that can easily be installed in individual houses mainly in rural sides.
- To reduce human effort over operating this.
- To reduce time consumption by the overall process.
- To use simplicity in the mechanism used, so that rural people can use it with ease.
- To reduce the cost of the final product.

2.2 Working Principle

In this mechanized grinder, a simple arrangement has been implemented by means of a 'belt-pulley system', 'modified traditional quern-stone', and a low powered 'fan'. Users can easily replace their grinding stone in this machine if they want. To operate the belt-drive, an electric motor has been attached with one of its pulley and power is transmitted from it to another pulley which rotates the upper stone of stone grain grinder further. A funnel-shaped pouring basin has been attached with the frame which makes the whole beans to pour into the centre hole of stone. To collect the crushed pulses after being split in between two stones, a collecting vessel has been attached with the frame. Here fan is optional. A Fan is for dehusking purpose of the pulses.

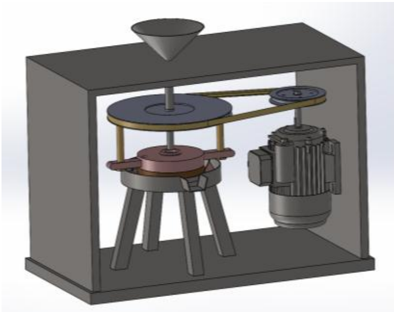

Fig -2: CAD Assembly model of Mechanized quern

2.2 Components

The CAD models of its every component are designed using SolidWorks 2016.

1. **Frame –** It is the main platform within which other components of the machine has been installed. It consists of one tray which is supported by four legs and one funnel-shaped structure attached with it in its upper surface. In the lower side of the funnel, a hollow tube-like support arrangement has been attached which is used to hold the big pulley over it. Its overall dimension is approx. 51.58 inch × 71 inch × 37.4 inch.

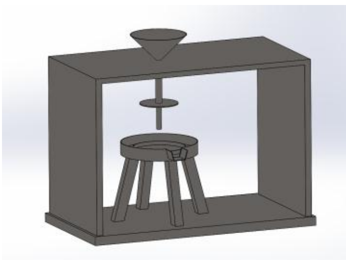

Fig -3: CAD model of Frame

2. **Modified Hand stone–** To rotate the upper stone properly, few modifications have to be carried out like attaching two 'handlers' where long screws are connected, attaching two small triangular-shaped sweepers with those handlers. The Sweeper is for displacing the heap of broken grains gathered in the tray. Its dimensions depend on the stone used. In this paper, the diameter of the stone is taken 15.75 inches.

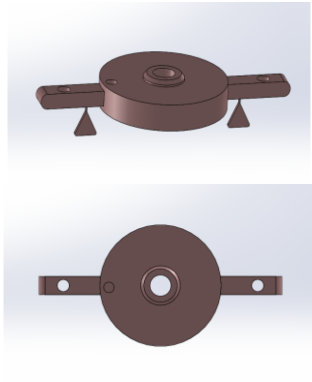

Fig -4: CAD model of Modified Hand Stone

3. **Belt Pulley system –** Here an open V-belt drive arrangement has been used to transmit power from the driving pulley, attached with the motor to the driven pulley. The reasons for choosing V belt over flat one here are the need for high power transmission and less slip [4]. Pitch diameters of Big and small pulleys are 630 mm and 125 mm respectively and centre distance is 823.3 mm.

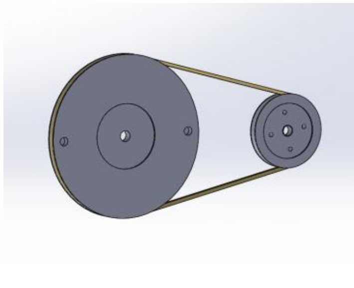

Fig -5: CAD model of Belt-Pulley

4. **Long Bolt and Nut –** For rotating the hand-stone with the big Pulley simultaneously, two 'bolt and nut' arrangements are used here. The holes present in handlers and big Pulley are internally grooved and the bolt is fixed with these two internal threads. The nut is used here to attach the bolt and handler. While assembling, we have to ensure that the axis of holes of both handlers and big pulley must have coincided.

Fig -6: CAD model of Hex. Bolt

5. **Motor –** One 2 HP 1440 rpm A.C. electric motor can be used for rotating the driving Pulley.

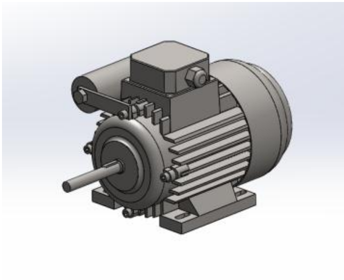

Fig -7: CAD model of AC Motor

3. DESIGN CALCULATION

3.1 Torque Calculation of Motor

Here if we use 2 HP 1440 rpm AC electric Motor, it can fulfil our objectives.
Rated Power of Motor = 2 HP
Revolution per minutes, n = 1440 rpm
We know, the mathematical relation in between power and torque of the motor is as follows:
$P = 2\times\pi\times n\times T / (60\times10^6)$
Here, P = 2 HP = (2×0.746) kW = 1.492 kW ~1.5 kW.

So, here torque is
$T = (60\times10^6) \times1.5 / (2\times\pi\times1440)$
T = 9947.2 N-mm.

3.2 Calculation of Belt-Drive

Here the V-belt is connected with a 2 HP, 1440 rpm motor and if we assume the operational time of the machine per day is 0 to 10 hours, then its calculation will be as follows.

According to "The Bureau of Indian Standards" [4], the correction factor (F_a) for the aforementioned service time will be $F_a = 1.2$
Design power, $P_d = 1.2\times1.5 = 1.8$ kW.

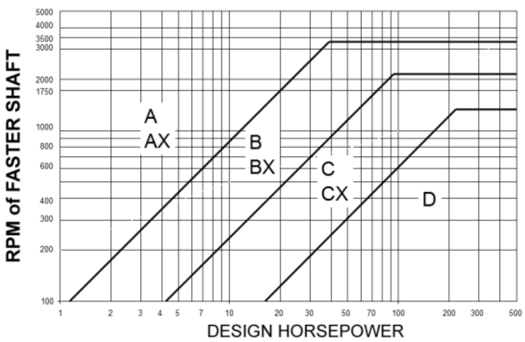

Chart-1: V-belt cross-section selection chart [5]

From above chart-1, we can easily predict that here the cross-section of the belt will be of 'A' type.

From data-book, we get, for 'A' type Belt-Section-
Pitch Width (W_p) = 11 mm.
Nominal top width (W) = 13 mm.
Nominal Height (T) = 8 mm.
The minimum pitch diameter of small pulley = 125 mm.

Pitch diameter of big pulley = (1440/300) ×125 = 600 mm. Now as 600 mm diameter is not a standard diameter according to Datebook, we preferred a standard diameter of 630 mm for Big Pulley.

d = 125 mm.
D = 630 mm.
Speed ratio = 1440/300 = 4.8

Initially, we take Centre Distance, C = 836 mm.
Pitch length of belt, $L = 2\times C + (\pi/2) \times (D+d) + (D-d)^2/4\times C$
$L = 2\times836 + (\pi/2) \times (125+630) + (630-125)^2/4\times836$
L = 2934.2 mm.

From the above value of L, we can choose the standard pitch length of 2910 mm for 'A' type belt and its corresponding correction factor will be 1.12.

$L = 2910 = 2\times C + (\pi/2) \times (630+125) + (630-125)^2/4\times C$
From above quadratic equation we get, C = 823.30 mm
The correct Centre distance is C = 823.30 mm.

Wrap angle for small pulley, $\alpha_s = 180 - 2\times\sin^{-1}((D-d)/2\times C)$.
Wrap angle, $\alpha_s = 180 - 2\times\sin^{-1}((630-125)/2\times823.30)$.
$\alpha_s = 144.3^\circ$ and from datebook, we get correction factor $F_d = 0.91$

The power rating of single V-belt will be (from datebook)
$P_r = 2.24+0.174 = 2.41$kW.

Number of belts = 1.5×1.2/ (2.41×1.12×0.91) =0.72~1.

3.3 Calculation of Bolt Size

Here the transmitted power is 2 HP or 1.5 kW and rpm of hand stone is 300.

The distance in between the axis of each bolt and the centre of hand stone is 260 mm.

External torque -
$T' = (60\times10^6) \times1.5/ (2\times\pi\times300) = 47746.5$ N-mm.

The shear stress acting in each two long bolts will be
$P = T'/ ((D/2) \times2) = 47746.5/ (260\times2) = 91.82$ N.

If bolts are made of plain carbon steel (30C8) and factor of safety (FOS) as 8, then the allowable shear stress will be = 400×0.5/8 = 25 N/mm^2

If we take bolt nominal diameter as d, then the equation will be 91.82 = 25 × (π/4) ×d^2
d = 3 mm but we can take for M10 for greater safety purpose.

4. CONCLUSION

This paper presents an alternative and medium-cost mechanism and its design idea that can serve grain grinding operation in the same principal of traditional stone grinder. This project is mainly focused on the rural situation and it can greatly reduce the physical effort of users in rotating those heavyweight hand stone and improve the grinding quality much better than the manual one.

REFERENCES

[1] British Museum - Quern stone used for making flour [Internet]. Web.archive.org. 2020 [cited 11 June 2020]. Available from: https://web.archive.org/web/20090421031008/https://www.britishmuseum.org/explore/highlights/highlight_objects/pe/q/quern_stone_for_making_flour.aspx
[2] Quern-stone [Internet]. En.wikipedia.org. 2020 [cited 11 June 2020]. Available from: https://en.wikipedia.org/wiki/Quern-stoneM. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
[3] Population of India | India population 2020 - StatisticsTimes.com [Internet]. Statisticstimes.com. 2020 [cited 11 June 2020]. Available from: http://statisticstimes.com/demographics/population-of-india.php
[4] V.B.Bhandari, "Design of Machine Elements", McGraw Hill Education(India) Private Limited,ISBN:978-93-392-2112-6,Vol-4,2017,pp.516-528
[5] V-Belts; Power Transmission Belts; Synchronous Belts; Timing Belts; Industrial V-Belts; Low Cost; Cheap Parts; Discount [Internet]. Bestorq.com. 2020 [cited 11 June 2020]. Available from: https://www.bestorq.com/crosssection.asp

BIOGRAPHIES

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