DEVELOPING A PORTABLE SINGLE ROLLER GINNING MACHINE WITH IMPROVED POWER TRANSMISSION FOR RURAL INDIA

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Abstract: ***The cotton ginning is the primary processing industry whose major function is to separate the lint from raw cotton. The cotton must ascertain the properties strength, span length, fibre fineness etc. The single roller portable ginning machine is an electrically operated portable ginning machine, specially build for the cotton breeders who can process at the site. This machine is specially made for domestic purposes where as it can be also operated in industries where the cotton breeds are to be examined. The primary aim of constructing this type of machine is compact size, portability and availability of the machine for domestic purpose, also less in weight. This roller gin machine parameters have no damaging effect on fibre properties or seed quality. The fibre properties of cotton also determine the price and are invariably taken into consideration by traders while buying the cotton. Hence, to facilitate cotton breeders, traders and farmers required portable type cotton ginning machines; even for short staple varieties the roller ginning machines can be used with modifications. Attempt is made to make the machine ready for sustainable rural development and rural industry.***

Keywords: Ginning, Portable single roller ginning machine, improved power transmission, Sustainable rural development

I. INTRODUCTION

India has the most land in cotton production of any country in the world with about eight million hectare and is third in total cotton production with 2.5 million tonnes. India now produces all the different quality cottons for the domestic need and has some remaining for export. The quality of cotton fibres, as they develop in the bolls on the plant, is mainly dependent on the pedigree of the plant and the conditions under which the plant is grown. A cotton gin is a machine that quickly and easily separates cotton fibres from their seeds, allowing for much greater productivity than manual cotton separation. The fibres are then processed into various cotton goods such as linens, while any undamaged cotton is used largely for textiles like clothing. Seeds may be used to grow more cotton or to produce cottonseed oil. The Single Roller Ginning has given the best fibre properties and was acceptable for all types of cotton varieties however; slow rate of production has made this uneconomical. The pulling actions of the roller on the fibres combined with the pushing action of moving knife are required to remove the fibres from each seed.

1.1 Major types of ginning machines

1.Roller gins- most commonly used in India, Egypt, Uganda, Tanzania etc. and

2.Saw gins- extensively used in countries like USA, China, Australia, and Uzbekistan etc.

Both types of gins are noted for certain advantages and disadvantages. The roller gin is used on high quality, fine fibred, extra-long staple cottons because of its tendencies to maintain fiber length and low NEP levels as opposed to the adverse effects on these characteristics by the saw gins. Using roller principle followed and in 1840 Fones McCarthy invented single roller gin. After India's independence Indian manufacturers have started manufacturing SR gins similar to Middletone SR gin and Monforts SR gin and major technological design modifications were not implemented for the improvement of the machine. It consists of two spirally grooved leather roller pressed against a fixed knife, are made to rotate at about 100-120 rpm. Moving blade combined with seed grids constitutes a central assembly known as beater which oscillates by means of an eccentric shaft, close to the fixed knife. When the seed cotton is fed to the machine in action, fibres adhere to the rough surface of the roller are carried in between the fixed knife and roller in such a way that the fibres are partially gripped between them. The oscillating knife beats the seed and separates the fibres. This process is repeated for number of times and due to push-pull-hit action the fibres are separated from the seed, carried forward on the roller and dropped out of machine. The ginned seeds drop down through the grid which is oscillating along with beater. By literature review and taking experiments, it is found that the output and lint quality is optimum at the speed of the roller and oscillation of beater shaft is increased to 120 rpm and 1200 OPM and 7 % moisture respectively.

II. OBJECTIVES

- The main objective of designing a ginning machine is to study the component, working and methodology to construct the machine with several parameters.
- Objective of fabricating a new single roller ginning machine is that it should be easily available to the people in villages at low cost and can be portable as well.
- To gain brief knowledge of each part of the machine and construct a sustainable portable machine using gear mechanism using composite material and using solar power as main driving member for the motors.

III. MATERIALS AND METHODS

3.1 Principle of operation of prototype Single Roller gin

The mini portable cotton gin machine works on the principle of McCarthy's gin. A chrome leather roller, fixed knife and moving knife are the main components of the gin. A spirally grooved roller is pressed against a fixed knife and is made to rotate at a definite speed. A moving knife reciprocates by means of a crank or eccentric shaft near the leather roller. When seed cotton is fed into the operating machine the fibre

adhere to the rough surface of the roller and are carried in between the fixed knife and the roller such that the fibres are partially gripped between them as shown in figure 1.

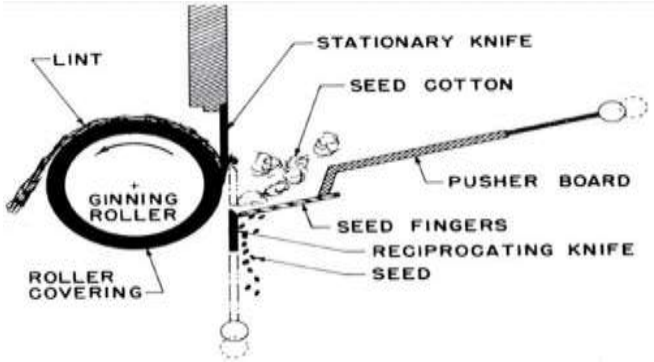

Figure 1: Principle of operation of single roller cotton gin

The moving knife beats the seeds and separates the fibres, which are gripped from the seed end. This "push and pull" action separates the fibres from the seed. The separated fibres are carried forward on the roller, pass upward and are dropped out of the machine. The ginned seeds drop down through the grid slots provided. The machine works by taking the cotton with seed and then moving the cotton fibres between the roller and fixed knife preventing the seeds to pass through. When the machine is working, at each elevation of the moving knife the grids lift the cotton to the level of the stationary knife-edge and of the exposed surface of the rollers. The free ends of the fibres are gripped, in the grooves of the rotating roller, and pulled forward till the seeds reach the edge of stationary knife. The downward motion of the moving knife, the seeds are detached from the cotton and are thrown out through the slots of the grid. The grooves of the rollers were kept well open and when the leather roller becomes smooth, rough file should be applied occasionally to the surface to keep the same grip and pull on the fibre. A Roller Cotton Gin consists of rollers made of leather or some other suitable material, a stationary knife and reciprocating knife or rotary knife. In this process, the cotton fibres are separated from their seeds by using rollers with a surface made of leather or other compatible material which attracts the cotton fibre towards the surface of the roller and carries it between the stationary knife and roller in such a way that the fibres are partially gripped between them. The oscillating knife or rotary knife beats the seed and the fibres are separated by a stretching action. The process is repeated, and due to the push-pull hit action, the fibres are separated from the seed continuously and carried forward for dropping out of the machine. This process is gentler as compared to saw ginning and is most suitable for ginning medium, long and extra-long staple cottons. The roller gin typically produces less short fibre content, fewer and delivers more impressive fibre length. Single Roller Gin is lies in picking and then moving the cotton fibres between the roller and fixed knife preventing the seeds to pass through. The seed cotton, when thrown into the hopper, passes through the machine. While the machine is working, at each elevation of the moving knife the grids lift the cotton to the level of the stationary knife-edge and of the exposed surface of the rollers. The free ends of the fibres are gripped, in the grooves of the rotating roller, and dragged forward till the seeds reach the edge of stationary knife.

IV. DESIGN OF PROTOTYPE SINGLE ROLLER GIN

4.1 Force for Cotton seed :

Average weight of fibre (for seed) = 0.05gram
Fibre seed attachment force = 64.1 CN.cm/mg = 64.1*0.05 CN*cm*g/mg
Torque = 0.32 N-m (per seed)
Assuming 120-150 seed at one time,
For 150 seeds,
Total torque = 150*0.32 =48 N-m

$$P = \frac{2\pi NT}{60} = \frac{2\pi * 100 * 48}{60} = 0.502KW \approx 0.7\ HP$$

Suitable motor to have a 1 HP motor power

4.2 To find forces on roller:

F = 3.2N (per seed)

4.2.1 V-belt Drive:

Motor =1 HP, 1440rpm, 3 phase
PR= 0.746KW, N_1 =1440rpm
Assume V.R=2.5

1. **Design power (P_d):**

$P_d = P_R * K_L$ (K_L=1.2 for line shaft)

2. **Select Belt designation:**

On the basis of design power, select belt Designation 'A'
Width (W) =13mm
Thickness (t) = 8mm
Min pulley dia.(D) =75mm
Centrifugal tension factor (K_c) = 2.52

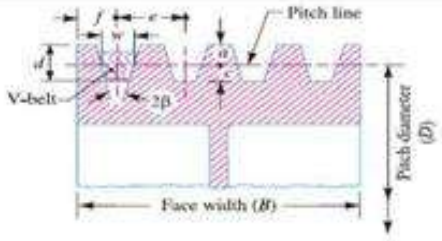

Figure 2: V-belt of SRGM

3. Belt Velocity (V_p):

Select dia. of driving pulley

D_1 = 90mm

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

(As V_p is in range of 300-1500m/min)

4. Belt tension (F_1&F_2):

Calculate dia of driven pulley, Due to wedge action, slip is neglected.

D1*N1 =D2*N2

Angle of lap for smaller pulley,

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

$F_1 - F_2 = \frac{P_d}{V_p}$ ----------.1.

Belt tension ratio :

$\frac{F_1}{F_2} = e^{\mu * \Theta * \operatorname{cosec}(\alpha/2)}$

μ = 0.3 (from table XV-10)

$F_1 = 12.18\ F_2$ ----------.2.

5. Power per belt :

Power per belt =

$F_w = W^2$

$F_c = K_c * (V_p/5)^2$

6. Design of pulley:-

L = (n-1)*e+2*f

α=38° , D_p = 200mm , b = 3.3mm , h= 8.7mm

Other pulley details are: types of construction = Arm type number of arms = 4

Rim thickness (t)= 0.375* $\sqrt{D}$ +3

A. Finding shaft diameter select shaft material Al6061 T6mat

S_{yt} =240 Mpa , S_{ut} = 290 Mpa

Assume, F.S = 2.5

By maximum shear theory,

$\tau = \frac{Sut}{2 * F.S}$ ----------.1.

Design torque,

$T_d = \frac{Pd * 60}{2\pi N_2}$

Also torque transmission capacity of shaft,

$\tau = \frac{16 * Td}{\pi d^3}$ ----------.2.

Increasing diameter by 50% on account of bending.

4.2.2 Chain & Sprocket :-

Design Power:- Assume 5% loss,

P_r = 0.8952* 0.95

P_r = 0.8504 KW

$P_d = P_r * K_l$ = 0.8504*1.2 (for line shaft)

1) Selecting chain number, pitch & number of strands:

P_d = 1.3678 HP

Therefore, for P = 1.36 HP,

Speed of smaller sprocket= 576 rpm

Selecting chain number = 35

Number of strands = 1

Teeth (t_1) = 15 teeth

Pitch = 9.525 mm

2) **V_p**

Pitch diameter of sprocket D $p_1 = \frac{P}{\sin(\frac{180}{t_1})}$

$V_p = \frac{\pi * D_{p_1} * N_1}{60 * 10^3}$

Hence OK.

3) **Maximum permissible bore of smaller sprocket:** Max. permissible bore diameter, d < $\frac{(T-5)*p}{4}$ [for p < 25.4]

For a 0.746 KW, 1440 rpm electric motor shaft dia. =19mm As shaft dia. < max. permissible bore Hence , OK.

4) **Power Capacity per strand:**

Power/strand = $p^2[\frac{V_p}{104} - \frac{V_{p_1}^{1.41} * (26 - 25\cos(\frac{180}{t_1}))}{526}]$

It should be single strand chain.

5) **Number of strands:**

No. of strands = $\frac{design\ power}{power/stroke}$

No. of strands =1

It should be single strand chain.

6) **No. of teeth on larger sprocket & pitch diameter :**

Teeth on larger sprocket

$N_1 * T_1 = N_2 * T_2$

Pitch diameter of larger sprocket,

$D_{p_2} = \frac{P}{\sin(\frac{180}{t_2})}$

7) **Sprocket Diameter:**

I. Width of sprocket teeth, $t_o = 0.58p-0.15$

II. Transverse pitch,
A = 1.1525*p

III. Corner relief, e = 0.125*p

IV. Chamfer radius, r = 0.54*p

V. Outside diameter,
$D_{o_1} = p[0.6+ \cot(\frac{180}{t_1})]$

VI. Root diameter,

$D_{o_2} = p[0.6+ \cot(\frac{180}{t_2})]$

V. CONSTRUCTIONAL FEATURE OF PROTOTYPE SINGLE ROLLER GIN

The essential machine parts of prototype single roller gin (figure 3 & figure 4) are

1. Main frame of machine
2. Chrome leather roller
3. Fixed blade
4. Moving blades
5. Power transmission system
6. Eccentric shaft

The main frame of the machine is fabricated. The frame is the supporting membrane of the machine. It acts as a skeleton to the machine. It holds the overall weight of the machine. It carries the motor, pulley, chain which move over the sprockets, the roller drum and the shafts. Thus, the frame should have the enough strength and rigidity to with stand the load of the various parts of the machine. Both the moving and fixed blade are alloyed steel. Roller is made of chrome composite leather washer. Single phase 1 HP motor is used to drive the roller and eccentric shaft along with the moving blade. The power to drive the roller is supplied by the chain and sprocket mechanism driven by eccentric shaft. The eccentric shaft drives the moving knife. The two screws are provide to adjust the height of fixed blade in order to adjust the overlap between the fixed knife and moving knife and roller. A suitable mechanism is provided to adjust the gap between the fixed and moving blade. The groves are made on roller on the periphery by width and depth of groove are 2mm. The belt pully and chain are having safety guard an handles are providing for ease of handling

Table 1:Parts of prototype single roller ginning machine

Part No.	Part Name
1	Bigger Sprocket
2	Smaller Sprocket
3	Bigger Pulley
4	Smaller Pulley
5	Eccentric Shaft
6	Connecting Rod
7	Electric Motor
8	Leather Roller
9	Moving Knife
10	Fixed Blade
11	Bearing Bracket
12	V-Belt

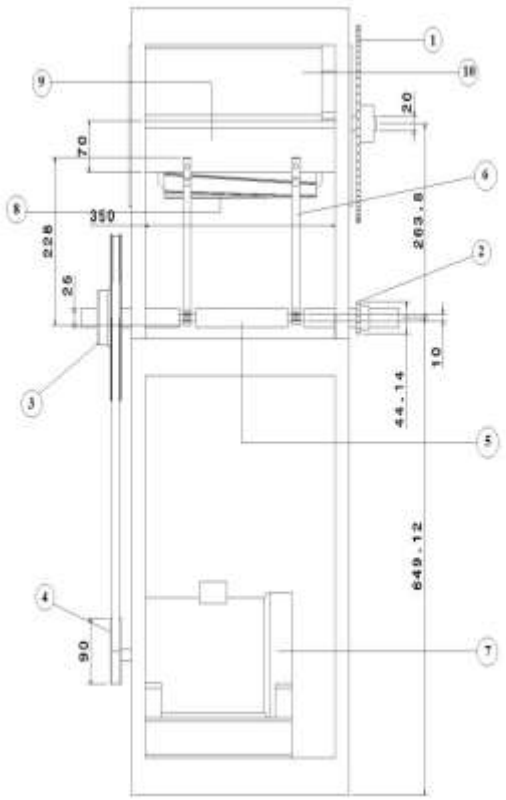

Figure 3: Front View of Prototype Single Roller Gin

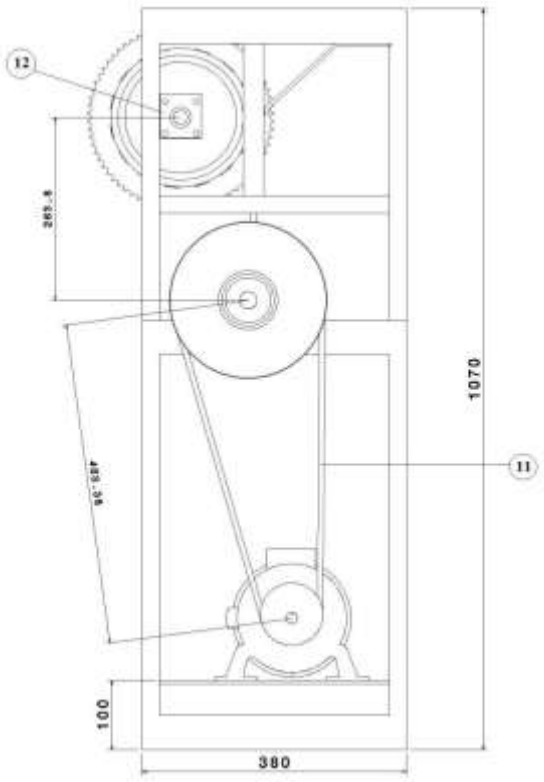

Figure 4: Side View of Single Roller Gin

VI. Conclusion

Development of portable single roller gin with improved power transmission is a result of higher productivity. Material selection for each and every component is considering an optimum strength to weight ratio, durability, cost effectiveness and feasibility. Apart from manufacturing issues, it is to be focused on to aspects like working of machine, achieving targets and this machine is having more benefit to the marginal traders. Attempt is made to make the machine ready for sustainable rural development and rural industry.

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