Design Modification and Analysis of Double Roller Mini Ginning Machine

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ABSTRACT

Indian Cotton Ginning Industry is the second largest in the world. Cotton ginning plays a very important role in the separation of fibers from cotton seed and converts field crop into a salable commodity i.e. lint. Ginning acts as a bridge between cotton farmer and textile industry. In India, cotton is ginned on double roller gins manufactured domestically. Indian Ginning Industry has been transformed into a remunerative business enterprise and has achieved global leadership in supply of quality cotton to domestic as well as international textile mills. There is a need to design and enhance the Double roller Ginning Machine to benefit the textile industries. The analysis of existing design has been carried out. This research presents design modifications and CAD model of Double Roller Ginning Machine. The analysis of modified design has been performed and the results were critically discussed.

Keywords: Lint, Ginning Machine.

I. INTRODUCTION

Ginning is the mechanical process for separating cotton into its constituents namely lint (Cotton Fiber) and Cotton Seed. The Seed Cotton that comes from the field has to be subjected to various treatments in the ginning factories depending upon its inherent characteristics such as trash contents, moisture contents, length of the fiber, variety of seed i.e. fuzzy or black, method of seed cotton transportation, storage practices, handling practices inside the ginning factories and finally subjected to ginning process for separation of fiber and seed before packing into bales etc.

Ideally the quality of the constituents i.e. cotton fiber and cotton seed before ginning and after ginning must be more or less same however it is seen that substantial damage is caused to quality parameters during processes in the ginning factories. The selection of cotton for spinning is made on the basis of fiber quality and any damage in the same during the process of ginning reduces the value of the fiber and results in lowering down of value in total textile value chain. The development of high speed spinning and weaving machinery has necessitated requirement of better cotton fiber parameters and any damage in quality caused while ginning cannot be rectified later and the defect is carried forward to yarn and fabrics during spinning and weaving process. The economics of ginning operation depends upon the proper selection of ginning technology suitable for various characteristics of the seed cotton to optimize the quality parameters and operational costs, thus the selection of suitable ginning technology is of paramount importance.
II. DOUBLE ROLLER GINNING MACHINE

It consists of two spirally grooved leather roller pressed against a fixed knife and a pulley and belt drive mechanism. Two moving blades combined with seed grids constitutes a central assembly known as beater which oscillates by means of a crank or eccentric shaft, close to the fixed knife.

When the seed cotton is fed to the machine in action, fibers adhere to the rough surface of the roller are carried in between the fixed knife and roller in such a way that the fibers are partially gripped between them. The oscillating knife beats the seed and separates the fibers. This process is repeated for number of times and due to push-pull-hit action the fibers 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.

III. DATA ACCUMULATION & CALCULATIONS

In present study, we have accumulated all the essential and necessary data of existing DR Ginning machine and carried out the design calculations to create the existing CAD model of DR Ginning machine.

Existing machine Data:

Data obtained from the existing machine:
Rated Power = 1 HP , Power factor = 1.1
Speed = 1425 RPM
The machine output capacity is 25-30 kg/hr.
The optimum roller speed is 140 rpm
The leather roller available is of diameter of 150 mm
Two rollers rolling in opposite direction with roller speed of 140 RPM,
1HP motor with 1425 RPM used
Roller 1 is connected with motor by means of belt and pulley reduction mechanism
Roller 2 is connected with motor with gear reduction and small pulley reduction mechanism as shown in below,

Roller 1 drive mechanism:
Rated Power of motor
\[ P_R = 746 \text{ Watt} \]
Design Power,
\[ P_d = P_R \times K_1 \]
\[ P_d = 746 \times 1.1 = 820.6 \text{ Watt} \]

From design data book
Designation A,
Normal width of pulley = 13mm
Nominal thickness = 8mm
Motor Pulley diameter(D1) = 75mm
Roller pulley diameter = D2
No. of strands = 6
Speed of motor (N1) = 1425 rpm
Speed of roller pulley = N2
\[ \frac{N_1}{N_2} = VR = 10.17 \]
\[ D_1 \frac{N_1}{N_2} = VR \]
\[ D_2 = \frac{N_1}{N_2} = 75 \times 10.17 = 765mm \]

Length of belt,
Center distance = 75 + 765 = 840 mm
\[ L = \left( \frac{\pi}{2} \right)(D_1 + D_2) + 2C + \frac{(D_1 + D_2)^2}{4C} \]
\[ L = \left( \frac{\pi}{2} \right)(75 + 765) + 2(558) + \frac{(50 + 508)^2}{4(840)} \]
\[ L = 3208.8 \text{ mm} \]
Consider coefficient of friction between belt and pulley,
μ = 0.3

For an open belt angle of contact,
\[ \sin \alpha = \frac{r_1 - r_2}{x} \]
\[ \alpha = \sin^{-1}(0.41) \]
\[ \alpha = 24.2^\circ \]
\[ \theta = 180 - 2(24.2) = 131.6^\circ \]
\[ \theta = 131.6 \times \frac{\pi}{180} \text{ rad} = 2.29 \text{ radian} \]

T1 = tension in tight side
T2 = tension in slack side
\[
\frac{T1}{T2} = e^{\mu \theta}
\]
\[
\frac{T1}{T2} = e^{0.3 \times 2.29} = 1.987
\]
\[ T1 = 1.987T2 \]

Where velocity of belt,
\[ v = \frac{\pi d N_1}{60} \]
\[ v = \frac{\pi \times 75 \times 1425}{60} \]
\[ v = 5.6 \text{ m/s} \]
\[ P = \frac{(T1 - T2)v}{1000} \]
\[ 0.746 = \frac{(T1 - T2) \times 5.6}{1000} \]
\[ (T1 - T2) = 133.2 \text{ N} \]

Substitute the value of T1 from tension ratio
\[ 1.987T2 - T2 = 133.2 \]
\[ T2 = 134.95N \]
\[ T1 = 268.14N \]

Initial Belt tension,
\[ T_0 = \frac{T1 + T2}{2} \]
\[ T_0 = 201.5 \text{ N} \]

Pulley1 is connected directly on motor shaft
Pulley1 torque = 5 N.m

Torque acting on Driven pulley
\[ T_{\text{driven}} = \frac{(T1 - T2)D_{\text{driven}}}{2} \]
\[ T_{\text{driven}} = \frac{(200.1) \times 0.508}{2} = 50.8 \text{ N.m} \]

Pulley Torque and speed ratio,
\[ T_{\text{drive}} \times N_1 = T_{\text{driven}} \times N_2 \]
\[ N2 = \frac{5 \times 1425}{50.8} = 140 \text{ RPM} \]

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**Roller 2 drive mechanism:**

Rated Power of motor
\[ P_R = 746 \text{ Watt} \]

Design Power,
\[ P_d = P_R \times K1 \]
\[ P_d = 746 \times 1.1 = 820.6 \text{ Watt} \]

Gear1 of 19 teeth connected on the motor shaft, meshed with gear2 of 89 teeth

Hence,
\[ t3 = 19 \text{ and } t4 = 89 \]
N3=1425 rpm

Gear ratio is given by,
\[ \frac{t4}{t3} = \frac{N3}{N4} \]
\[ N4 = 304 \text{ rpm} \]

Small pulley rotating on the same shaft of gear2 and large pulley on roller2,
Small pulley speed (N5) = 304 rpm
roller pulley (N6) = 140 rpm

From data book
Designation A,
Normal width of pulley = 13mm
Nominal thickness = 8mm
Pulley diameter(D5) = 75mm
Roller pulley diameter = D6

No. of strands = 6
\[ \frac{N5}{N6} = \frac{VR}{2.17} \]
\[ \frac{D5}{D6} = VR \]
Length of belt,
\[L = \frac{\pi}{2} (D5 + D6) + 2C + \frac{(D5 + D6)^2}{4C}\]
\[L = \frac{\pi}{2} (75 + 163) + 2(238) + \frac{(75 + 163)^2}{4(238)}\]
\[L = 909 \text{mm}\]

Consider coefficient of friction between belt and pulley,
\[\mu = 0.3\]

For an open belt angle of contact,
\[\sin \alpha = \frac{r1 - r2}{x}\]
\[\alpha = \sin^{-1}(0.18)\]
\[\alpha = 10.36\]

\[\theta = 180 - 2(10.36)\]
\[\theta = 159.28 \times \frac{\pi}{180} \text{ rad} = 2.78 \text{ radian}\]

\[T3 = \text{tension in tight side}\]
\[T4 = \text{tension in slack side}\]

\[\frac{T3}{T4} = e^{\mu \theta}\]

\[\frac{T3}{T4} = e^{0.3 \times 2.78} = 2.3\]
\[T3 = 2.3T4\]

Where velocity of belt,
\[v = \frac{\pi d5 N5}{60}\]
\[v = \frac{\pi \times 75 \times 304}{60}\]
\[v = 1.194 \text{ m/s}\]

\[P = \frac{(T3 - T4)v}{1000}\]
\[0.746 = \frac{(1105.38 - 480.6) \times 0.163}{2} = 50.9 \text{ N.m}\]

Pulley Torque and speed ratio,
\[Tdrive \times N5 = Tdriven \times N6\]
\[N6 = \frac{23.4 \times 304}{50.9} = 140 \text{ RPM}\]

The critical design parameters were identified and design modifications in the existing design has been carried out.

**Trail 1:**
To determine the capacity of machine theoretically.

Roller length= 500 mm, Roller speed= 140 rpm
The weight of cotton that occupies the space where the ginning is taking place= 30gms
Rotation of roller to process 30gms of cotton= 20 rotation of 140 rpm.
Cotton processed in 1 min= 140/20 x 30 = 210gms/min
Cotton processed in 1 hr= 210 x 60 = 12600gms = 12.60Kg/hr
Therefore, 12.60Kg/hr is the capacity of one roller For two rollers = 2 x 12.60 = 25.20 kg/hr Hence theoretically the capacity of the machine will be approximately 25-30 kg/hr.

If Roller length= 700 mm, ii. Roller speed= 140 rpm )
The weight of cotton that occupies the space where the ginning is taking place= 42gms

Motor Power = 746 watt
Torque of motor,
\[P = \frac{2\pi NT_{motor}}{60}\]
\[746 = \frac{2 \times \pi \times 1425 \times T_{motor}}{60}\]

Gear speed and Torque ratio,
\[\frac{T_{gear1}}{t1} = \frac{T_{gear2}}{t2}\]
\[T_{drive} = \frac{89}{19} \times 5 = 23.4 \text{ N.m}\]

Gear 2 and pulley 1 is connected on same shaft, pulley1 torque = 23.4 N.m
Torque acting on Driven pulley
\[T_{driven} = \frac{(T3 - T4)D_{driven}}{2}\]

Pulley Torque and speed ratio,
\[T_{drive} \times N5 = T_{driven} \times N6\]
\[N6 = \frac{23.4 \times 304}{50.9} = 140 \text{ RPM}\]
The cutting tool is withdrawn immediately after it fails or if possible just before it totally fails. For that one must understand that the tool has failed or is going to fail shortly. It is understood or considered that the tool has failed or about to fail by one or more of the following conditions.
- Total breakage of tool or tool tip
- Massive fracture at the cutting edge
- Excessive increase in cutting forces and vibrations
- Average wear (flank and crater)

Assuming Tailor's tool life equation,
This relationship is credited to F. W. Taylor (~1900)
\[ vT^n = C \]

where \( v \) = cutting speed; \( T \) = tool life; and \( n \) and \( C \) are parameters that depend on feed, depth of cut, work material, tooling material, and the tool life criterion used

- \( n \) is the slope of the plot
- \( C \) is the intercept on the speed axis

**Typical Values of \( n \) and \( C \) in Tailor Tool Life Equation**

<table>
<thead>
<tr>
<th>Tool material</th>
<th>( n )</th>
<th>( C ) (m/min)</th>
<th>( C )</th>
</tr>
</thead>
<tbody>
<tr>
<td>High speed steel:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-steel work</td>
<td>0.125</td>
<td>120</td>
<td>350</td>
</tr>
<tr>
<td>Steel work</td>
<td>0.125</td>
<td>70</td>
<td>200</td>
</tr>
<tr>
<td>Cemented carbide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-steel work</td>
<td>0.25</td>
<td>900</td>
<td>2700</td>
</tr>
<tr>
<td>Steel work</td>
<td>0.25</td>
<td>500</td>
<td>1500</td>
</tr>
<tr>
<td>Ceramic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel work</td>
<td>0.6</td>
<td>3000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

\[ v = 140 \text{ rpm} = 66 \text{ m/min} \]
\[ 66 \times T^{0.125} = 350 \]
\[ T = 625421.8 \text{ cycle} \]

**Table 1**
IV. CONCLUSIONS

The result of the research predicts the considerable enhancement in the tool life. The modifications in design of DR ginning machine removes almost all difficulties found with existing machine. Hence it can be concluded that the productivity will increase to a considerable extent. The down time required for overhauling and restoring the components in machine like belts, etc as observed in existing machine, will be reduce significantly and thus the reliability of the product will be increased.

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