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Component Design Verification and Modification of Double Roller Ginning Machine

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***Abstract*- Ginning is an energy intensive process. This paper evaluates the energy usage inside cotton gins. The main objective of present research work was to design and develop a modified double roller gin that had a higher ginning rate, less oil and grease contamination to lint and comparatively budgeting cost. Detail design study revealed that present Double Roller (DR) Gin carries several drawbacks. In order to remove these drawbacks conceptual modified models of DR gin were designed using Pro-E software. Best design of modified DR gin found to be simple in operation, energy efficient, requires minimum operational cost, and consumes less spares. Saving in cost compare to present DR Gin machine keeping in the mind of output. This modified design minimized lubricating points and application of grease. This design facilitates precise control over roller pressure. Machine manufacturing is very easy. This machine is very sturdy and operator friendly.**

Index terms: Ginning Rate, Lint Quality, Lubricating points, Roller Speed.

I. INTRODUCTION

Double Roller Gin machine history: - The first mechanical gin (Churka) was a roller gin consisting of two rollers (one metals, one hardwood) less than one inch in diameter, turned together by means of the hand crank. In 1840 Fones McCarthy invented a more efficient roller gin which consisted of a single leather ginning roller, a stationary knife, and a reciprocating knife which pulled the seed from the lint as the lint was held by the roller and stationary knife. Although the McCarthy gin was the major improvement over the Churka type-gin. Machine vibration due to reciprocating knife along with maintenance problems prohibited high ginning rates. In the late 1950's and early 1960's a rotary knife roller gin was developed by the USDA southwestern cotton ginning research laboratory, gin manufactures, and private ginneries. The ginning roller and stationary knife were retained from the McCarthy gin while a rotary knife replaced the reciprocating knife, eliminating the lost time of the backstroke of the reciprocating knife and reducing the vibration. The rotary knife allowed increased ginning rate. It is currently the only roller type gin used in united state a typical rotary knife roller gin as shown in figure 1. The cotton ginning process separates lint fiber from cottonseed while removing the trash from seed cotton and lint fiber. The materials in this system are pneumatically conveyed with numerous processing streams and exhaust points [1].

There are mainly two types of gins
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. Double roller (DR) gins are commonly used in rural India for ginning and producing about 2.8 million tonnes of lint. In India about 50 000 DR gins are working in around 4000 ginning factories and there is demand of around 1500 DR gins every year towards new addition as well as replacement of old one. During 1700's some developments

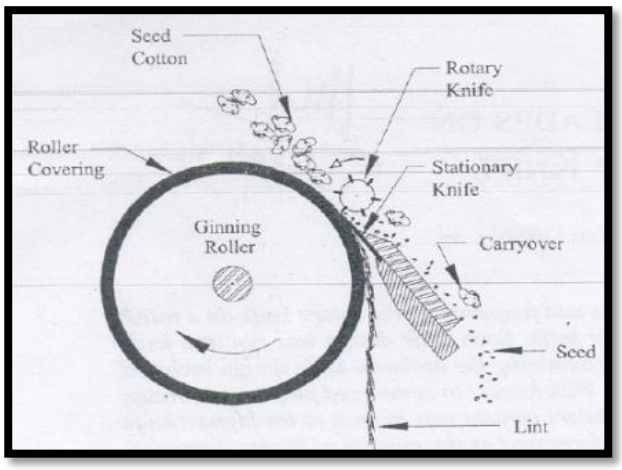


Figure 1. Working of double roller gin machine [1]

using roller principle followed and in 1840 Fones McCarthy invented single roller gin. The British Middletone model of DR gin used 40 inches (1016mm) roller length while the American Foss model DR gin used 60 inches (1524mm) long roller. Britishers introduced Middleton Double Roller gin manufactured by Platt Saco Lowell (UK) Ltd and Monforts M. Gladbach (Volkart) DR gin in India in the beginning of 20th Century. After India's independence Indian manufacturers have started manufacturing DR gins similar to Middletone DR gin and Monforts DR gin and major technological design modifications were not implemented for the improvement of the machine [2].

II. EXISTING DESIGN AND WORKING PRINCIPLE OF DOUBLE ROLLER GIN

It consists of two spirally grooved leather roller pressed against a fixed knife, are made to rotate at about 100-120 rpm. 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, 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 [3].

III. DRAWBACKS IN PRESENT DESIGN OF DR GIN

Detail design study revealed that present DR gin carries several drawbacks. One of the most important drawbacks is complicated power transmission system. It includes six planetary gears which not only oscillates beater at 960 oscillations per minute but also rotate the rollers at 95 rpm as shown in Figure 2. Nineteen teeth gear is fitted on main shaft, which transmits the motion to the gear having 89 teeth so that it rotates with 205 rpm. Gear with 46 teeth is fitted on the same shaft on which gear with 89 teeth is fitted. This gear (with 46 teeth) is transmitting motion to helical gear having 99 teeth which rotates the leather roller (left hand side) at 95 rpm and in clockwise direction. To rotate right hand side roller, the drive is taken from matching gear having 46 teeth so that direction is changed i.e. (anticlockwise) and this gear then transmitting motion to helical gear having 99 teeth which rotates the leather roller (right hand side) at 95 rpm.

This system requires about 20 kg grease or 18 litre lubricating oil per machine per season. This grease/oil due to leakage fall on the floor surface, and damages the lint quality, which is considered as serious contamination worldwide.

In present design, 21 bearings of different sizes and types are used which makes the maintenance complicated and costly. Also lubrication points are more i.e. 18 in number (Swing lever 8 points, hub 1 point, wrist pin 1 point, gear side pipe 2 points, weight lever 4 points, beater shaft 2 points). Uniform pressure between fixed knife and roller plays an important role in quality and output of the lint. In present design the roller is pressed against fixed knife with the help of hanging dead weights (total weight of 1158 N i.e. 324 N and 255 N/roller on gear box side and offside respectively) mounted on the weight lever of 495 mm in length. This method does not ensure uniform pressure between roller and fixed knife, occupies more space, and also makes it difficult to remove the roller for maintenance. Presently rollers are made of chrome composite leather washers and wear rate of roller is 0.02 mm/h of working (i.e. it has life of around 1200 working hours). Besides this in rainy season it has tendency to absorb water and get swelled to reduce the life of material further. Studies revealed that chromium particles generated during the process of ginning produce deleterious effect on the people working in the vicinity.

Theoretically energy required to remove 1 kg lint (fibres) varies between 1075 to 2775 joules but actual energy consumed by present DR is about 118000 joules/kg lint. This is about 60 to 120 times more. This poor energy utilization efficiency is mainly due to improper design of gearbox, unscientific way of applying pressure etc. Machine noise level is reasonably high (93 dB) due to the reciprocating action of beater and gearbox. Noise levels of 85 dB and above have shown to cause hearing impairment after prolonged exposure. Study conducted on commercial ginning factory for past three years revealed that spare parts repairs and replacements and maintenance cost including grease/oil per season was found to be around 25 % of the initial cost (Rs. 40 000) of the machine because of drawbacks mentioned as above[4].

IV. SUGGESTED CONCEPTUAL DESIGN MODIFICATIONS AND IMPROVEMENTS

In order to remove drawbacks mentioned above, conceptual modified parts and models of DR Gins were designed using Pro-E software and after detailed analysis, better design is used for actual fabrication.

1. The most Important conceptual Idea is to take the two stage of beater shaft assembly to increase the net output of DR gin.For that the frame is designed as the arrangement of beater shaft assembly, roller shaft, and rail assembly and Cross bar arrangement.
2. Two connecting rods are mounted on same eccentric shaft to oscillate two beater shaft assembly, lower stage and upper stage.
3. Arrangement of separate electric motors 1 hp each is provided to rotate both the roller. To rotate the upper stage roller pulley and belt drive is used from lower stage pulley. Power transmission from motor to shaft mounted speed reducer is achieved by pulley and V-belt arrangement for 3 hp motor. Crankshaft with

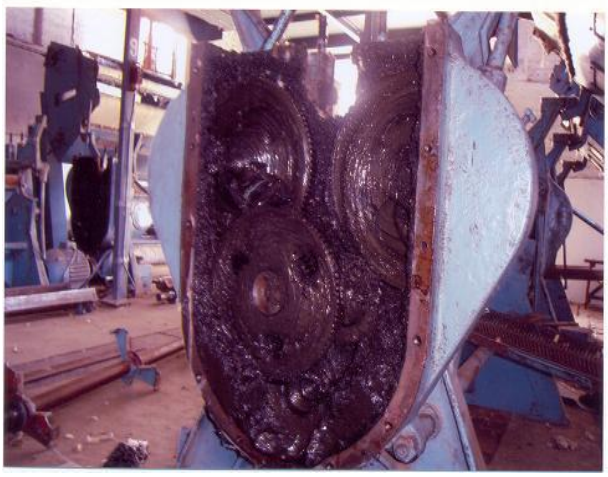


Figure 2. Gear box of existing DR gin machine [4]

eccentric is used to convert rotary motion of shaft into reciprocating motion of beater shaft through oscillating head. Split Coupling is provided for removing the roller for routine grooving and maintenance. The nut and screw mechanism to adjust the beater in respect of fixed knife is provided from the top of the side frames.

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 [5].

A. Torque required to drive the roller shaft.

Weight of the roller shaft = 70kg = 686.7 N
Diameter of the roller shaft = 50 mm
Radius of the roller shaft = 25mm
Torque = Force x Perpendicular Distance [6]
= 17.16 N.m
Power = $\frac{2\pi x N x T}{60}$ = = 179.69 watt

B. Component Design

a) Modified DR Gin frame

The frame is designed as the arrangement of beater shaft assembly, roller shaft, and rail assembly and cross bar arrangement.

Table1: Modified and present DR gin

Particulars	Modified DR Gin	Present DR Gin
Height of frame	2143mm	1180 mm
Length of frame	1688mm	930 mm
Thickness of frame	52.5mm	35 mm
Material	Cast iron	Cast iron

The modified DR gin is Economical, output and maintenance point of view because this output is given by two DR gin of Present machine.

b) V-belt and pulley design[7].

Electric Motor Specification
P =1 HP = 0.745 kw
N = 100 rpm
From table, P = 0.745 kw
A Grade belt is used.
Therefore,
Diameter of pulley (D) mm = ≥75 mm , **take 100 mm**
Top width (b) = 13 mm
Thickness (t) = 8 mm
Centre distance between pulleys = 840 mm
w/m length = 1.06 N
∴ *A grade pulley is used*
W = 11 c = 8.7
d = 12 f = 10
a = 3.3 e = 15

No. of sheave grooves (n) = 6
Groove angle $(2\beta) = 32, 34, 38$
Face width, B = (n – 1)× e + 2f
B = 95 mm
B ≤ 95 mm
Centrifugal force:
$\sigma_{t=\rho\times v^2}$
σ_t=3769.91 kg/m^2s

$\sin\propto = \frac{r_{2-r_1}}{x}$, $\propto = \mathbf{0}$
Rap angle $(\propto) = 0$
Angle of lap (motor pulley) $(\theta) = 180 - 2\alpha$
= 3.14 radian
Angle of lap (m/c pulley) $(\theta) = 180 + 2\alpha$
= 3.14 radian

Table 2: Summary of V-belt

Sr.No.	V-belt particular	Value
1	Lap angle with pulley(motor, machine)	180°, 180°
2	Rap angle with pulley	0°
3	Top width(b1)	13mm
4	Length of belt	940 mm
5	Power transmitted by V- Belt (P)	0.75 KW

3 electric motors are utilized as an input power, 2 are of 1 hp, 3 phase and 1 is of 3 hp, 3 phase AC motor. The speed of electric motor can be reduced with the help of gear box. In new ccentric shaft is designed as it mounts two connecting rod. Both connecting rods are arranged at 10 mm eccentric axis at opposite sides.

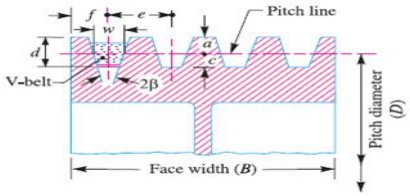
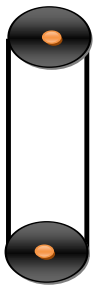


Figure 3.Cross section of V-grooved pulley [6]

Upper stage pulley



Lower stage pulley

Figure 4. CAD model of pulley with belt

Modified DR Gin assembly CAD model

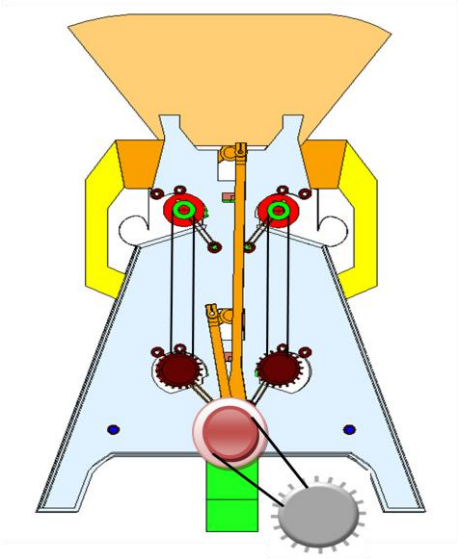


Figure 5. CAD model of Modified DR Gin machine

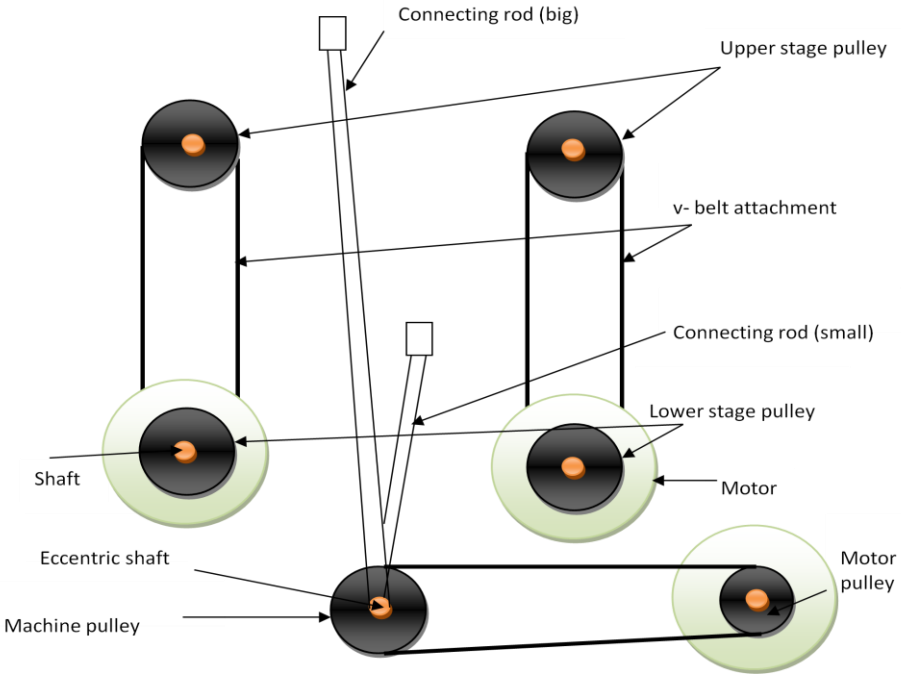


Figure 6. Block diagram of power transmission system of modified DR Gin machine

V. CONCLUSIONS

1. The output is approximately 120 to 150 kg/hr due to the two stages of beater shaft oscillation mechanism.
2. Efficiency is more.
3. Simple in operation.
4. Cost is low compare to existing DR Gin, output and maintenance point of view.
5. Lubricating points are less and grease is not required in the gear box.
6. The present research is carried out to design and develop a Double Roller Gin machine which mitigate existing failures and can increase m/c output with incurred cost reduction..
7. Test data will generated through calculation on a specially designed set up employed on an existing commercial DR gin. The data will then used to design and develop a modified DR gin.
8. The ginning performance of the modified DR gin will then evaluated in terms of per hour output, energy consumption, man power requirement.

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