TITLE: 2176 Improving Lint Quality using Modified Double Roller Gins in India

DISCIPLINE: Engineering & Ginning

AUTHORS:

P. G. Patil (Corresponding Author)
Central Institute for Research on Cotton Technology,
Nagpur 440023, India
Phone: 91 712 2500592
Fax: 91 712 2500592
E-mail: pgpatil_ngp@yahoo.co.in

P. M. Padole
Visvesvaraya National Institute of Technology,
Nagpur, India

A. B. Dahake
Central Institute for Research on Cotton Technology,
Nagpur 440023, India

K. M. Paralikar,
Central Institute for Research on Cotton Technology,
Mumbai, India

J. F. Agrawal
Yeshwantrao Chavan College of Engineering,
Nagpur, India

ACKNOWLEDGEMENTS: The authors would like to acknowledge Dr. S. Sreenivasan, Director, Central Institute for Research on Cotton Technology, Mumbai, India for providing facilities and financial assistance in our experiments. The authors would also like to M/s Bajaj Steel Industries Ltd., Nagpur, India for their help in experimentation.

ABBREVIATIONS:

DR (Double Roller)
HVI (High Volume Instrument)
AFIS (Advanced Fiber Instrumentation System)
RPM (Revolutions Per Minute)

ABSTRACT

In India, the double roller (DR) gins are used for ginning about 80 % of its total cotton production. But studies reveal that slow ginning rates and oil and grease contamination are the limitations of the DR gin. The main objective of present research work was to design and develop a modified double roller gin that had a higher ginning rate and less oil and grease contamination to lint. Experiments were carried out on a specially designed microcontroller and PC based experimental setup to select optimal operating parameters for existing DR gins. Seed cottons of different staple lengths were ginned at three levels of roller and beater speed and moisture contents. Duncan's Multiple Range Test revealed that a roller speed of 120 RPM and a beater speed of 1200 oscillations per minute (OPM) coupled with 7 % seed cotton moisture content showed the highest ginning rate with maximum savings in electric energy. It was observed that fibre properties of lint measured using the HVI and AFIS systems were unaffected by the test parameters. Using these optimized parameters, the power transmission system of an existing DR gin was modified and a modified DR gin was developed. Analysis of results of the power requirement for ginning the various types of cotton on the modified DR gin revealed that the saving in electrical energy ranged from 8 to 23 %. Further, the ginning rate of the modified DR gin was found to be 28 to 62 % higher than the existing DR gin. The fibre parameters of both machines are equivalent with no significant differences being observed. Further, the modified DR gin drive requires less grease, hence there exists a very low prospect of grease and oil contamination from leakage. The lower rate of grease leakage results in less lint contamination and improved lint quality.

KEYWORDS

Electric Energy, Ginning Rate, Lint Quality, Moisture Content, Roller Speed

INTRODUCTION

Cotton is the principal raw material for a flourishing textile industry in India. According to the International Cotton Advisory Committee (USA), the total production of lint in India during 2005-2006 is 4.148 million tonnes (24.4 million bales of 170 kg each) which accounts for 16.8 % of world production [ICAC, 2005]. Ginning is the process by which seed cotton is separated into lint (fibres) and seed; and the machine used for its separation is called a gin. There are mainly two types of gins (i) the roller gin (rotary-knife roller gin and the reciprocating-knife double roller gin) and (ii) the saw gin, which are commercially used for ginning worldwide. Several research workers have reported that the saw gin is highly productive, energy efficient and produces un-contaminated lint but its harsher treatment to the cotton fibre results in deterioration of some fibre characteristics (Chapman and Stedronsky, 1965). On the other hand, the double roller gin is less productive, less energy efficient, but being gentler, better preserves some fibre characteristics. However the current DR gin produces oil and grease contaminated lint. In India, the DR gin is mostly used for commercial ginning. About 50,000 DR gins are in operation in India which produced 3.32 million tonnes of fibres (about 80 % of total cotton lint production) during the 2005-2006 production years. Further, annual oil and grease consumption by DR gins in India is estimated to be 1500 tonnes which costs approximately Rs.120 to 150 millions (US $ 3 to 3.75 millions). Oil and grease contamination in the ginned lint and a slow ginning rate are the principal limitations of DR gins and make them expensive to maintain and operate. Because of these limitations, the DR gin is unable to meet the requirements and expectations of textile mills (Patil and Padole, 2003).

Researchers have carried out experiments to investigate the effect of various process parameters on ginning rate and quality of lint. William Martin *et al.*, [1940], Arvind J. Johnson *et al.*, [1977] and S. B. Jadhav [2002] studied the effects of increasing the roller speed and crank (beater) speed on ginning rate in reciprocating-knife roller gins. Investigation revealed that with the increase in roller and beater speed, ginning rate was increased considerably. Further, it was observed that the staple length of the cotton was not affected by increasing the roller speed. On a similar line, Gillum M.N. [1983] also studied the ginning performance of a rotary knife roller gin using an experimental automatic feed control. He found that there was a linear relation between ginning rate and rotary knife power. Also, ginning rate did not significantly ($P>0.05$) affect fiber 2.5 % span length or uniformity ratio, colorimeter reflectance and yellowness, or micronaire readings.

The International Textile Manufactures Federation’s (ITMF) [2005] evaluation of Indian cotton contamination in 2005 with regards to grease/ oil confirmed that grease/oil contamination is still prevalent in India. The majority of Indian cotton is being ginned on DR gins. Studies in India revealed that the design of the planetary gear train that is used for the power transmission in the existing DR gin is fully embedded in grease. The gear box design requires it to be filled by grease up to 20 % of its capacity. The amount of grease weighs about 20 kg and 500 grams is added weekly to maintain the required level of grease in the gearbox. During the running of the DR gin, there is leakage of the grease from the gearbox, which subsequently falls on the floor surface of the gin house. Much of the lint after ginning and before pressing contacts the greasy floor, and becomes contaminated with grease, which damages the lint quality. Even though the fibre quality is good from a DR gin there is a need to improve the power transmission design of the DR gin to reduce lint contamination by grease.

From above discussion and the identified drawbacks of the existing DR gin, it is evident that a modified DR gin is required. The ginning machine should be such that it should produce better quality of lint with improved productivity. Therefore the main objectives of the present research work were (1) to investigate systematically the effect of roller speed, beater speed, moisture content of seed cotton etc. on ginning rate, electric energy consumption and quality of lint, (2) to optimize the ginning process parameters, and (3) to increase the ginning rate of the DR gin and, [4] produce a contamination-free lint by developing a modified DR gin with an improved power transmission system, requiring a minimum of grease and oil lubrication.

MATERIALS AND METHODS

Conduct of engineering experimentation: An experimental set up

The microcontroller and PC based experimental set up similar to what Gillum, (1983) employed was specially designed for an existing DR gin. A photo of set up used to conduct experiments is shown in Figure 1. The desired roller speed was achieved by varying the frequency of an A.C. drive. The roller speed and temperature were recorded by sensors. Detailed technical specifications of the equipment used are given in Table 1.

The Data Acquisition System is designed using microprocessor (ATMEL's AT89c51 microcontroller). For measurements of current through the AC motor, current transformer is used, which was calibrated in the laboratory. Power is derived from the RMS current value. The opto-coupler is used for measurement of RPM, which produces one pulse per revolution. The time interval is measured in the processor and then it is converted to RPM. For measurement of temperature, the DS1621 (DALLAS CHIP) is used, which is pre-calibrated with ± 0.5 degrees accuracy. It also has on chip analog to digital converter and I2C (Inter Integrated Bus), so the temperature is available in serial and digital form, which is readable to the microprocessor. For sending data to PC, the data acquisition system having RS232 chip is used, which is a communication standard protocol for serial communication to the PC. Data acquisition system is performing one cycle of reading all parameters in around 1.4 sec and transfer the parameters to PC @ 1.4 sec approximately. The baud rate for data transfer is 9600 bits per seconds. For PC database generation, windows OS having hyper terminal software which communicate with external systems through serial port is used. This software can transmit as well as receive data on the serial port. So, using this software the data transfer by the data acquisition system is received and stored in the MS-Word files.

Methodology used during conduct of engineering experiments

Seed cottons of different 2.5 % span length (Cotton A: 29.1-31.8 mm, Cotton B: 30-31 mm and Cotton C: 23-24 mm) were subjected to three levels of roller speeds (80, 100, & 120 RPM) and three levels of seed cotton moisture contents (5, 7 & 9 % on wet basis). Seed grids of the DR gin were selected as per seed size as defined by Mohsenin [1978].

The tests were conducted and analyzed as a completely randomized design replicated two times. In all, 54 experiments were conducted to ensure an adequate response in ginning rate, power consumption and quality of lint. The approach proposed by H. Schenck [1961] was used for planning and execution of all experiments. A weight of 20 kg of seed cotton was used in each ginning lot. The cotton crop was raised in selected farmers' fields and the seed cotton used in the ginning lots was the mixture from the first two pickings.

Important fibre properties such as 2.5 % span length, micronaire, fibre tenacity and uniformity ratio were determined using High Volume Instrument HVI-900 of Uster Technologies (USA), and maturity ratio, neps, seed coat neps and immature fibre content were determined using the Advanced Fibre Information System (AFIS).

Identification of optimal parameters for ginning cotton

Typical power versus time graph

Figure 2 shows the typical power versus time graph for cotton A having a 7 % moisture content with roller speed of 120 RPM. The average power required by the DR gin when the roller is rotating in contact with stationary knife but no ginning was undertaken (Zone A) was found to average 2928 W. As soon as cotton was fed to the machine, and the process of ginning started, the power consumed by the ginning machine recorded to its maximum value (Zone B) of 4218 W. The power then stabilized during the course of ginning (Zone C) to an average of 3860 W.

Effect of roller and beater speed and moisture content on ginning rate

Summery of results of experimental tests presented in Table 2 showed that there exists a definite relationship between the roller speed, moisture content and ginning rate. Since existing machine works at roller speed of 100 RPM, data analysis was also carried out considering 100 RPM as reference point, and roller speed was varied from 80 RPM to 120 RPM in stages. Beater speed was also varied from 800 to 1200 OPM.

Increase of roller speed from 80 to 100 RPM

For seed cotton having moisture content of 5 %, study revealed that by increasing the speed of roller from 80 to 100 revolutions per minute (25 %), the amount of lint ginned in kg per hour increases from 44.6 to 52.2 (17 %), 34.6 to 45.0 (30 %) and 44.6 to 60.0 (34 %) for cotton A, B and C respectively. For seed cotton having moisture content of 7%, the amount of lint ginned in kg per hour increased from 46.3 to 55 (19 %), 39.3 to 47.3 (20 %) and 50.1 to 60.8 (21 %) for cotton A, B and C respectively. For seed cotton moisture content of 9 %, it is observed that by increasing the speed of roller from 80 to 100 revolutions per minute (25 %), the amount of lint ginned in kg per hour increased from 44.3 to 50.3 (13.5 %), 35.6 to 45.5 (28 %) and 50.0 to 61.0 (22 %) for cotton A, B and C respectively.

Increase of roller speed from 100 to 120 RPM

For seed cotton moisture content of 5 %, study revealed that by increasing the speed of roller from 100 to 120 revolutions per minute (20 %), the amount of lint ginned in kg per hour increased from 52.2 to 85.4 (64 %), 45.0 to 64.4 (43 %) and 60 to 69.4 (16%) for cotton A, B and C respectively. For seed cotton having moisture content of 7%, study showed that by increasing the speed of roller from 100 to 120 revolutions per minute (20%), the amount of lint ginned in kg per hour increased from 55 to 88.8 (61 %), 47.3 to 75.1 (59%) and 60.8 to 77.3 (27 %) for cotton A, B and C respectively. For seed cotton having moisture content of 9%, it was observed that by increasing the speed of roller from 100 to 120 revolutions per minute (20 %), the amount of lint ginned in kg per hour increased from 50.3 to 84.4 (67.8 %), 45.5 to 65 (42.8 %) and 61 to 84.2 (38 %) for cotton A, B and C respectively. The analysis clearly indicates that maximum increase in ginning rate was observed for higher staple length of fibre (Cotton A & B) as compared to lower staple length of fibre (Cotton C). Statistical analysis by Duncan's Multiple Range Test ($p>0.05$) shown in Table 3 revealed that there is significant increase in lint output with the increase in speed of roller.

Effect of roller speed and moisture content on electric energy consumption

Results revealed that, for a moisture content of 7 %, and an increase in roller speed from 80 to 100 RPM (25 %), the electric energy consumed in watts by the gin stand increased from 2512 to 3201 (27 %), 2548 to 3281 (29 %), 2677 to 3398 (27 %) for cotton A, B and C respectively. It was also noticed that, for moisture content of 7 %, with an increase in roller speed from 100 to 120 RPM (20%), the energy consumed in watts by the gin stand was increased from 3201 to 3860 (20.5%), 3281 to 4049 (23.4%), 3398 to 3945 (16 %) for cotton A, B and C respectively.

Power consumption increases with roller speed but roller speed also increases the lint output. During experimentation on cotton A having 7 % moisture, it was observed that for a roller speed of 80 RPM, the average power requirement and lint output were found to be 2512 watt and 45.7 kg/h respectively. When the roller speed was increased from 80 to 100 RPM, the average power requirement and lint output were also increased to 3201 watts and 56.8 kg/h respectively. A further increase in roller speed from 100 to 120 RPM, again increased the average power requirement to 3860 watts and average lint output was increased to 84.9 kg/h.

Results as shown in Table 2 revealed that electrical units consumed to gin 100 kg lint was lowest for 7 % moisture content and roller speed of 120 RPM and found to be 4.34, 5.39 and 5.1 kWh for cotton A, B and C respectively. Also at the roller speed of 120 RPM, there is a savings in electricity consumption of 25.4, 22.2 and 8.7 % for cotton A, B and C respectively when compared to a roller speed of 100 RPM. Therefore it is concluded that for achieving the maximum ginning rate and minimum electrical consumption, optimum seed cotton moisture and speed of the roller was found to be 7 % and 120 RPM respectively. Figure 3 shows the relationship between the speed of the roller and power consumed for ginning 100 kg lint for different varieties of cottons.

Statistical analysis by Duncan's Multiple Range Test ($p>0.05$) presented in Table 3 revealed that the power requirement in kWh for ginning 100 kg lint varies significantly with roller RPM for long staple (30 mm) cottons like cotton A and B but for short staple (24mm) cotton C, the difference in power requirement is not significant between roller speeds.

Effect of roller and beater speed on quality of lint

Duncan's Multiple Range Test analysis for cotton A and C in Table 4 showed that there is no significant variation of the 2.5 % span length, UR %, Mic, Tenacity, MR, SCN, neps, IFC % with different roller speeds of 80, 100 and 120 RPM. Further, Duncan's Multiple Range Test analysis for cotton B showed that there is no significant variation of the 2.5 % span length, UR %, Mic, Tenacity, MR, SCN, IFC % with different roller speeds of 80, 100 and 120 RPM. But for cotton B, Duncan's Multiple Range Test analysis showed significant variation for neps with different roller speeds of 80, 100 and 120 RPM.

Selection of optimal parameters for ginning cotton

Analysis of the data generated during extensive experimentation conducted on existing DR gin revealed that the power requirement increased with an increase in the speed of the roller. However, the ginning output also increased. The power requirement of 3984 watts at a roller speed 120 RPM and beater speed of 1200 oscillations per minute (OPM) resulted in the maximum ginning rate and minimum electrical consumption for all the cottons studied and were selected as optimal parameters. It was not possible to change the roller length and diameter during the experiment as the length of 1360 mm and diameter of 170 mm were optimized by the machinery manufacturers. The study further revealed that 7 % seed cotton moisture was found to be optimum to obtain the highest ginning output without compromising the quality of lint. These combinations resulted in the highest production was obtained with the highest energy saving without affecting fibre quality.

Mechanical design and fabrication of modified double roller gin:

Based on the data generated from experiments conducted on an existing DR gin, the optimum levels of operating parameters like the speed of the roller, beater oscillations, moisture content etc. were finalized. The design of the Modified DR Gin is based on these optimized parameters. The Modified DR Gin consists of a mechanical power transmission system, stationary knives, a beater and moving knife, leather rollers and side frames.

The mechanical power transmission system of the modified DR gin is shown in Figure 4. The power is transmitted using v-belt drive from a 6 hp, 1440 RPM electric motor (E) to the eccentric shaft (N) which runs at 1168 RPM. The big end of the connecting rod (CR) is mounted on an eccentric shaft and the small end is connected to an oscillating beater shaft (BS) operating at 1168 oscillations per minute (OPM).

A helical pinion (G1) having 19 teeth is mounted also on the eccentric shaft which transmits power to a helical gear G2 having 99 teeth. The gear G2 thus operates at 224 RPM. A driving sprocket S1 for the roller chain drive is mounted on the gear shaft to transmit power to the right hand and left hand rollers (RS1 and RS2) at a speed of 120 RPM. Thus the redesigned DR drive uses a combination of v-belt, helical gears and chain drive to transmit the 6 hp to the roller gin. Specification details of the various elements of the mechanical power transmission system for the modified DR gin are shown in Table 5. A complete assembly of the modified double roller gin showing the improved power transmission system and also the gear train of an existing DR gin are shown in Figure 5.

RESULTS AND DISCUSSION

Performance evaluation of the modified DR gin and economics of operation:

Field trials on the fabricated modified double roller gin were conducted for H.4 (2.5% span length (SL) of 28 mm) and Bunny (2.5% SL of 30 mm) cotton cultivars in a commercial ginning factory in Seloo, Dist. Wardha (India) for about 40 days. This gin has 18 existing commercial-size double roller gins. Tests of the modified DR gin were conducted versus the regular double roller gins to compare the performance of the two types of machines in exactly the same working conditions. It was found that the modified DR gin worked satisfactorily during commercial trials. The amount of lint ginned with the H.4 cotton cultivar was found to be 59.3 kg/h and 67.3 kg/h for the existing DR gin and modified DR gin respectively. Further, the amount of lint ginned with the Bunny variety was found to be 60.0 kg/h and 69.7 kg/h for the existing DR gin and the modified DR gin respectively. Similar trials were also conducted on the existing DR gin and the modified DR gin in a laboratory on different varieties of cottons B and C.

Analysis of results revealed that the power requirement of the modified DR machine at roller speed of 120 RPM for cotton B was 4082.5 Watts which was 24 % higher than the commercial ginning machine (3281 Watts at a roller speed of 100 RPM). The power requirement for the modified double roller gin for cotton C was found to be 4009 Watts at roller speed of 120 RPM which was 18 % higher than the commercial DR gin (3398 Watts at roller speed of 100 RPM). However, the data presented in Table 6 shows that the lint output for the modified double roller gin showed a steep increase over the commercial DR gin. The lint output of the modified DR gin was found to be 76.7 and 78.05 kg/ hour as compared to the existing commercial DR gin lint output of 47.3 and 60.8 kg/hour for cottons B and C respectively.

The average electric units (kWh) requirement for ginning 100 kg lint gives the correct understanding of the energy efficiency of the two types of DR gins. Results showed that for the modified double roller gin, to gin 100 kg lint of cotton B required 5.32 kWh as compared to 6.94 kWh for the commercial DR gin. This is equivalent to a 23 % saving in electric units when using the modified DR gin. Further, for cotton C, it was found that 5.14 kWh and 5.59 kWh were use for the modified double roller gin and commercial DR gin respectively which amounts to an 8 % saving in electric energy. Therefore it was concluded that the modified double roller gin was a more energy efficient machine than the existing commercial DR gin.

From Table 6 it is also shown that there is no significant difference in the average fibre quality of lint obtained by both machines. Further, the drive design of the modified DR gin helps to ensure that grease and oil contamination is avoided when using the modified double roller gin. Hence, it is concluded that overall fibre quality of lint obtained during ginning by modified double roller gin is improved because of the avoidance of lint contamination from grease and oil.

CONCLUSIONS

The present research work was carried out to design and develop a modified double roller gin. Test data was generated through experiments conducted on a specially designed experimental set up employed on an existing commercial DR gin. Those data were then used to design and develop a modified DR gin. The ginning performance of the modified DR gin was then evaluated.

The following conclusions were made on different aspects of a DR gin.

1. The important parameters that influence the ginning rate and energy consumption for a DR gin, are the speed of the rotating roller, the oscillating speed of the beater, and the moisture and staple length of the cotton.
2. There was a significant increase in lint output with the increase in speed of the roller.
3. Power consumption increased with roller speed, however, there was also an increase in ginning output with increased roller speed. Tests showed that, on the average across cotton varieties tested, the optimum seed cotton moisture, speed of the roller and speed of the beater were found to be 7 % 120 RPM and 1200 OPM respectively for achieving maximum ginning rate and minimum electrical consumption per unit lint ginned.
4. The chain-sprocket arrangement selected for the power transmission of the modified DR gin was determined in the field tests to be satisfactory. The modified DR gin requires less grease/oil and could save up to Rs. 3000 (US $ 65) per machine per season over the existing commercial DR gin design of about 30 grease required per machine. For a total number of about 50,000 DR gins working in India, the overall saving on grease/oil could be estimated to be as much as Rs. 100 to 125 million (US $ 2.2 to 2.7 million) if all existing DR gins were converted to the modified drive design.
5. Although the instantaneous power requirement, of the modified DR gin was higher than the commercial DR gin, the actual electrical units required per unit lint ginned was less with the modified DR gin than with the commercial DR gin across cotton varieties tested. Therefore it was concluded that modified DR gin is a more energy efficient machine than the existing commercial DR gin.
6. The possibility of grease and oil contamination to lint is greatly reduced due to the design of modified DR gin. Therefore it was concluded that overall fibre quality of lint obtained during ginning by the modified DR gin would be improved over current practice.

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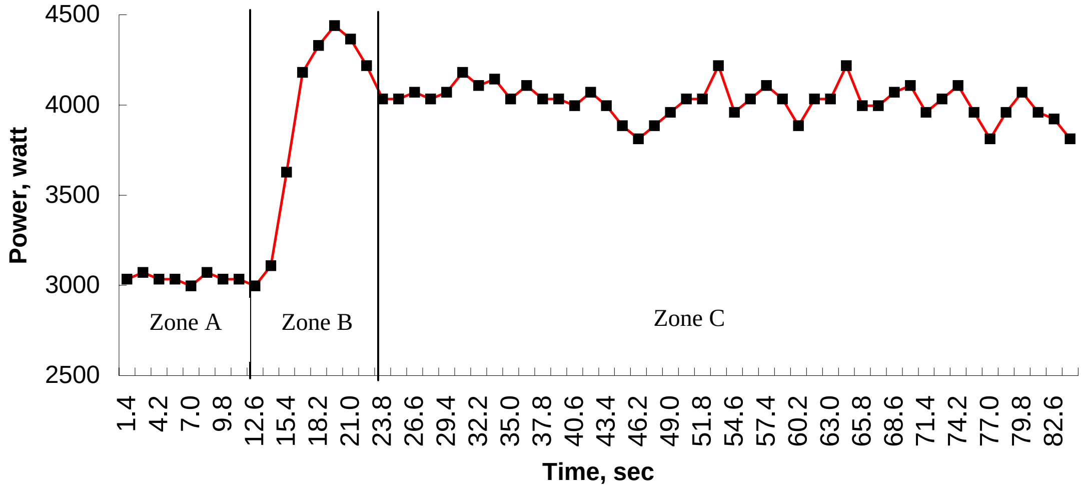
Figure 1 Microcontroller and PC based experimental set up



Zone A: No ginning, Zone B: Start of ginning, Zone C: Ginning process

Figure 2 Typical power versus time graph

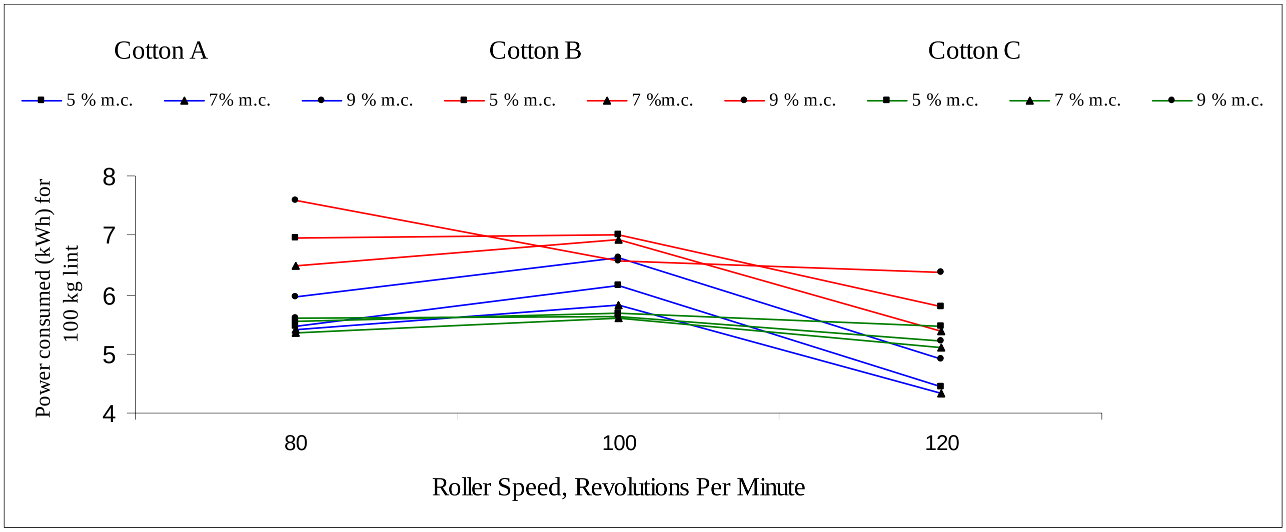
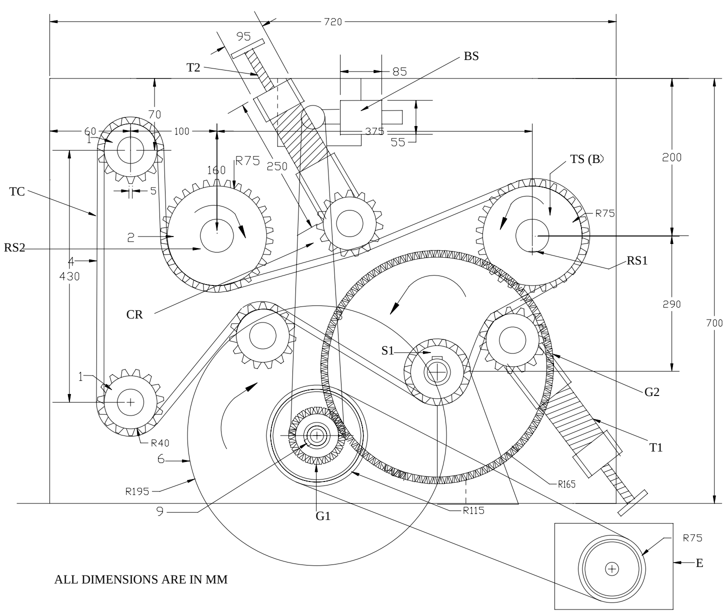


Fig. 3 Roller speed Vs. Electrical units



NOMENCLATURE

BS = BEATER SHAFT
CR = CONNECTING ROD
E = ELECTRIC MOTOR
G1 = PINION GEAR
G2 = BIG GEAR
RS1 = ROLLER SHAFT (RIGHT)
RS2 = ROLLER SHAFT (LEFT)
S1 = CHIAN SPROCKET
T1 = CHAIN TENSIONER (BOTTOM)
T2 = CHAIN TENSIONER (TOP)
TC= TRIPLEX CHAIN
TS (S) = TRIPLEX CHAIN SPROCKET SMALL
TS (B) = TRIPLEX CHAIN SPROCKET BIG

Figure 4 Mechanical power transmission system in a modified double roller gin

Figure 5 (Left) Modified DR gin showing the improved power transmission system and (Right) the gear train of existing DR gin.

Table 1 Specification of instruments used in experimental set up

Sr. No.	Instrument	Specifications
1.	Micro controller based power, RPM and roller temperature measurement system.	20 A. 100 mA Current Transformer; 1 R slot Sensor: RPM measurement; DS 1621, Dallas calibrated serial Temperature Sensor.
2.	Digital portable moisture meter.	230 V AC, 3.5 to 20 % moisture,
3.	Double Roller Gin Make: M/s Bajaj Steel Industries Limited, Nagpur (India)	Roller length: 1360 mm Roller Diameter: 170mm Roller Materials: Chrome composite leather Electric motor: 5 hp, 3 phase, 1440 RPM
4.	A.C. Drive	X 4 C 40 100 C 1 P 66, 10 hp Input volts: 380 - 460 ± 15 % Input Ampere: 19.7/16.3 Output volts: 0 - 380/460, 3 phase Output Ampere: 15.6/14 A
5.	Computer	P-IV-266, 40 GB Seagate HDD, 512 DDR RAM

Table 2 Effect of roller RPM and moisture content on ginning rate, and electrical energy consumption in a DR gin

Cotton – A

Moisture Content %		5			7			9	
Roller Speed, RPM	80	100	120	80	100	120	80	100	120
1) Ginning Rate, g/m/s	9.1	10.6	17.4	9.4	11.2	18.1	9.0	10.3	17.2
Lint output, kg / h	44.6	52.2	85.4	46.3	55	88.8	44.3	50.3	84.4
2) Electric Energy consumption for ginning 100 kg lint, kWh	5.46	6.16	4.45	5.42	5.82	4.34	5.95	6.62	4.92

Cotton – B

Moisture Content, %		5			7			9	
Roller Speed, RPM	80	100	120	80	100	120	80	100	120
1) Ginning Rate, g/m/s	7.1	9.2	13.1	8.0	9.6	15.3	7.3	9.3	13.3
Lint output, kg/h	34.6	45	64.4	39.3	47.3	75.1	35.6	45.5	65
2) Electric Energy consumption for ginning 100 kg lint, kWh	6.94	7.02	5.78	6.48	6.93	5.39	7.58	6.57	6.38

Cotton – C

Moisture Content, %		5			7			9	
Roller Speed, RPM	80	100	120	80	100	120	80	100	120
1) Ginning Rate, g/m/s	9.1	12.2	14.2	10.2	12.4	15.6	10.2	12.4	17.2
Lint output, kg/h	44.6	60	69.4	50.1	60.8	77.3	50	61	84.2
2) Electric Energy consumption for ginning 100 kg lint, kWh	5.55	5.68	5.46	5.34	5.59	5.10	5.6	5.63	5.2

Table 3 Statistical analysis by Duncan's Multiple Range Test for lint output and power consumption ^{z}

Roller speed, RPM	Lint Output ^{y}, Kg/h	Power requirement ^{y} kWh for ginning 100 kg lint
	Cotton A	
80	45.1 a	5.617 a
100	52.5 b	6.205 b
120	86.2 c	4.573 c
	Cotton B	
80	36.5 a	7.00 a
100	45.8 b	6.96 a
120	68.2 c	5.85 b
	Cotton C	
80	48.2 a	5.512 a
100	60.6 b	5.642 a
120	76.6 c	5.257 a

^{z} Means with the same letter not significantly different based on Duncan's Multiple Range Test at 5 % significance level

^{y} Based on 54 sets of measurements of two replications and three moisture contents

Table 4 Statistical analysis by Duncan's Multiple Range Test for lint quality data [z]

Roller speed, RPM	2.5% SL [y] mm	UR [y] %	MIC [y]	Tenacity [y] g/tex	NEPS [y] cnt/gm	SCN [y] cnt/gm	MR [y]	IFC [y] %
				Cotton A				
80	30.27 a	47.8 a	3.9 a	23.4 a	141.3 a	32.8 a	0.84 a	8.2 a
100	30.25 a	47.3 a	4.0 a	22.9 a	164.5 a	33.5 a	0.83 a	8.7 a
120	30.35 a	48.0 a	4.1 a	23.7 a	138.3 a	37 a	0.84 a	8.4 a
				Cotton B				
80	30.5 a	47.8 a	3.9 a	24.7 a	104 b	33.8 a	0.89 a	6.8 a
100	30.6 a	47.3 a	3.9 a	24.3 a	119.2 a, b	51.8 a	0.89 a	6.6 a
120	30.4 a	48.2 a	4.0 a	24.2 a	138.8 a	57.3 a	0.89 a	6.7 a
				Cotton C				
80	23.5 a	47.8 a	5.5 a	16.2 a	90.7 a	12 a	0.92 a	5.8 a
100	23.7 a	47.3 a	5.5 a	15.7a	88.7 a	14.6 a	0.92 a	5.8 a
120	23.9 a	48.2 a	5.6 a	15.8 a	84.3 a	11.2 a	0.92 a	5.6 a

[z] means with the same letter not significantly different based on Duncan's Multiple Range Test at 5 % significance level

[y] Based on 54 sets of measurements of two replications and three moisture contents

Table 5 Specification of various elements of power transmission system in modified DR gin

Sr. No.	Element	Dimension and Quantity	
A	Electric motor	6 hp, 1440 RPM One	
B	V-belt drive		
1	Motor pulley diameter	146 mm, One	
2	Driven pulley diameter	180 mm, One	
3	Type of belt	B section, Two	
4	Length of belt	1912 mm	
C	Gear elements	Pinion One	Gear One
1	No. of teeth	19	99
2	Module, mm	2	2
3	Tooth width, mm	28	28
4	Diameter, mm	41.3	330
D	Sprocket –chain		
1	Chain Type, No. of strands	Triple strand No. 60	
2	Pitch,	18.75 mm	
3	No. of teeth & OD of driving sprocket	15, 100 mm	
4	No. of teeth & OD of driven sprocket	28, 178 mm	
5	Root dia. (driving)& Driven sprocket	77.58, 155.74 mm	
6	Width of sprocket teeth	10.35 mm	
7	Total width of sprocket	53.56 mm	

Table 6 Comparative performance evaluation of existing and Modified DR Gin

Particulars	Commercial Double Roller Gin		Modified Double Roller Gin		Remark
1. Roller length, mm	1360		1360		Same
2. Roller diameter, mm	170		170		Same
3. Roller RPM	100		120		20 % Increase
4. Electric motor	5 hp, 1440 RPM, 3 Φ		6 hp, 1440 RPM, 3 Φ		20 % more
5. Lint output, kg/h					
Cotton B	47.3		76.7		62 % increase
Cotton C	60.8		78.05		28 % increase
6. Power requirement, Watt					
Cotton B	3281		4082.5		24 % more
Cotton C	3398		4009.0		18 % more
7. Electric consumption for ginning 100 kg lint, kWh					
Cotton B	6.94		5.32		23 % saving
Cotton C	5.59		5.14		8 % saving
8. Grease/oil requirement kg/season	30 (Rs. 3000)		5 (Rs. 500)		600 % saving
9.Grease-oil contamination prospect	Enormous		None		Improvement in lint quality
10. Cost of machine, INR (US $)	90,000 (2250)		90,000 (2250)		Same
11. Fibre Quality	Cotton B	Cotton C	Cotton B	Cotton C	
2.5 % SL	30.8	24.0	30.7	23.7	Preservation of fibre quality parameters
UR %	47	51	50	50	
Mic	4.0	5.6	4.0	5.3	
Tenacity g/tex	24	16	24.2	17.2	
Neps cnt/g	125	82	125	98.4	
SCN cnt/g	60	14	50.1	13.2	