Single Locking Cotton Feeder for Enhancing Ginning Efficiency of Double Roller Gin

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Abstract

Single locking cotton feeder was designed and fabricated with an aim to maintain constant feeding rate of individual locules at the ginning point of Double Roller (DR) gin. It comprises of a pair of feed roller, spiked cylinders, grid, feeder hopper and distributor chute. Spiked cylinder has spikes, its tips were spaced closer to the feed rollers than the thickness of a lock of cotton. The spiked cylinder travel at a greater linear speed than the feed rollers, whereby cotton bolls held between the feed rollers are struck by the spikes of spiked cylinder, thus ensuring single locking of cotton. The effect of single locking of cotton on ginning efficiency of DR gin was studied. Extent of unlocking was determined by measuring the change in bulk density of cotton before and after passing through the feeder which decreased with increase in spike cylinder speed. DR gin output was found to increase by 15-20% with use of single locking feeder as compared to conventional feeding system comprising of auto-feeder and micro-feeder. Cotton quality was also found to improve in terms of colour grade. Single locking feeder observed to be highly useful for Indian cotton ginneries.

Keywords: single locking, feeder, cotton, double roller gin, ginning

Introduction

Cotton is an important commercial crop of India and about 338 lakh (33.8 million) bales of cotton were produced during 2016-17. More than 95% of the cotton produced in India is ginned on Double Roller (DR) gins. The output capacity of DR gins is very low as compared to the Saw gins and Rotary Knife Roller gins which are mostly used in USA, Brazil and China. The output capacity of DR gin ranges from 40-90 kg lint/h depending on the length of the gin machine. The capacities of commercially available Saw gins range from 500-1000 kg lint/h and that of Rotary Knife Roller gin is about from 400-450 kg lint/h. Quality of the cotton ginned on DR gins is better than that of Saw gins (Sharma, 2014). Despite of this, DR are gins are less preferred across the world except in India and some African counties, the main constraint for its wide spread adoption is its low production capacity.

The DR gins are modified on varioua aspects to increase the ginning efficiency which is mainly governed by lint output, lint quality and eneergy conssumption (Patil et al., 2007). The manufacturers of DR gins have developed improved versions of DR gin by increasing roller length from 1,065 to 1,525 mm with an increase in output from 40 to 90 kg lint/h. Improvements are carried out in the material of construction in parts such as beater shaft, knives, gears, connecting rod and eccentric shaft to increase working life of parts and to reduce the downtime due to unexpected breakdown. In an effort to increase the productivity of DR gin, the gear box of the gin is modified to have the roller and beater drives de-linked and were driven independent of each other. This modifiction is referred as 'Variablle Speed DR gin'. The speed variations of roller and beater are possible for diferent staple cotton to get better quality and productivity (Patil et al., 2003). Self grooving rub-

ber roller was developed to increase the gin productivity and roller life and also to reduce the drudgery of grooving operation associated with the leather roller. These modifications improved working efficiency of the DR gin to some extent.

The efficiency of DR gin in terms of output primarily depends upon the roller speed, beater speed, setting and adjustments, machine condition, moisture content, staple length and trash content in the cotton and cotton feeding mechanism used over the DR gin. Type of feeder plays an important role in deciding the ginning efficiency. The Indian ginneries mostly use auto-feeder in combination with micro-feeder and screw conveyor as feeding system. Commonly encountered problems in auto-feeder are frequent stoppages, feeding of seed cotton in lumps, non-uniform feeding to beater of DR gin, falling of seed cotton outside the DR gin, damage to cloth belts, shifting of belt cloth to one side and seeds coming out of lower portion of hopper. In this systems of feeding, flow rate is often erratic. Feeding becomes difficult due to entanglement and difficult to maintain the optimum feed rate to DR gin. Ginning efficiency of the DR gins gets affected significantly due to these problems. To improve ginning efficiency, careful attention needs to be given to improve the feeding system.

Efficient ginning is achieved on gin machinery with constant and uniform flow rate and uniform of seed cotton. Feeder output must be uniform and steady. The primary function of the feeding device is to feed seed cotton to the gin machine precisely. Seed cotton feeding should be limited to that which is essential to ensure smooth and trouble free ginning in order to obtain optimum bale value (Antony, 1994).

It is necessary to modify and restructure feeders, in order to get efficient ginning with enhanced capacity of DR gin. The efficiency of DR gin can be enhanced by replacing the conventional method of cotton feeding comprised of micro-feeder and auto-feeder with a new concept of feeding individual locules of seed cotton at the ginning point. This principle of single locking of seed cotton is employed in Saw and Rotary Knife Roller gins to achieve the efficient ginning with the desired gin capacity and bale value. Saw and Rotary Knife Roller gins employ extractor feeders to feed seed cotton in single locks uniformly to the gin stand at controllable rates. Feed rollers of the extractor feeder control the feed rate of seed cotton to the gin. It provides even flow of seed cotton to the knife edges of rotary gin and saw tips in saw gins (Lummus, 2003). Single locking of seed cotton ensures controlled feed rate and increases the production capacity with the increased bale value (Baker et al., 1994).

Development of single locking feeder especially for DR gin would help to eliminate the flaws in the existing ginning process and would help in improve the ginning efficiency. It is expected to increase the ginning efficiency in terms of increased output, controlled feed rate, increased ginning percentage, improved grade of lint and yarn, reduced downtime, wastage and contamination. The developed feeder would be useful for ginning machinery manufactures, cotton ginners to understand how the gin feeder affects the overall performance of the ginning machine which would enhance profits of growers and ginners.

Materials and Methods

Spike cylinder type single locking cotton feeder cum cleaner was designed at ICAR-Central institute for Research on Cotton Technology, Mumbai by using standard design methodology and procedure. Each subassembly and its individual component were designed by selecting the appropriate materials so as to achieve the intended function effectively. Two and three dimensional drawings of each machine component and subassembly were prepared using AUTOCAD. The prototype of the designed feeder cum cleaner was fabricated and its performance was evaluated. The effect of single locking of cotton on ginning efficiency of DR gin was studied by evaluating the performance of the prototype in terms of degree of unlocking of cotton bolls, cleaning efficiency, energy consumption and output capacity of DR gin and quality of ginned lint. Extent of unlocking was determined by measuring change in bulk density of cotton before and after passing through the feeder.

The developed prototype was mounted on the commercial double roller gin with roller length of 1,360 mm. The spike cylinder speed was varied from 100-500 rpm with the help of variable frequency drive. Long staple cotton with 2.5% span length of about 30 mm was processed during testing. The moisture content of the cotton varied from 5-9%. The Clamp on Power Meter (CW240) manufactured by Yokogawa, Japan was used for measurement of energy consumption. The fibre quality parameters were measured on High Volume Instrument (HVI) and Advanced Fibre Information System (AFIS). The trash analyser was used to measure the trash content.

Principle of Working

Seed cotton is fed through feed roller assembly. Spiked cylinder has spikes, its tips were spaced closer to the feed rollers than the thickness of a lock of cotton. The spiked cylinder travel at a greater linear speed than the feed rollers, whereby bolls of cotton momentarily held between the feed rollers are struck by the spikes, thus ensuring single locking of cotton. The individual locules so formed are passed over and between the spike cylinders and the grid underneath. Foreign matter gets dislodged from the cotton by the agitating and scrubbing action of the cylinders and

falls through grid. The trash gets accumulated in the trash chamber. The individual locules are carried forward by the centrifugal action of the spike cylinder and dropped into the distribution chute mounted below the feeder. The distribution chute equally distributes the cotton in the form of a continuous matt on either side of the beater of the DR gin. Fibres adhere to the ginning roller of DR gin and are carried in between the fixed knife and the roller such that the fibres are partially gripped between them. The oscillating motion of the beater beats the seeds and separates the fibres. This process gets repeated for each individual locule thus ensuring the ginning of the cotton (**Fig. 1**)

Results and Discussion

Single locking cotton feeder cum cleaner (**Fig. 2**) was designed with an aim to maintain constant and optimum feeding rate of individual locules to ensure locule feeding exactly at the ginning point across the knife edges of double roller gin. The designed feeding mechanism replaces the micro-feeder and auto-feeder of conventional feeding system.

Design and Fabrication

Spike cylinder type single locking cotton feeder cum cleaner was designed and fabricated (**Fig. 3**). Feeding mechanism comprises of a pair of feed roller, pair of spiked cylinders and grid bar housed in a feeder hopper, chute for cotton distribution on either side of the beater of DR gin and power drive arrangement.

Feed Roller Assembly

The function of the feed roller assembly is to regulate the supply of seed cotton to the spike cylinders in a controlled manner at a rate in synchronization with the capacity of the DR gin. Feed roller assembly (**Fig. 4**) comprises of a pair of counter rotating fluted rollers with roller length of 1,283.5 mm. The main components of feed roller are shaft, flats, driving and driven pin. Six number of 40 × 3 mm M.S. flats are mounted on the periphery of the shaft at an equal angular spacing of 600. The overall diameter of the feed roller is 124.5 mm. The 16 mm clearance is maintained between the tips of the flats of two counter rotating feed rollers. The feed rollers are driven by 30W DC motor (24 V and 1.5 A). Variable frequency drive and voltage control drive is used to vary the speed of feed rollers.

Spike Cylinder Assembly

The primary function of the spike cylinders is to ensure the unlocking or single locking of the seed cotton bolls and the secondary function is to remove the foreign matter from the seed cotton. It consists of a pair of spiked cylinders. Each cylinder (**Fig. 5**) comprises of shaft, cylinder, spikes and centre plates. The cylinder with 1,283.5 mm length and 228.6 mm diameter is made out of sheet metal. The overall dimeter of the cylinder with the spikes is 279.4 mm. Altogether 200 spikes are mounted in zig zag pattern in eight rows over the periphery of cylinder. The spacing of 50 mm is maintained between the two spikes. The 10 mm clearance is maintained between the tips of spikes of two cylinders. The spike cylinders are driven by 2 hp, 1,440 rpm electric motor. Variable frequency drive is used to vary the speed of the cylinders.

Grid Assembly

The function of the grid is to ensure further unlocking of seed cotton by agitating and scrubbing action between spikes and its surface. The dislodged foreign matter falls through

Fig. 1 Schematic diagram of spike cylinder single locking cotton feeder with DR gin

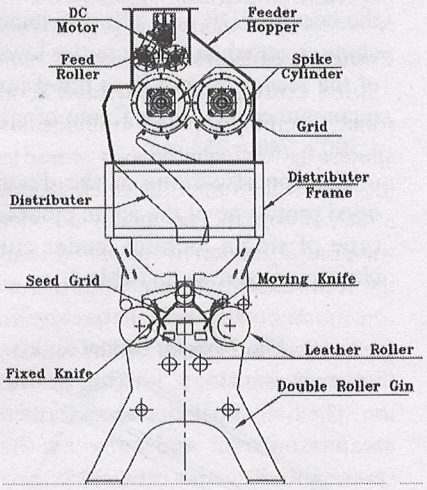


Fig. 2 Schematic diagram of spike cylinder single locking cotton feeder

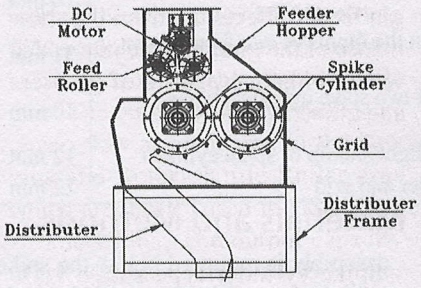


Fig. 3 Prototype of spike cylinder single locking cotton feeder

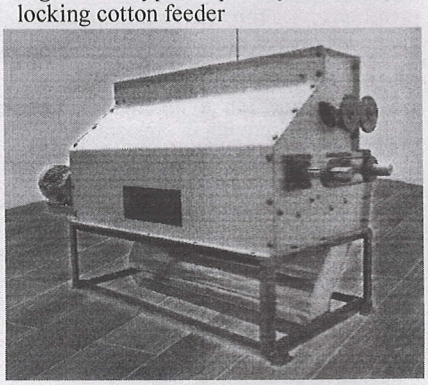


Fig. 4 Feed roller

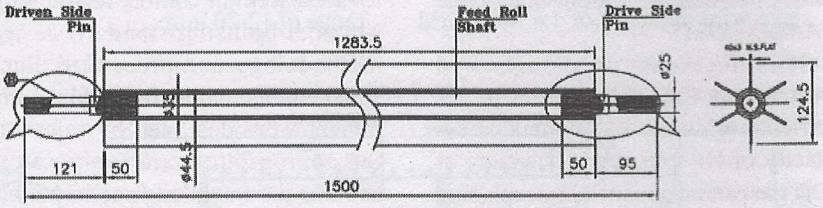


Table 1 Specifications of spike cylinder single locking cotton feeder

Particulars	Values
A. Feed roller assembly	
1. Length of feed roller (mm)	1,283.5
2. Number of flats on each feed roller	6
3. Feed roller diameter (mm)	124.5
4. DC motor power to drive feed rollers (W)	30
5. Feed roller speed (rpm)	1-5
B. Spike cylinder assembly	
1. Cylinder length (mm)	1,283.5
2. Spike length (mm)	25.0
3. Cylinder diameter with spikes (mm)	279.4
4. Number of spike rows on cylinder	8
5. Spike to spike distance in a row (mm)	50
6. Power to drive spike cylinder (hp)	2
7. Spike cylinder speed (rpm)	100-500
C. Grid assembly	
1. Sieve mesh size (mm)	11.2
2. Sieve wire diameter (mm)	1.6
3. Grid concave radius (mm)	150
D. Feeder hopper assembly	
1. Length (mm)	1,300
2. Top width (mm)	277
3. Bottom width (mm)	671
4. Height (mm)	739
E. Distributor chute assembly	
1. Distributor chute width (mm)	250
2. Distributor chute length (mm)	1,283.5
3. Frame Size (mm)	1,300 × 749 × 353

Table 2 Optimum setting and adjustments for spike cylinder single locking cotton feeder

Settings and adjustments	Values
1. Minimum tip to tip clearance between the flights of two feed rollers when diametrically aligned	16 mm
2. Maximum tip to tip clearance between the flights of two feed rollers while moving in opposite direction	31 mm
3. Tip to tip clearance between spikes of two spike cylinders when diametrically aligned	10 mm
4. Clearance between tip of feed roller flight and tip of spike cylinder	12 mm
5. Clearance between tip of spike cylinder and grid	12 mm

the grid openings. The concave shape grid assembly (**Fig. 6**) with radius of 150 mm is made out of a square wire mesh of sieve size 11.2 mm with sieve wire diameter of 1.6 mm. Grid assembly is mounted below the spike cylinder assembly. Provision is made to vary clearance between the tips of spike on cylinder and the grid in the range of 12-20 mm.

Fig. 5 Spike cylinder

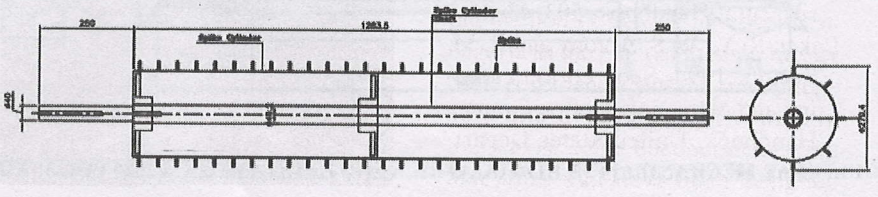
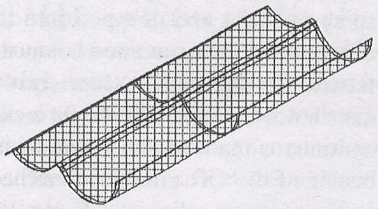


Fig. 6 Grid



Feeder Hopper

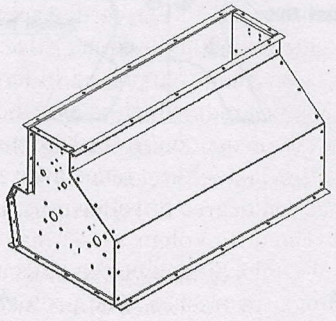
The feeder hopper (**Fig. 7**) is designed to house all the three assemblies, namely, feed roller, spike cylinder and grid. The hopper is provided with suitable inlet to receive the seed cotton and an appropriate outlet to deliver the unlocked and cleaned seed cotton to the distributor mounted below it. The grid assembly is mounted underneath the spike cylinders. The trash chamber is provided below the grid to collect the trash obtained during cleaning operation. A sliding window is provided in the hopper to remove the trash manually. The overall dimensions of the feeder hopper are 1,300 × 671 × 739 mm.

Distributor Chute

It is designed to receive the unlocked cotton from the feeder hopper outlet to convey and drop it evenly along the length and on either side of the beater of DR gin. The distributor chute is attached to the outlet lower of the feeder hopper. It is fitted in a rectangular angle iron frame of size 1,300 × 749 × 353 mm.

The specifications of the developed prototype of the spike cylinder type of single locking feeder cum cleaner are shown in **Table 1**.

Fig. 7 Feeder hopper



Performance Evaluation

The prototype of single locking feeder cum cleaner was set and adjusted to the settings as depicted in **Table 2**. A view of DR gin with single locking feeder cum cleaner in operation is shown in **Fig. 8**. The designed mechanism comprising of pair of feed rollers and spike cylinders and gird was found to unlock the cotton bolls to individual locules to the desired extent. The developed prototype successfully opened the lumps of seed cotton and unlocked bolls to individual locules. The principle on which the prototype was designed i.e. to ensure single locking of cotton bolls and to deliver the individual locules to the ginning point of DR gin was found to work satisfactorily. The desired unlocking of cotton bolls was obtained that resulted in efficient ginning on DR gin. Single locking was evidenced by decrease in bulk density of the cotton.

Bulk density was found to decrease with the increase in the speed of spike cylinders. Bulk density found to decrease by 10-30% with increase in cylinder speed from 200-400 rpm. Output of the DR gin was found to increase by 15-20% with use of single locking feeder cum cleaner as compared to the conventional feeding system comprising of auto-feeder and micro feeder. The increase in output may be attributed to opening of lumps of cotton, removal of entanglements within the boll and individualisation of fibres adhering the cottonseed. Unlocking increased the surface area of cotton thereby more number of fibres came in contact and adhered to the ginning roller in the given time. The energy consumption of the feeder was found to vary between 0.18-0.25 kW/h for the speeds ranging from 200-400 rpm (**Table 3**).

Cotton quality improved in terms of colour grade which is evidenced from the reduction in trash content, increase in degree of reflectance and reduction degree of yellowness. Improvement in colour grade may be due to unlocking of cotton bolls and removal of trashes. The prototype successfully removed fine trashes, leaf bits, dust etc. The cleaning efficiency was found to vary from 20-30 % depending on the initial condition of the cotton. The degree of whiteness was found to increase by 5-10% whereas the degree of yellowness found to decrease by 5-10%. The other quality parameters such as fibre length, strength and micronaire remain unaffected.

Table 3 Performance evaluation of spike cylinder single locking feeder in comparison to conventional feeder

Parameters	Values
1. Increase in capacity of double roller gin (%)	15-20
2. Degree of unlocking in terms of decrease in bulk density (%)	10-30
3. Cleaning efficiency (%)	20-30
4. Increase in energy consumption (%)	5-7
5. Increase in degree of whiteness (Rd) of lint (%)	5-10
6. Reduction in degree of yellowness (b+) (%)	5-10

Conclusions

Spike cylinder type single locking cotton feeder cum cleaner was observed to be successful for single locking of cotton bolls that resulted in enhancing the ginning efficiency of double roller gin. The output of the double roller gin with the use of single locking feeder was found to increase by 15-20%. The fibre quality of the cotton processed using feeder was improved in terms of reduction in trash, improved whiteness and reduction in degree of yellowness. With the above advantages, the single locking feeder would be highly useful for Indian cotton ginneries.

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Fig. 8 A view of DR gin with spike cylinder single cotton locking feeder in operation