Recent Advances in Cotton Ginning Technology in India

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Abstract

Indian Cotton Ginning Industry is the second largest in the world. Cotton ginning plays very important role of separation of fibres from cottonseed and converts field crop into a saleable 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. About 36.5 and 38 million bales were ginned during 2012-13 and 2013-14, respectively in about 1500 modern and 2500 semi-modern ginneries. By introduction of efficient ginning, pre and post cleaning and novel material handling machinery along with implementation of skill development programmes, Indian Ginning Industry has been transformed into remunerative business enterprise and has achieved global leadership in supply of quality cotton to domestic as well as international textile mills. The present paper describes recent advances which have taken place in: *(i) loading - unloading and feeding mechanisms for cotton, (ii) moisture control in seed cotton, (iii) efficient cleaning devices for seed cotton and lint, (iv) uniform feeding of seed cotton to gin machine, (v) power efficient seed cotton feeding system for individual gin machine, (vi) modern DR Gin, (vii) moisture control in lint, (viii) modern baling presses (up packing and down packing), (ix) fire detection and diversion system, (x) fibre friendly seed cotton and lint suction systems, (xi) contamination scanners, (xii) mechanical bale handling system, etc.* The paper also covers the machinery sequence and economics for small, medium and large scale ginning factories suitable for Asian countries for quality ginning of cotton.

Keywords : Double Roller Gin, Saw gin, Ginning out-turn, Moisture content, Pre-cleaner, Bale Press, Tower Dryer, Conveyor system**,** Contamination, Fire detection, Lint suction system

1. Introduction

Cotton Ginning is a primary processing industry whose major function is to clean and gin the seed cotton, clean the lint and form a bale. During 2012-13 and 2013-14 in about 1500 modern and 2500 semi-modern ginneries using double roller gins could able to gin about 36.5 and 38 million bales, respectively.

The four Ginning Technologies, i.e., 1) Saw Ginning (about 55%) 2) Double Roller Ginning (about 35%) 3) Rotobar or Rotary Knife Roller Gin (about 5%) and 4) Single Roller (about 5%) being used in the world. These technologies are having their own considerations and the competitiveness of the cotton processing which in turn affects their adaptation.

In advanced countries most of the ginning is performed on saw gins. Of late, however, there has been renewed interest in roller ginning, especially, its advantages over saw ginning in respect of higher ginning percentage and better retention of fibre length. It may be mentioned here that the saw ginning always results in loss of fibres sometimes to the extent of 2%. Further, most short fibres with length less than 12 mm are left un-ginned requiring further processing. It is also known that saw ginning leads to more neps in the yarn. Maintenance of saw gin is costly as compared to roller gins and spare parts are not easily available. Rotary Knife roller ginning technology is having major disadvantages like seed cut, fibre neps and un-ginned cotton going with seeds.

From various studies it is observed that roller ginning gives 1 to 2 % more ginning out-turn (GOT) and also improves fibre properties like length, uniformity, fineness and lowers the neps. Yarn made from roller ginned fibres is stronger and has fewer end breaks. It is well established that double roller ginning technology is the most gentle and fibre friendly technology which can be used in cost effective manner for all type of cottons. Roller gins proved to be a good alternative to saw gins because of its various advantages.

The introduction of Technology Mission on Cotton (TMC) by the Govt. of India and the Central Institute for Research on Cotton Technology, Mumbai since year 2000 have made a great impact on the modernization of ginning sector in India by devising technical specifications, creating trained manpower and conducting awareness programmes. Even after the completion of TMC in the year 2010, has created a trend of automated and modernized ginning factories in India. Hence a majority of new ginning factories are being established even after the year 2010 in India are following the guidelines of TMC. Thus this has resulted in complete transformation of Indian ginning industry from an outdated status, inefficient machinery, poor infrastructure to the most modern, efficient automated industry with significant reduction of trash and contamination in Indian cotton. The Indian cotton has got a wide acceptance across the globe on quality parameters and India has achieved the status of second largest exporter of cotton in the world.

Most of the developments have taken place during a recent period throughout the India whereas elsewhere in the world such as USA and China no significant developments except the development of high capacity saw gins have taken place. The journey of modernization of various operations in a ginning & pressing factory are being continued to further improve the quality and cost efficiency as well as ease of operations for ginning & pressing factories. Many research advances have taken place in the past few years to improve the processing of this unique crop, each component of which is having multiple uses. A continued journey of advances is improving day by day in the areas remaining to be addressed for the cotton processing sector in a most beneficial manner.

2. Recent Advances in Cotton Processing Technologies

Recent advances in cotton processing technologies which have taken place in India includes: *(i) loading - unloading and feeding mechanisms for cotton, (ii) moisture control in seed cotton, (iii) efficient cleaning devices for seed cotton and lint, (iv) uniform feeding of seed cotton to gin machine, (v) power efficient seed cotton feeding system for individual gin machine, (vi) modern DR Gin, (vii) moisture control in lint, (viii) modern baling presses (up packing and down packing), (ix) fire detection and diversion system, (x) fibre friendly seed cotton and lint suction systems, (xi) contamination scanners, (xii) mechanical bale handling system, etc*.

The Central Institute for Research on Cotton Technology (CIRCOT), Mumbai in collaboration with leading gin machinery manufacture in India namely M/s. Bajaj Steel Industries Ltd, Nagpur have put up great efforts in providing improved machineries for achieving the optimum results in respect of all the areas referred above and some of the recent advances introduced in ginning sector are elaborated below.

(i) Loading - Unloading and Feeding Mechanisms for Cotton

Manual unloading of vehicles, heap making and feeding to suction or other mechanical conveying systems were being practiced upto the year 2010. These were highly labour oriented and contamination prone methods. To improve this situation, tractor mounted

attachments for various applications such as; unloading of vehicles, heap making and feeding through seed cotton conveying systems as well as seed heaping and loading have been introduced. These attachments helped to reduce manpower and contamination in the cotton ginning factories in India. Loading of cotton bales in trucks have been made easy by such Tractors. These attachments have eased out the loading, unloading and feeding of seed cotton in the ginning factories and saved significant manpower.

Fig. 1: Tractor Attachment for Cotton Loading and Unloading

Fig. 2: Tractor Attachment for Heaping of Cotton

(ii) Moisture Control in Seed Cotton

The moisture content of seed cotton is a significant attribute in the ginning process. It has a direct impact on fibre quality, cleanability and consistency which in turn reflects in quality of yarn and fabrics produced from cotton. In each gin process, there is requirement of optimum fibre moisture content. The effort required to control moisture pay dividends in gin operating efficiency and market value of the baled cotton. Many approaches are being used to restore moisture in seed cotton in the ginneries. Among these the latest development is the sensor controlled on-line hot air humidification system for uniform application of moisture when the cotton is dry.

The optimum cleaning efficiency is achieved only when the moisture contents in the seed cotton are around 6%. In the early cotton season the moisture contents in seed cotton are observed to be around 10 -15 % which makes it difficult to clean the cotton and also affects the ginning efficiency. Efficient ginning can be achieved only when the moisture content in the seed cotton is around 8%. Moisture content much below or above the recommended levels reduces the ginning capacities significantly as well as damages the quality of cotton. In view of this it was felt necessary that the drying process should be done for moist cotton to bring down the moisture content to the desired levels. Therefore the vertical tower dryers of different capacities are introduced. Seed cotton is dried to the recommended moisture level before feeding into gin machine when the incoming seed cotton is having excessive moisture. A picture of most preferred dryer which is recently introduced for Indian ginning factories is shown in Fig 3.

Fig. 3: Vertical Tower Dryer

(iii) Efficient Cleaning Devices for Seed Cotton and Lint

In the process of hand picking, sometimes labourers pick the cotton with large amount of trash such as leaves, stems, bracts and immature and unopened bolls. The trash content in the seed cotton ranges from 4-6 %. If pre-cleaning is not done; trash particles are made to adhere to the fibres during the high pressure baling process. Subsequent removal of trash in the blow room at spinning mills becomes difficult, expensive and detrimental to fibre quality. Pre-cleaning is necessary to improve gin stand performance and lint quality. Cylinder cleaners are used for removing finely divided particles and for opening and preparing the seed cotton for the drying and extraction processes.

The picking methods of seed cotton i.e. hand picking, hand stripping, machine picking, machine stripping etc. require different treatments for cleaning of seed cotton. Because in India mainly hand picking is practiced the spiked cylinder pre-cleaners are primarily used in ginning industries. Cylinder cleaners are either inclined or horizontal depending on the arrangement of the cylinders in it. Inclined pre-cleaners are currently manufactured in widths of 1.2-2.4 m with rated capacities of 3-6 tonnes seed cotton/h. Inclined pre-cleaners are employed with 4 to 6 cylinders depending on the cleaning efficiency required. The cleaning efficiency of cylinder pre-cleaner mainly depends on the number of cylinder employed. The cleaning efficiency is observed in the range of 25-30%. Besides this the spade and cylinder type lint cleaners are commonly employed to clean the lint obtained after ginning. The cleaning efficiency of lint cleaners is found in the range of 20-25%.

Moreover the experimental trials on mechanical picking have been started in some part of India and are likely to increase in the near future. Hence the extra cleaning of cotton becomes very important. To optimize cleaning for different varieties and different parameters of seed cotton, a number of advanced machines have been introduced during the last two years. These advanced cleaning equipment include stick machine, impact cleaner and stripper cleaner that offers complete solution to all machine picked cottons.

Fig. 4: CIRCOT-Bajaj Pre-cleaner

(iv) Uniform Feeding of Seed Cotton to Gin Machine

The hand feeding could never offer uniform and consistent feeding which normally results in loss of efficiency upto 20% and makes a significant impact on production costs. Uniform feeding of seed cotton to drying, cleaning and ginning machines is very important to obtain proper efficiency of these machines. During the last few years some machines such as Cotton Dispenser and Cotton Feed Control Box have been successfully introduced to effectively achieve uniform feeding, which has immensely benefitted the cotton ginning factories in India. The introduction of these equipment have improved the efficiency of processing machines by over 20% as compared to hand feeding.

Fig. 5: Seed Cotton Dispenser

v) Energy Efficient Individual Gin Machine Seed Cotton Feeding System

Various kinds of mechanical, pneumatic and electromechanical conveying systems are practiced for seed cotton feeding to individual DR gins. Overhead distribution conveyor system with auto regulators was the most preferred for each line for feeding of each gin. However the same was consuming extra power and also resulting in extra capital cost. In the year 2012, a twin line overhead distribution conveyor system with advanced auto regulator to simultaneously feed two gin machines on two parallel lines is introduced, which has revolutionized the individual gin feeding for double roller ginning plants and has reduced the capital cost and power consumption. This system has also introduced a slide where one can control the escaping of short fibres coming out from seed cotton during the feeding system and can be covered up to the feeding point to the Auto Feeder which finally results in the control of spreading of small fibres in the ginning area and is environment friendly.


Fig. 6: Twin Auto Regulator Individual Gin Feeding Conveyor System

(vi) Modern Double Roller (DR) Gin

In India about 90% of cotton produced is subjected to ginning by using double roller (DR) gins. Ginning output of DR gins was considered as quite low, thereby the operating cost was higher and the ginning was uneconomical. Now the highest capacity model ginning machines have been introduced in the year 2011-12. The productivity of this machine is about 100 kg lint/h. The operating cost per kg of lint ginned has been reduced drastically due to increased productivity and also because of no additional requirement of power and labour for improved versions of DR gin. This is the most versatile ginning machine available. The power consumption per unit of production is lowest for this machine. Features of a typical improved double roller gin are described as follows:

- Roller length: 1521 mm (60")
- Roller diameter: 171 mm
- Roller speed: 100 rpm
- Oscillatory knife speed: 950/1000 ops
- Capacity = 90 - 100 kg lint/ h
- Capacity in number of bales = 0.6 bale/ h
- Power for Ginning = 60 kWh/t lint

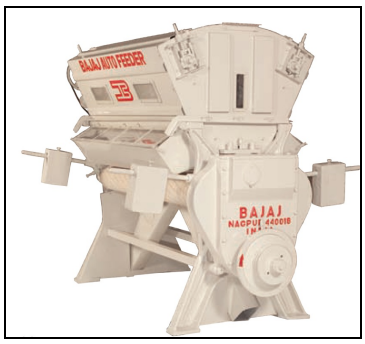


Fig. 7(a): Double Roller Gin

Fig. 7(b): DR gin during operation

Double Roller Gin with Self-Grooving Rubber Roller

Roller ginneries across the world primarily use chrome composite leather as a roller material. Non-consistent output due to faster roller wear, downtime due to periodical grooving, uneven ginning, chromium contamination and health hazards to workers are some of the problems associated with the leather roller. To overcome these problems encountered in chrome composite leather roller and to provide an alternate material for ginning roller an effort was made to develop self-grooving rubber roller. Self-grooving rubber roller was made out of rubber discs of hard and soft rubber compound prepared in a specially designed die by

moulding technique. Roller was made with nitrile rubber having radial layers of softer rubber compound to form grooves. Compounding ingredients in an appropriate proportion were added to provide sufficient hardness, temperature resistance and to ensure the efficient ginning. Self-grooving rubber roller was tested on commercial double roller (DR) ginning machines at different roller speeds. Roller speed of about 40 rpm was found to be optimum to achieve the efficient ginning without any adverse effect on the fibre and seed quality as against 100 rpm in a leather roller. The gear box of the DR gin was suitably modified to run at 40 rpm. The modified DR gin with rubber roller was tested in a commercial cotton ginnery. Ginning performance of self-grooving rubber roller in terms of capacity, energy consumption, effect on fibre quality and cost economics was studied and compared with that of a leather roller. Use of the self-grooving rubber rollers was found to increase the productivity of the DR gin by 25 to 30%. Periodical grooving and drudgery involved in grooving operation was eliminated in a rubber roller which consequently resulted in reduction in machine downtime up to 2 h/day. Energy consumption was found to be 15 to 18% lower than that of the leather roller gin. Working life of the rubber roller was estimated to be 5000 h as against 1000 h in a leather roller. Rubber roller is an eco-friendly roller and there is no environmental pollution and health hazard to workers as there is no chromium contamination while ginning. It was observed that one time investment on the modification can be paid back within a period of 76 working days of 20 h each. Self-grooving rubber roller can be used as a substitute to the leather roller for use in roller gins after making recommended modifications in double roller gin.

Fig. 8 : Double Roller Gin with self-grooving rubber roller

(vii) Moisture Control in Lint

The study has also shown the significant difference in bale moisture when measured at the time of baling and after 24 h of storage when the cold water spray method is used for moisturisation. It creates a lot of vibration in the baling process and extra power is used to make the bale when cold water is used. Thus the cold moisturisation totally defeats the purpose of moisturisation rather creates losses due to wastage of lint and operational problems. The cotton ginning industry now realized that humid-air is the proper method of moisturisation as moisture contents are retained for a longer time being getting imbibed in to the web of fibre and reduces the power consumption of baling process apart from significantly improving the quality parameters of lint. Thus creating benefits to the ginner by getting a higher price for better quality lint.

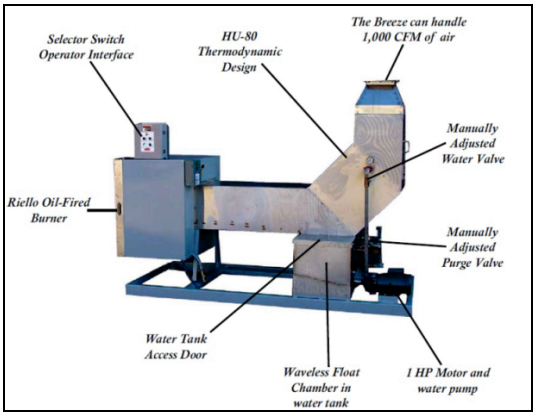


Fig. 9: Hot Air Humidification System

(viii) Modern Baling Presses (Up-packing and Down-packing) with Bale Handling System

Upto 2002 majority of the bale presses in India were conventional double stage type which was very old. Increased contamination, non uniform weight and density, requirement of large manpower were some of the drawbacks in those presses. Nowadays automatic single stage presses are becoming more popular in India. These presses are either single box or double box, up packing or down packing type. The most modern down packing presses of smaller capacities as well as higher capacity have optimized the utilization of plant capacities. Earlier only few models were available and in various cases the capacity utilization was not optimized. Moreover, to meet the requirement of lower height buildings, modern Up-packing presses in various capacities have been introduced in the Indian market apart from high capacity (60-80 bales/h) for overseas high capacities plants.

Fig. 10 Down-packing Press

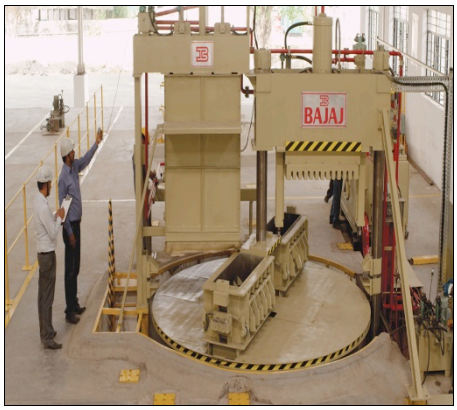
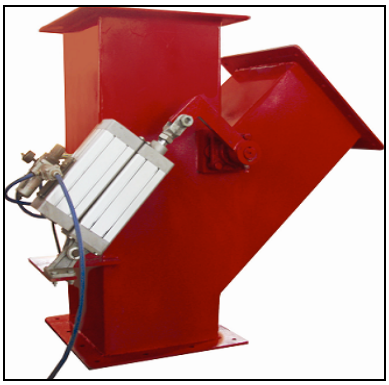


Fig. 11 Up-packing Press

In India some of the ginning factories have been introduced the cotton bale size of 1067 mm x 533 mm (42" x 21") as per International Bale Standard ISO 8115. By introducing this these factories can optimize the container loading as well as bale weight to the international standard which will certainly be a need of the future. The Automatic bale handling and bale bagging system has facilitated the making of fully covered bales. The computerization of bale weight and bale marking has also improved the bale making process and now the bar coding of the bales is being promoted. These measures will certainly improve the acceptability of Indian cotton bales worldwide apart from saving the wastage and reduction in contamination.

(ix) Fire Detection and Diversion System

Ginning industries are prone to catch fires. The risk of fire hazard is increased due to increased automation and use of large volume of air for material handling. The sensor based fire detection and diversion systems have been introduced which effectively control the risk of fire hazards.



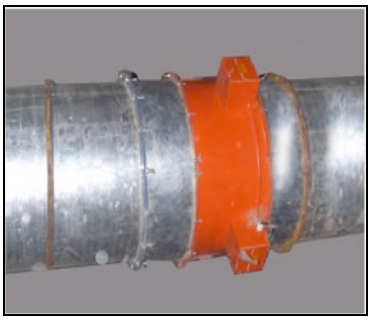


Fig. 12: Fire Diversion and Detection System

(x) Seed cotton, Lint and Cottonseed Handling Systems

The cotton was getting trashier in conventional ginneries due to manual handling from heaps to the press leading to contamination at every stage of processing. But with the technological innovations by Indian manufacturers, a rapid transformation has taken place in this area. Various kinds of mechanical, pneumatic and electromechanical conveying systems for seed cotton, lint and seed are developed indigenously. The belt type of seed conveying system to transport the cotton from the heap to the pre-cleaner and from pre-cleaner to the distribution system and then to the DR gins are developed. Also the belt conveyor systems to convey the lint from the individual DR gins to the lint cleaner are developed. These systems are cost effective and require less power to operate. In this system, the cotton is exposed to the open atmosphere while conveying and hence is subjected to contamination. The pneumatic conveying system for conveying seed cotton and lint are developed and widely used by Indian ginneries. The pnuematic conveying system consists of a suction fan, a ducting line, air separator and a cyclone. The developments in the conveying system for handling of cottonseeds from gin house to the seed platforms have reduced the drudgery of carrying the seeds manually. The mechanical conveyors or the air handling systems are developed for seed conveying. The mechanical system consists of mainly a screw conveyor and bucket elevator. The developments in air handling systems include roots blower type system and pneumatic suction type of system for seed conveying.

Fig. 13: Seed Cotton and Lint Handling System

Fig. 14: Seed Handling System

(xi) Contamination Scanners

At present a very few ginning factories use the high capacity colour sensing contamination sorters. However education to various ginners is being widely extended where the ginning factories are encouraged to stop the pre-cleaners at the raw cotton stage for few minutes after desired intervals to remove the contamination trapped in the cleaners. This will significantly reduce the furtherance of contaminates and work is going on for the higher capacity colour contamination sorters which may be available to ginning industry in the near future.

Fig. 15: Contamination Scanner

3. Economics of Roller Ginning

The economics of ginning operation depends upon the proper selection of ginning machinery depending on the plant capacity and desired lint quality. Thus the selection of suitable ginning machines is of paramount importance. Ginning industries can be classified in threes major groups based on the plant capacity - small, medium and large scale industries. The classification is tabulated below:

Class of Ginning Industry	Capacity (bale/h)	DR Gin (Number)	Capital Investment on Machinery (INR in Millions)	Break Even Point (Bales/year)	Return on Investment (%)
Small Scale	8-10	18	15	15000	20
Medium Scale	12-15	36	25	25000	24
Large Scale	>25	>54	35	50000	28

Salient Features of Double Roller Ginning Technology

- Gentle ginning and hence less or no damage to fibres and seed
- Better fibre parameters
- Higher length of fibre compared to other ginning methods
- Retaining of natural luster and moisture
- Lower nep content
- Higher ginning outturn of fibre
- Enabling of oil crushing without delinting because of less linter on cottonseed
- Lower power consumption:
- Lower cost of project
- Possibility of smallest size plant & biggest size plant
- Premium rates by buying mills

4. Relevance of Double Roller Ginning Technology in Bangladesh

Cotton is one of the important cash crops in Bangladesh. It is the main raw materials of textile industry. Annual requirement of raw cotton for textile industry of Bangladesh is estimated around 2.5 million bales. Local production is only about 0.1 million bales. Around 4-5% of the national requirement is fulfilled through the local production; remaining 95-96% is fulfilled by importing raw cotton from USA, CIS, India, Australia, Pakistan, South Africa and other cotton producing countries.

Cotton Development Board (CDB) has nine ginning centers located at different farms and cotton growing areas. The ginning centres have a total of ten Lumus 40×12 inch saw- gins with a capacity of about 3 tonnes seed cotton per 8-hour shift each. Besides, these there are four local made ginning machines. CDB does provide ginning facilities to the cotton growers, there are large number of private ginners in the nearby locations of the cotton growing areas, who provide ginning facilities to the cotton growers. There are more than 50 private ginners in the country and they play an important role for cotton production and marketing. They purchase seed cotton from the farmers through competition. They sell lint to the spinning mills after ginning from their own ginning centres.

Two types of cotton are grown in Bangladesh namely- i) Upland cotton (*Gossypium hirsutum*) & ii) Hill cotton (*Gossypium arboreum*). The 2.5% span length of the cotton ranges between 26-32 mm. Entire cotton produced in Bangladesh is ginned on a saw gin. However it could be effectively ginned on roller gins and fibre quality could be preserved. Roller ginning has certain advantages over the saw ginning as stated above. The roller ginning plant can be customised as per the requirements of the ginner. The small capacity plants with 4-6 double roller gins with matching pre-cleaner and a suitable bale press could be established in the cotton growing areas. Ginning the cotton on roller gins will fetch the premium rates from the spinning mills.

5. Conclusion

Remarkable advancement has taken place in the ginning technologies in during and post TMC era in India. It has kept the momentum of modernization of cotton ginning & pressing sector of India. Increased productivity of ginning machines, reduction of manpower and electrical power, reduction in contamination and improved cotton quality are benefits of these developments which resulted in increased export of cotton from India. Further, the developments taken in the cotton ginning & pressing technologies in India have made India a net exporter of these technologies, machinery and turnkey projects to various countries. Roller ginning technology would be a viable alternative for ginning the cotton produced in Bangladesh.

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