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A Review Paper on Design and Development of Natural Air Cooling Arrangement for "High Speed Single Roller Rotary Knife Gin"

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1. Abstract

In recent times, the importance of roller ginning is increasing rapidly as evidenced by the fact that only fifteen percent of the world cotton was ginned on roller gins in the year 2000, and by the year up to 2021-22. the quantity of the most in world cotton is ginned on roller gins which has surpassed with thirty five percent and more. Roller-type ginning is used to process long staple Pima and Upland cotton around the world. From a capacity standpoint, the rotary-knife roller gin stand is a higher-capacity option versus other ginning technology typically without compromising fiber-spinning quality. While roller-type ginning has long been shown to be a gentle way of separating the cotton lint from the seed, the low capacities typically obtained in traditional roller gins provide an economic barrier to their more widespread application.

Keywords- Single Roller, Double Roller, Speed, Rotary Knife, Stationary Knife, Gin roll Covering, Cotton Fibers, Moisture, Temperature, Seed Cotton, Cooling Nozzle, Cooling Fan etc.

2. Introduction

A Roller Gin consists of rollers to carry the seed cotton to a stationary knife and reciprocating knife or rotary knife. In this process the cotton fibers are separated from the seeds by adhering to the ginning rollers with a surface of leather or other suitable material which holds the cotton fibre on the surface and carries it between the stationary knife and roller in such a way that the fibers are partially gripped between them. The oscillating knife or rotary knife beats the seed so that the fibers are separated by a stretching action. The process is repeated for number of times and due to a push-pull-hit action the fibers are separated from the seeds continuously and carried forward to be dropped out of the machine. This process is gentle as compared to saw ginning and is most suitable for ginning medium, long and extra long staple cotton varieties. Roller gins typically produce less short fibre content, fewer neps and deliver all around more impressive fibre length.

The capacity and quality of the ginning system is directly affect to spinning performance of the lint which is depend upon the operating condition and adjustment of the gin stands. It is important to maintain the gin stand in good mechanical condition, to gin at recommended moisture levels, and not to exceed the nominal capacity of the gin stand or other components of the system. The quality of the cotton may be reduced if in stands are overloaded. Short fiber content increases if the ginning rate exceeds the manufacturer's recommendations. Short fiber also increases as saw speed increases. Increased ginning rate also increases yarn imperfections. Seed damage can also result from excessive ginning rate, especially when the seeds are dry. Ginning causes "neppiness" in cotton lint. Maintaining proper moisture and eliminating unnecessary processing steps during ginning reduces neps formation.

In worldwide Roller Ginning is divided in following types

I. Single Roller Gin (McCarthy)

II. Single Roller Rotary Knife Gin (Rotobar)

III. Double Roller (Close type)

I. Single Roller Stationary & Reciprocating Knife Roller Gin

The working principle of single roller gins is popularly known as the McCarthy principle, named after its proponent and shown in below Figures (1) and (2) below:

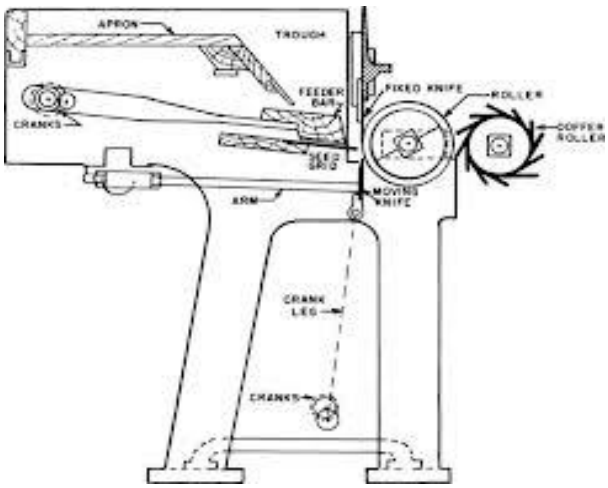

Figure (1)

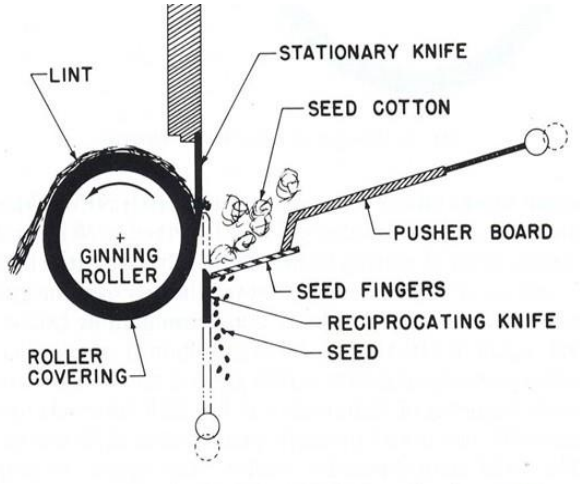

Figure (2)

The McCarthy roller gin utilizes a leather or composite roller to draw the fibers between a fixed knife and the roller. The roller rotates counter-clockwise (below) while touching the Stationary / fixed knife and the cotton is coming out from the top. The stationary knife is fixed with the sharp edge down while The Single Roller gin has long been the preferred method for ginning extra-long-staple, fine-fibre Sea Island, Egyptian, American-Egyptian, and Pima cottons (Bennett, 1956). While it is possible to gin these types of cotton with a saw gin, the resulting quality is substantially lower than that obtained with roller gins. Saw Ginning tends to decrease the fiber length of these types of cotton and to greatly increase their nep content (Chapman and Stedronsky, 1965) while one major disadvantage of the McCarthy Roller Gin is its low ginning capacity.

The Single Roller McCarthy Gin technology is most suitable for handpicked, low trash cottons of medium, long and extra long staple length. This technology retains maximum natural fibre parameters of the cotton during the ginning process; hence the treatment of the cotton is best with the Single Roller Gin.

II. Double Roller Stationary and Reciprocating Knife Roller Gin

The Double Roller Gins currently available are either an improved version of the Volcart design (manufactured by Montfort in Germany) or the Platt Brothers UK design gins. They are now manufactured in large quantities only in India.

In a double roller (DR) gin, two spirally grooved leather rollers, pressed against two stationary knives with the help of adjustable dead loads, are made to rotate in opposite directions at a definite speed. The three beater arms (two at end and one at the centre of beater shaft) are inserted in the beater shaft and two moving knives are then fixed to the beater arms. This assembly is known as beater assembly, which oscillates by means of a crank or eccentric shaft, close to the leather roller. When the seed cotton is fed to the machine in motion, fibers adhere to the rough surface of the roller and are carried between the fixed knife and the roller and the fibers are partially gripped between them. The oscillating knives (moving knives) beat / drag the seeds from top in the opposite direction causing separation of fibers from the seed end by pull-push process. This process is repeated a number of times until all spinnable fibers are separated from the seeds. The fibers, so detached from the seeds, are carried forward on the roller, under the fixed knife, and doffed out of the machine. The ginned seeds drop down through the slots provided on the seed grid and the gap between the end of seed grid and the rail. The grid is part of beater assembly and oscillates along with the moving knives helping quick removal of the seeds.

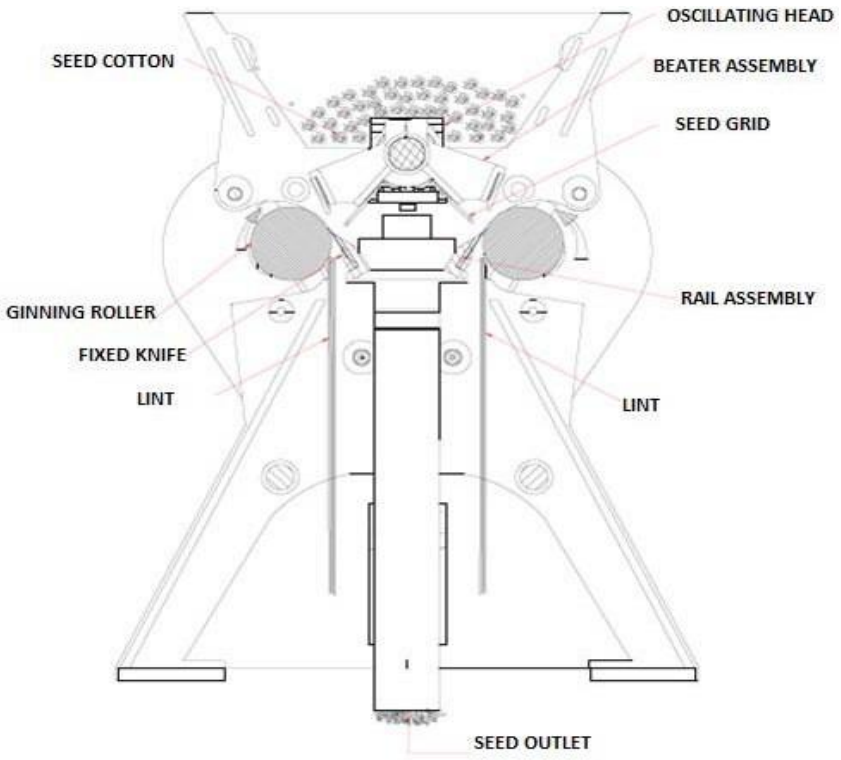

Figure (II) Double Roller Gin

This ginning technology is very gentle on the cotton and can gin all types of cleaned cotton. The best productivity however is obtained on medium, long and extra long fuzzy as well as black seeded cotton. Among all roller gin technologies, the electrical power consumption per unit of production is lowest in Double Roller technology, as the production with the same 5 HP (3.75 kW) motor produces almost three times the fibre as compared to McCarthy roller gin with same fibre parameters. Double Roller Ginning even consumes less power per unit of production than the Rotobar Rotary Knife Roller Gin; hence the use of this technology is rapidly increasing in South Asia, including India, Africa and other countries which have resulted in the rapid share increase of roller ginning in the world market. The Double Roller Gin is also tolerant of higher moisture to a great extent and can gin cotton at higher moisture content where drying is not available. Double Roller Gins have rapidly replaced McCarthy Single Roller Gins and Saw Gins in India and Eastern Africa in the recent past.

III. Single Roller Rotary Knife Rotobar (Spiral or Straight) Gin

In the Rotobar Rotary Knife Single Roller Gin, roller rotates in clockwise direction similar to Double Roller Gin while touching to the Stationary (fixed knife). The fibre is pulled under the stationary knife and dropped from the lower portion of the roller. This gin has a rotating knife rather than an oscillating beater bar. The rotary knife vibrates less due to rotary motion and is more efficient than the reciprocating knife, which loses effective time during its backstroke. The ginning rate and carryover (un-ginned seed cotton that accompanies the seed) increase with feed rate. A re-claiming machine is required to remove the excess seed cotton from the seed flow and return it to the gin. The main components of rotary knife roller gin stand include the stationary knife, rotary knife and ginning roller. The ginning roller is the most important and expensive component in the roller gin stand. The material covering the roller is made of 13 layers of woven cotton fabrics cemented together with rubber a compound. The seed cotton slides down the feeder apron and enters the gin between the ginning roller and the rotary knife. The ginning roller, which rotates constantly, is held tightly against the stationary knife. The lint is pulled under the stationary knife and the seeds, too big to pass under the stationary knife, are swept away by the rotary knife which spins in the opposite direction of the ginning roller.

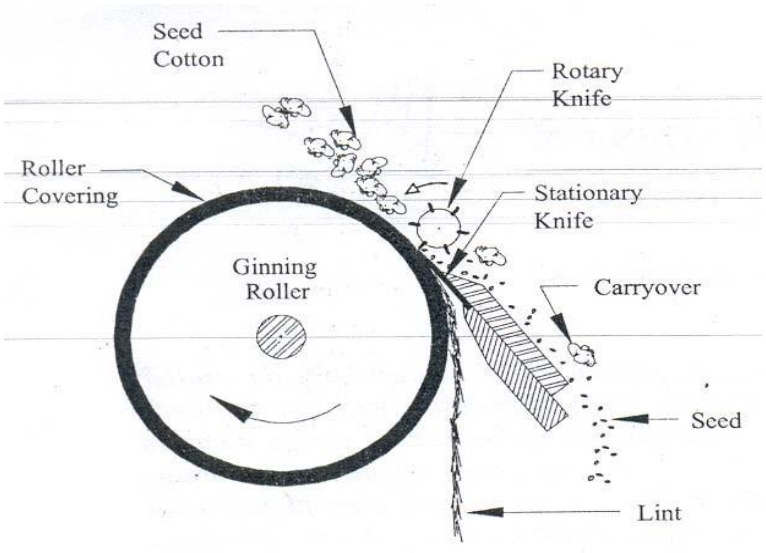

Figure (III): Single Roller Rotary Knife Gin

3. Brief details of development in roller ginning during 1960-2010

During this period the developments in McCarthy Single Roller Gins stagnated as the cost of ginning with this method became higher compared to the other two roller ginning technologies. The developments in Rotary Knife Roller Gin were taken up in USA by the United States Department of Agriculture, South Western Cotton Ginning Research Laboratory in Mesilla Park, New Mexico in conjunction with machinery manufacturers M/s. Lummus Corporation, Continental Eagle Corporation and Consolidated Cotton Gin Manufacturing Co. The developments in Double Roller Ginning Technology were taken up in India by Bajaj Steel Industries Ltd. with the Central Institute for Research on Cotton Technology - Indian Council of Agricultural Research (CIRCOT) Govt. of India.

4. Brief Overview of Developments in High Speed Rotobar Rotary Knife Roller Ginning during 1960-2013

The basic mechanics of the High Speed roller gin are essentially the same as those of the conventional Rotary Knife roller gin. However, improvements in the way the seed cotton is introduced to the ginning point, increased surface speeds of the ginning roll and rotary knife, addition of a cooling nozzle to minimize the impact of gin roll covering temperature rise and a highly responsive gin feed control combined to allow for the higher through puts experienced in 2005 and 2006 field operations. The primary focus of these modifications was toward the increase of the surface speed of the roller and the counter measures to address the increase of temperature due to increased friction on the roll surface. A cooling fan was added to reduce the temperature and higher output was achieved. To avoid repetition it would be advisable to refer to the publications listed above for the details.

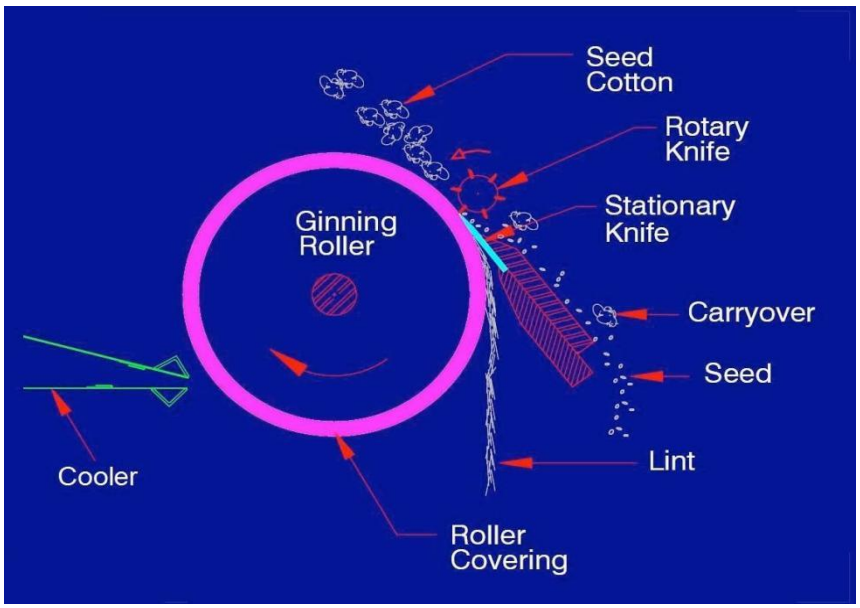

Figure (4)- Natural Air Cooling Jet for High Speed Rotary Knife Single Roller Gin

5. Developments in Rotobar Rotary Knife Roller Ginning during 2011-2013

Until 2010 Rotobar Rotary Knife Roller Gins were being used primarily for Pima varieties, where the fibre attachment to the seed is weaker and high speed Rotobar Gins could produce almost the same capacity as that of lower capacity saw gins. However, due to upland cotton's stronger attachment force to the seed the capacity was lower and there were some other issues.

This study has shown that, in recent time, selective breeding has improved upland cotton fibre properties and the samples of upland cotton ginned on high speed roller gin tasted on HVI and AFIS have shown that the Rotary Knife Roller Gin (conventional and high speed) produced fibre that was longer, more uniform, had less short fibre and fewer neps than the saw gin stand. Turnout, colour grade, and leaf were not different among gin stand types. With respect to yarn properties the conventional / high speed Rotary Knife Roller gin had fewer thick places but was higher in vegetable and foreign dark matter, seed coats and neps. The composition of neps changed as fibre was processed in to yarn. The conventional/high-speed roller gin had fewer raw stock and card mat neps than the saw gin stand, but more neps in finished yarn.

Differences among cultivars were prevalent throughout the study. In addition to differences in length, strength, and immature fiber content, the cultivar that was stripper harvested had double the trash content at the harvest. There were differences in most fibre properties but not in yarn properties. Among lint cleaner types, the Rotobar Roller Gin lint cleaning was less aggressive than saw type lint cleaning and had longer fibre, better uniformity and fewer neps. Saw type lint cleaning had better colour and leaf grades, and less lint trash. There was no appreciable difference between two types of Rotobar Roller Gin lint cleaning used but one saw type lint cleaner as opposed to two was less damaging to the fibre. It is felt that in view of the better fibre properties obtained on Rotobar Roller Gin for upland cotton and the value given by the textile mills for higher quality obtained from Rotobar Roller Gin, newer upland cultivar may make roller ginning a viable option in parts of the United States where Rotobar Roller Ginning has not been introduced previously. (For details please see the paper referenced above).

6. New Direction of Rotobar Rotary Knife Roller Ginning

In view of High Speed Rotobar Rotary Knife Roller Ginning now being found suitable for ginning of upland cotton, there is a likelihood that the use of this technology will increase further. Some new plants, based on this technology, have already come up in different parts of the world, apart from the USA and some of the plants are totally dedicated to the ginning of upland varieties apart from some plants working on Pima or similar varieties. The high speed Rotobar Rotary Knife Roller Gins, with almost same capacity as some saw gins, has made the cost of production on Rotobar Rotary Knife Roller Gins affordable. Many ginners may opt for use of this technology extensively, giving preference over Saw Ginning in near future, due to better fibre parameters.

7. References

1. In the late 1970's a patent was applied by Mr. A.L. Vandergriff (Patent No. 4153976) in which the radial blades on the rotary knife were replaced by spiral blades which helped in reducing overflow of un-ginned cotton into the seed flow.

2. The major development in Rotary Knife Roller Ginning during 1960-2010 however, was the increase in throughput capacity causing these machines to be referred to as 'High Speed Roller Gins'. Mr. C.B. Armijo, Mr. J. A. Foulk, Mr. D. P. Whitelock, Mr. S.E. Hughs, Mr. G.A. Holt and Mr. M. N. Gillum worked extensively to increase the capacity of the Rotary Knife Roller Gin.

3. Their experiments are documented in several papers including the following: Fiber and Yarn Properties from High-speed Roller Ginning of Upland Cotton by C.B. Armijo, J.A. Foulk, D. P. Whitelock, S.E. Hughs, G.A. Holt and M. N. Gillum,

4. New Developments in Cotton Ginning from Lummus by Ross Rutherford, Product General Manager, Lummus Corporation, Lubbock, Texas.

5. High Speed Roller Ginning (A Little Bit of History and Recap of One Season's Commercial operation) by Joe W. Thomas, DeWitt, Darrell Isbell, Daniel Riggs, Robert Santiago, Don Van Doorn, Lummus Corporation - Savannah, GA USA.

6. To address these issues and to make Rotary Knife Roller Gin suitable for ginning upland cotton, a test and study was carried out by Mr. C. B. Armijo, Mr. J. A. Foulk, Mr. D. P. Whitelock, Mr. S. E. Hughs.

7. Mr. G A. Holt and Mr. M. N. Gillum and published with the title 'Fiber and Yard Properties from High Speed Roller Ginning of Upland Cotton' in 2013 American Society of Agriculture and Biological Engineers ISSM0883-8542 Volume 29 (4)461-471.

8. Future trends in cotton Ginning and Pressing Technology by Mr. Lav Bajaj, Dr. MK Sharma, Bajaj Steel Industries Limited, Nagpur, Maharashtra India.

9. New Direction in Roller Ginning Industry by Dr. MK Sharma President at Nagpur Maharashtra and Whole time director of Bajaj ConEagle LLC USA.

10. Recent Advances in Cotton Ginning Technology in India by Dr. P.G Patil Director, Central Institute of Research on cotton Technology (ICAR) Mumbai, Er V.G Arude Scientist, Central Institute of Research on cotton Technology (ICAR) Mumbai.