International Conference on Systems, Science, Control, Communication, Engineering and Technology 2016 [ICSSCCET 2016]

ISBN	978-81-929866-6-1	**VOL**	02
Website	icssccet.org	**eMail**	icssccet@asdf.res.in
Received	25 – February – 2016	**Accepted**	10 - March – 2016
Article ID	ICSSCCET159	**eAID**	ICSSCCET.2016.159

Comparison of Yarn Quality of Ring and Rotor Spun Yarns for Denim Fabric Manufacture

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Abstract: *Ring spun and Rotor spun yarns are the commercially used spinning systems for the manufacture of yarns meant for denim fabrics. In weaving of denim fabrics ring spun yarns are generally used as warp yarns and rotor spun yarns are used as filling yarns. Alternatively, rotor spun yarns can also be used in both warp and weft directions in weaving. Depending upon the fashion requirements, the rotor spun yarns have occupied 70% of the total yarn volume. The denim fabrics are manufactured in various varieties which differs in terms of color, raw material, finishing treatment, GSM of the fabric and other parameters. Rotor spinning method is a commercial successful in producing cotton yarns which was earlier produced by ring spinning system in the coarser counts due to its higher productivity by three to four times, less imperfection values by 15% to 20%, fewer end breaks by 70% and the yarn faults by 80% than its counterpart ring spun yarns. In order to manufacture a regular, well defined fabric structure in both warp and weft directions in denim fabric with low level of irregularities and imperfections, rotor spun yarns fare better than the ring spun yarns. Rotor spun yarns offer considerable flexibility in the selection of raw material and the fiber lengths from 10mm to 60mm can be processed successfully both in natural and man-made fibers and in blends.*

Keywords: *GSM, imperfections, denim, end breaks. ring spinning, rotor spinning., fiber length, imperfections, denim*

I. INTRODUCTION

Among the various spinning systems available in the spinning technology, ring spinning is still dominant for more than 150 years. It is due to the versatility of this spinning system tp produce wide range of counts ranging from coarser to superfine counts in natural, manmade and blends. It can produce yarns meant for knitting and also for high twist yarns like voile yarns. With the development of individual splicers in winding machines, the problem of knots have been dispensed. However, there are some problems associated with the spinning system like production per spindle, small sized ring cop which can hold yarn content of 40 gms to 320 gms which need to be converted in to bigger packages in auto winders for further processing. The power consumption for driving the spindle is also mounting high with the ring spinning systems. in addition the yarn irregularities and yarn faults introduced in the number of process stages from blow room to ring spinning need to be cleared in winding process.

This has not prevented rotor spinning system for producing coarser yarn counts meant for denims since ring spinning systems require higher ring diameter and spindle lift. There is no doubt that despite some technical difficulties in the ring spinning system, it produces the strongest yarn as compared to its counterparts like rotor, friction, air jet and wrap spinning system. On the other hand, rotor spinning systems have merits like higher production capacity (6 to 8 times) higher production than ring spinning system. Elimination of speed frame and cone winding processes , automatic cleaning of rotor spin box, auto piecing by robots, lower level of drafting irregularities and yarn faults and online monitoring of yarn faults . The potential draw backs of the rotor spinning system are the low yarn strength, more number of fibers required per cross section (100 to110) which is the main factor limiting the rotor spinning in

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spinning fine count yarns. The fabric feel of the yarns made out of rotor spun yarns is harsh due to the three part yarn structure due to the presence of wrapper fibers on the third part. However, the wrapper fibers give good abrasion resistance to the rotor yarns than the ring spun yarns. The first part in the rotor yarn structure is tightly packed and the fibers assume helical configuration as like ring spun yarns. The second part is densely packed and the degree of orientation is less in the second part. The third part of the rotor yarn structure is the wrapper fibers which will not occupy a place in the rotor groove and binds directly in to the surface of the outgoing yarn during spinning. These wrapper fibers are also called as "bridging fibers" or "belts" and will not contribute any strength to the yarn.

Nowadays, the application of rotor spun yarns is very wide in the manufacture of denim fabrics. At the first instant when the rotor yarns were introduced in the market, it was used as filling yarns in weaving due to its low strength. Nowadays, the denim fabric manufacturers utilize the rotor spun yarns in both warp and weft directions in weaving.The dominant factor for the success of denim by rotor spun yarn has principally been the high profitability of the spinning system due to its higher yarn production per spinning position.

The attributes required for the manufacture of high quality denim fabrics are

- Yarn should have low variation in count (CV% of count)
- Yarn should have low strength variation; means CV% of RKM should be low which govers the breakages in the loom.
- Knot free lengths of yarn
- Low level of imperfections like thin, thick and neps
- Low level of Hairiness value
- Yarns should have good abrasion resistance to withstand the weaving operation.

In order to produce a good quality yarn meant for denim, the fiber properties in mixing plays a major role. Some of the important fiber properties required for the manufacture of Ne 7 and Ne 14 OE yarns are:

- Fiber length (mm) = 26 to 27.4
- Short fiber % (< 12mm) = 20%
- Fiber bundle strength (g/tex) = 20 to 22
- Fiber linear density (mTex) = 149 to 165
- Fiber maturity = > 75
- Trash % in input sliver = 0.2%
- Micro dust = 5 to 35mg/kg.

II. Materials and Methods

Ne 14 and Ne 16 yarns carded are produced out from 100% cotton in both ring spun and rotor spun system in the modern machineries for the production of denim fabrics. The yarns are manufactured from Ring spinning with a spindle speed of 17500 rpm .The rotor yarns are manufactured with a rotor diameter of 40 mm, rotor speed of 70,000 rpm and the opening roller speed is 8000 rpm. Identical sliver count is maintained for both the processes and two draw frame passages were given before the yarn was made. The yarns produced were tested for their physical properties in the testing laboratory. The yarn samples were conditioned in the testing atmosphere of 65%RH and 25^0C to get reliability in the results. Later, these yarn samples will be converted in to denim fabrics with the twill construction of 3up 1 down weave structure with the appropriate ends per inch and picks per inch. The influence of the selected cotton fiber properties and the corresponding yarn qualities in ring and rotor spinning methods are compared for their imperfection level in the yarns, hairiness index, elongation and RKM values.

III. Results and Discussions

The mechanical processing of the 100%cotton manufactured to produce carded yarns in Ring spinning and Rotor spinning systems have been studied The physical properties of the yarns in terms of Unevenness percentage, imperfection level like thin places, thick places, neps, hairiness values, count cv% single yarn strength and elongation of the yarns have been dealt in the following sections.

III a. Influence OF 100% Carded Cotton on Ring and Rotor spinning on Unevenness and Imperfection of Yarns

The imperfections and unevenness values for 100% cotton spun on Ring and Rotor yarns for the two carded counts is shown in the Table 1.

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Table 1: Imperfections and Unevenness values for yarns spun on Ring and Rotor spinning systems

Yarn count	Spinning system	U%	Thin places (-50%)	Thick places (+50%)	Neps (+200%)	Total IPI/km	CV* Of count
Ne 14	Ring	13.52	2	100	103	205	1.51
Ne 16	Ring	14.63	3	151	117	271	1.42
Ne 14	Rotor	12.25	0	17	14	31	0.54
Ne 16	Rotor	12.67	0	21	9	30	0.67

From the Table 1, the yarn qualities like imperfection values were tested in the Evenness tester. Yarn count was assessed using wrap reel by taking a sample of 20 cops and 20 cheeses in ring and rotor spinning systems. It has been observed that in both the counts Ne 14 and Ne 16 in ring and rotor spinning, the yarn quality is superior in the rotor spinning in terms of imperfection values and also in count Cv%. Unevenness U% value of rotor spun yarns is better by 9.39% and 13.3% in Ne 14 & Ne 16 count than the ring spun yarns. It is due to the fact that in the rotor spinning process, the processes like speed frame is eliminated and moreover the drafting irregularities are less as compared to the ring spinning system. The lower count cv% of the rotor spun yarns by 64%is due to the back doubling in the rotor which is attributed to the lower count cv% than the ring spinning system. The elimination of speed frame process also avoids the problem of stretching which is one of the contributing factors for increase in count cv% in ring spun yarns.

III b. Influence of the Spinning Systems on Hairiness Values

Hairiness in staple fiber yarns is defined as the protruding fibers from the body of the yarn. This property has greater influence in knitting and weaving. Lower the hairiness value, lower the coefficient of friction in the healds and in knitting needles and better is the running performance. Table 2 shows the yarn hairiness values measured in Uster Evenness tester for the 100% cotton spun on two spinning systems namely ring and rotor.

Table 2: Hairiness Index values for 100% cotton spun on two spinning systems

Yarn count	Spinning system	Hairiness Index
Ne 14	Ring	5.24
Ne 16	Ring	5.02
Ne 14	Rotor	4.40
Ne 16	Rotor	4. 09

From the Table 2, it has been observed that the rotor spun yarns have better hairiness values by 16$ in both the counts. It is mainly due to the better control of the fibers in the rotor spinning during yarn formation. In the ring spinning, many factors contribute to hairiness like spindle speed, twist factor, spinning geometry and the fibers which emerge from the front roller nip have no control which is the main factor contributing for higher hairiness values.

III c .Influence of the Spinning Systems on Breaking Elongation and RKM Value

The breaking elongation of the yarns and single yarn strength (RKM) are the important factors which determine the performance in the weaving machines during their performance at high speed. Yarns which have higher RKM and breaking elongation values perform better in the weaving process with less stops, higher efficiency and with lesser fabric defects. The breaking elongation and RKM values of the carded cotton yarns spun on ring and rotor spinning systems are shown in the Table 3.

Table 3: Breaking Elongation & RKM values for 100% cotton on two spinning systems

Yarn count (Ne)	Spinning system	TPM/TM	RKM values	RKM Cv%	Elongation%
Ne 14	Ring	684/4.64	16.24	6.96	6.26
Ne 16	Ring	691/4.38	16.92	7.15	5.73
Ne 14	Rotor	655/4.45	11.40	7.41	5.25
Ne 16	Rotor	745/4.72	11.19	7.78	5.15

From the Table 3, it has been observed that even though the appearance, regularity of the rotor spun yarns are better than the ring spun yarns, the strength of the single yarn is lower by 29% and 33% than the ring spun yarns in both the counts. The breaking elongation of the rotor spun yarns are lower by 16% and 10% in both the counts. The twist per meter or the twist factor is considerably higher in rotor spun yarns. This is due to the fact that in the ring spinning system, since the process of twisting and binding of yarns takes place under considerable tension, the fibers are well integrated in to the yarn structure. It is also attributed by

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the fibre migration behavior in which the fibers migrate from inside to outside and outside to inside. This is practically less in rotor spun yarns due to low migration and the process of yarn formation involves less tension. Rotor spun yarns are characterized by hooked or looped fibers, three part yarn structure especially with the wrapper fibers on the outer structure which leads to poor load distribution during the tensile testing of the yarns. It is evident in both the counts of rotor spun yarns.

IV. Conclusions

The influence the spinning systems have a greater impact on denim yarn characteristics for the two counts of Ne 14 and Ne 16 have been studied. Rotor spun yarns show better unevenness and imperfection values in both the counts than the ring spinning system. This is because in ring spinning system, drafting irregularities give rise to "drafting waves" in the drafting field which is the main factor contributing higher yarn unevenness and imperfections… Hairiness values are better in rotor spun yarns is due to the better control of fibers in the rotor spinning whereas in ring spinning, the fibers emerge out from the front roller nip cannot be controlled which leads to higher hairiness in the yarns. There is a significant difference in breaking elongation and RKM values of the yarns spun from rotor spinning system. This is mainly attributed to the formation of yarns in rotor and its yarn structure.

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