Study on the Interactions between Melange Yarn Properties and Fiber Damage

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Abstract

Cotton yarns are widely used in manufacturing of various types of fabrics and apparels due to their special physical and aesthetic properties. This work, aims at studying on cotton fiber damage and its effects on cotton melange yarns properties, in production of rotor and ring melange yarns with equal percentages (50/50). Dyed and grey cotton fibers were mixed in draw frame. To assess the fiber damage effect on the dyed and grey cotton fibers assemblies in yarns, 100% dyed and grey yarns were produced as well. After yarn production and random sampling, length parameters of dyed and grey fibers were examined. The results show that dyeing and mechanical process lead to decrease of effective length and increase of short fiber content. Increasing of short dyed fibers in rotor melange yarn caused the drop in tenacity and elongation at break, increased imperfections, unevenness and hairiness in melange yarn. Also fiber damage in rotor melange yarn was more than ring melange yarn due to the further opening by opening roller. These variations are indicative of damage in dyed cotton fibers on melange yarn manufacturing. SEM micrographs confirm that fiber damage occurs in dyed cotton fiber.

Keywords: Fiber damage, Cotton, Draw frame, Rotor spinning, Melange yarn

1. Introduction

Cotton melange yarns are spun from a number of cotton fibers with different colors. Mixing dyed and undyed fibers with varying degrees, is a common method of producing of a variety of fancy yarns. Mixing of fibers with different colors could be done either in the blow room at the start of spinning preparation or by feeding different dyed fibers to the draw frames. Studies show that scouring and dyeing process of cotton fibers lead to a greater entanglement and cohesion among them, decreasing of fibers strength and removal of a part of the wax present on the surface of cotton fibers. Further mechanical processes on these fibers lead to fiber damage and decreasing of their length parameters. These variations on fibers not only affect the efficiency of spinning process, but also the mechanical and physical properties of the final yarn and fabric. Spinning of dyed cotton fibers and their blended with grey cotton fibers in the rotor spinning system in comparison to ring spinning system is not so popular, perhaps due to the problem of excessive fiber breakage by reason of opening roller and deposition of trash and dye particles in rotor groove. The main advantage of dyed cotton fibers using in rotor spinning is that random and homogenous blending of dyed and grey fibers is possible even if it is blended at draw frame. The history of study on fiber damage dates back to as early as 1940. A number of studies have been reported on different aspects of ring and rotor spinning with grey cotton but very little works have been made on different aspects of ring and rotor spinning with dyed cotton and their blended with grey cotton. Clegg [1], Wakeham [2] and Byatt et al [3] studied on grey fiber damage in production ring spun yarns separately with different methods. Also Grant et al [4], Williams et al [5] studied the effect of mechanical processing on the properties of cotton after ginning up to yarn formation. Rebenfeld [6] studied the effect of several processing steps on cotton fiber mechanical properties. Koo et al [7], Behara et al [8] and Ishtiaque [9] studied mechanical and physical changes in grey and dyed cotton fibers and investigated their effects on melange yarn properties. Also we studied dyed fiber damage in production of melange yarn on ring spinning system [10]. The results of this research showed that fiber length parameters decreased after fiber pretreatment and dyeing. Also, this study showed that mechanical properties of yarn decrease and unevenness and hairiness yarn increase. In the present paper, the damage inflicted on the dyed cotton fibers during yarn manufacturing by opening roller in rotor machine investigated and the effect of this damage on the properties rotor spun melange yarns (50% black and 50% white) as well as a 100% black and white yarn is studied.

2. Experimental

Scouring, dyeing and Yarn production

The cotton fiber employed in this research was of the type grade one (Gorgan) with an average length of 28 mm, linear density of 0.15 tex and an average strength of 21g/tex. The scouring of fibers was carried out in a boiling bath containing 3g/l of sodium carbonate and 1 g/l of detergent for 45 minutes with a liquor ratio of 30:1. This was followed by 10 minutes of rinsing at about 50ºC. Dyeing of the scoured fibers was carried out in dyeing machine manufactured by Platt company with 6% (owf) Benzonerol Black 600% VSF (C.I. Direct B class) and 6.5 g/l. of sodium sulfate. Liquor ratio was 30:1. Dyeing was started at 50ºC and the temperature was raised to boil in 30 minutes. 15 minutes later, sodium sulfate was added to the boiling bath and dyeing was continued for another 45 minutes at boil. At the end, the dyed fibers were rinsed (40ºC) for 10 minutes, hydroextracted by centrifuge and finally dried in hot air. Three kinds of rotor spun cotton yarns (Ne 20), namely 100% white, 50% white and 50% dyed (melange) as well as 100% dyed were produced. The two 100% white and 100% black yarns were produced by passing the related fibers through blending, carding, drawframe, rotor spinning machines. For production of rotor spun melange yarn, grey and dyed slivers were blended in the draw frame with equal percentages (50/50). In order to investigate the fiber damage, Philips scanning electron microscope (X230-series B) was employed. The spun length 2.5% and short fibers less than 12 mm of the fiber samples after opening roller were measured by Star Fiber Lab (FL-900). For measuring the strength and elongation at break, Zwick tensometer (Model 1446) was employed according to ASTM D2256-97. The parameters related to the evenness of the yarns were measured by Uster 4 according to ASTM D1425-96. Yarn Hairiness was measured by SDL Yarn hairiness/Friction Tester Y089/6 according to ASTM D3108.

3. Results and Discussion

Micrographs of SEM tests show a variety of damages inflicted upon the white and colored fibers after opening action of beater in rotor spinning machine. SEM micrographs, shows tip fibrillation, end rupture, transverse cracks, deep cracks, saw tooth effect and rippling damage. SEM studies indicate a sever damage that fibers experience during various stages of yarn manufacturing. After dyeing, the fiber compactness is increased and fibers experience various stresses during opening and cleaning processes. So, the dyed fibers are more prone to damage than the undyed ones. It must be pointed out that even before blending, the cotton fibers may experience some damage during previous processes namely, ginning. As far as the preparation and spinning processes are concerned it seems that the spikes of Kirschner in blending, clothing elements of carding and the opening roller of rotor spinning machine cause most of the induced damages. Figure 1 and 2 are samples of occurred damage in dyed fibers. Figure 3 and 4 show the spun length 2.5% and percentage of fibers with length shorter than 12 mm of the sample of white, melange and black cotton fibers before blending and after blending, carding, drawing, and in the groove of the rotor of rotor spinning machine respectively. As it could be seen, the samples containing dyed fibers have suffered a noticeable reduction in their effective length. This reduction increases from melange yarn to the yarn with 100% dyed cotton fibers. Also, the damage inflicted upon even the white cotton fibers by the beater of the rotor spinning system is considerable. Figures 5 and 6 show the strength and elongation at break for rotor yarns respectively. It is seen that from the ring yarns, the 100% white and 100% black ones shows the highest and lowest strength respectively. As far as extension at break is concerned, the 100% dyed and melange yarns show the lowest and highest value respectively. Figures 7 to 11 show the average of coefficient of variation (CV%), irregularity index (U%), number of thin places (-50%), number of thick places (+50%) and the number of neps (280%) for five test specimen of each rotor yarn samples. The results show that influence of dyed fibers in yarn and inflicted damages to them in mechanical processes such as blowing, carding and opening roller lead to increased unevenness and imperfections in rotor yarns. Figure 12 shows the hairiness (equal to or less than 3 mm) of the rotor yarns. It is seen that the hairiness of yarns are increased with increasing dyed fibers content in rotor spun yarns. This is due to the fact that dyed fiber damage is more then grey fiber damage by opening roller in rotor machine. Therefore, this subject lead to increasing percentage of short fibers which in turn decreased the effective length of fibers. Figure 3 and 4 confirm the above facts. Short fibers tend to move to the outer surface of yarn during fiber migration and increase hairiness yarn.

4. Conclusion

The results obtained from the present study and comparison them with the results from ring melange yarns are summarized as followings:

1- Flock dyeing of cotton and the consequent mechanical processes lead to an increased amount of fiber damage in comparison to undyed fibers.
2- Quantity of dyed short fibers content in rotor spinning due to presence opening roller is more than ring spinning.
3- In the case of rotor spinning, the presence of dyed short fibers lead to a considerable decrease in the mechanical properties of the melange yarns, but no considerable negative effect was considered for the ring spun yarns. This could be due to presence of opening roller in rotor machine.
4- In spite of negative effect of opening roller on addition of short fibers content, unevenness, imperfections and hairiness of rotor melange yarn is less than ring melange yarn.
5- The spinnability of melange yarns in ring spinning is better than rotor spinning due to the problems of deposition of detached particles on rotor groove.

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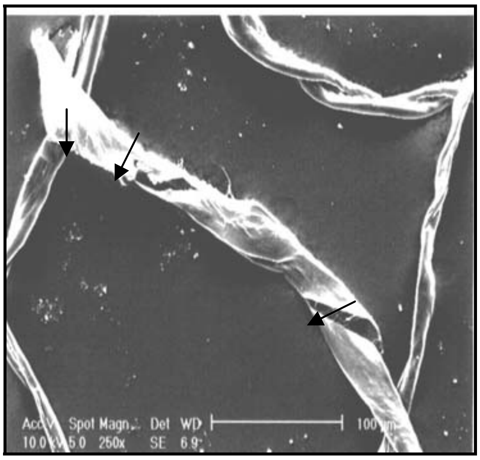

Fig 1: Deep cracks (dyed fiber)

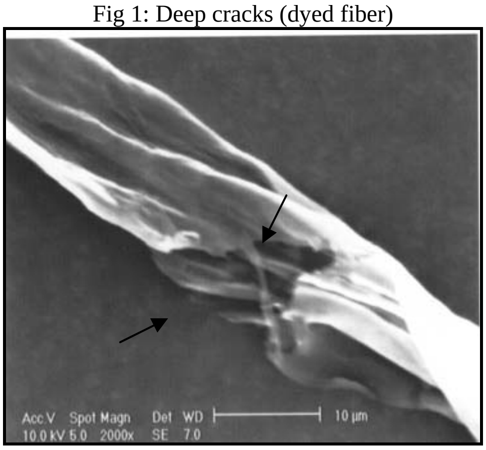

Fig 2: Saw tooth effect (dyed fiber)

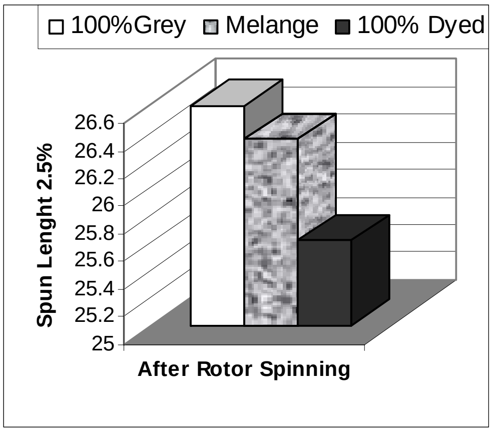

Fig 3: Spun length 2.5% of samples

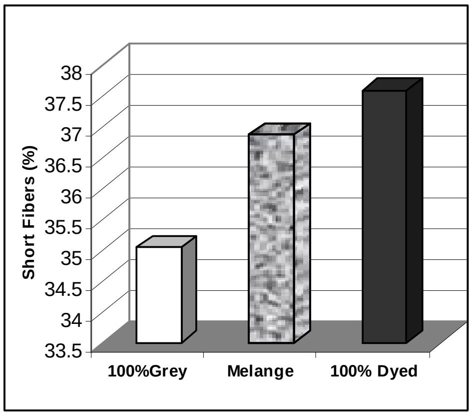

Fig 4: Percentage of short fibers (<12 mm)

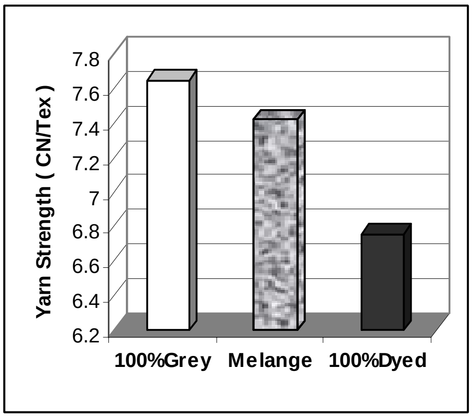

Fig 5: Strength of test yarns

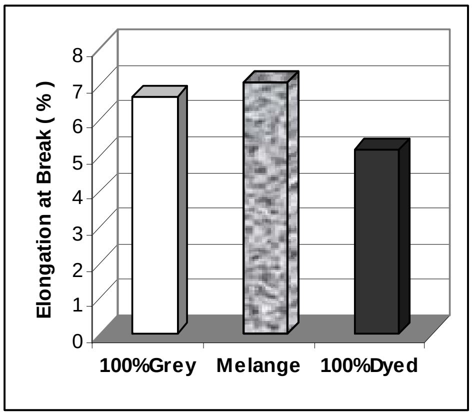

Fig 6: Elongation at break of test yarns

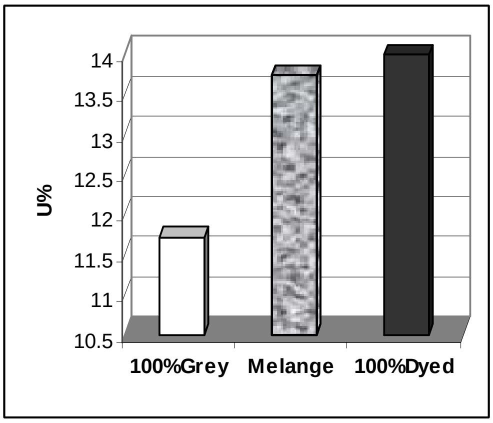

Fig 7: Irregularity index of test yarns

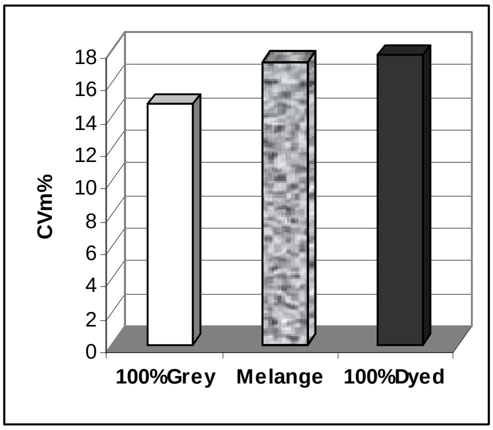

Fig 8: Coefficient of variation of test yarns

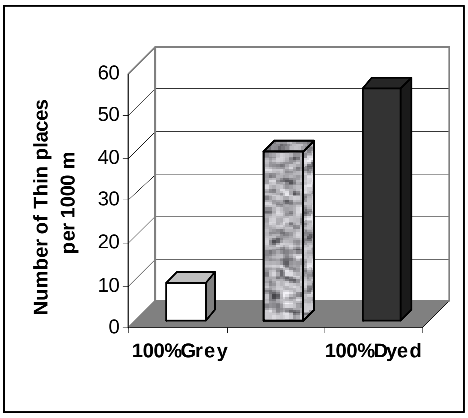

Fig 9: Number of thin places of test yarns

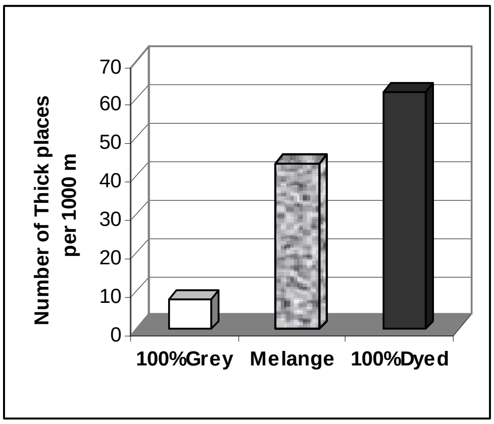

Fig 10: Number of thick places of test yarns

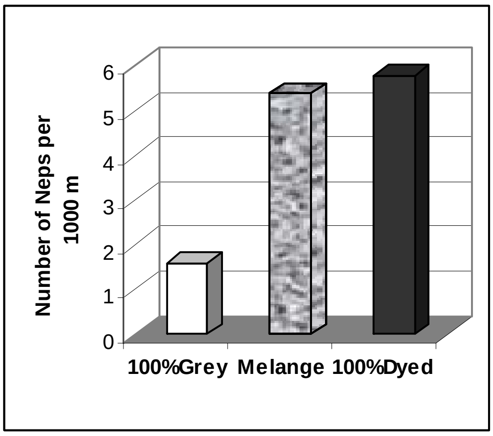

Fig 11: Number of neps of test yarns

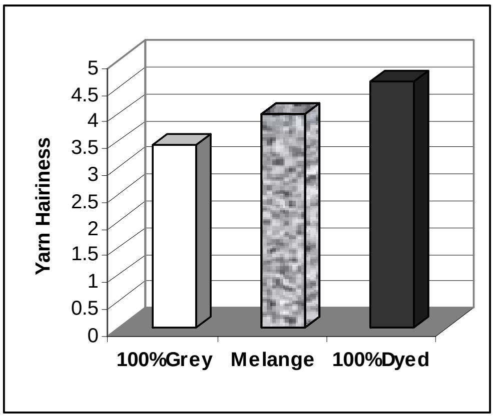

Fig 12: Hairiness of test yarns