Frictional and mechanical properties of mercerized ring- and rotor-spun yarns

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The response of cotton ring- and rotor-spun yarns to mercerization treatment has been investigated. It is observed that the caustic mercerization causes major changes in the mechanical and frictional behaviour of yarns, though the magnitudes of changes are different for different ring- and rotor-yarns, depending on the process parameters used. Both mercerized ring and rotor yarns display higher knot and loop strength and lower extensibility, elastic recovery and surface friction than the corresponding unmercerized yarns. Mercerization is an effective means of reducing hairiness and twist liveliness of both types of yarn.

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Various chemical treatments widely applied during the processing of cotton and polyester-cotton yarns and fabrics are very important because they alter the yarns and fabrics performance properties. Strong solutions of alkaline hydrates react with cellulose fibrous materials such as cotton, linen, ramie and viscose rayon. The alkaline hydrates cause structural changes in the cellulose present in the secondary wall of cotton fibre, thus improving the tensile strength, dyeability and lustre\textsuperscript{1}. The efficiency of this treatment and the uniformity of product manufactured depend, to a large extent, on the geometry and structure of the yarns used. Though many studies\textsuperscript{2-7} on the response of cotton and polyester-cotton OE rotor-spun yarns to mercerization have been performed with a view to modify their behaviour during weaving and post-chemical treatments, there seems to be a need for a dialogue on the role of mercerization in influencing the knittability of ring- and rotor-spun cotton yarns produced with varying twists and rotor speeds, because most of the earlier studies have put emphasis on the selective tensile properties. The present paper reports the frictional and mechanical properties of cotton ring- and rotor-spun yarns as a consequence of mercerization treatment.

J-34 cotton (2.5% span length, 24.3 mm; micronaire, 4.2; and tenacity at 3 mm stelometer gauge, 19.8 g/tex) was processed on a Lakshmi Rieters' blow room line and carded on a MMC card. The carded sliver was given two passages on a Lakshmi Rieters' drawframe DO/2S to produce a finished sliver of 2.5 ktex. This sliver was spun into yarns (29.5 and 59.0 tex) on Inglostadt rotor spinner RU II/RU80 (4602) operated under normal mill conditions. The process parameters used to produce these yarns involved a 48 mm rotor operating at 833.33 and 1000 rps speeds, an opening roller speed of 100 rps and twist factors of 40.19, 44.02, 47.85 and 51.67. To produce equivalent ring yarns, the drawn sliver was converted into a suitable rove of 1.5 hank on a Texmaco Howa Simplex and the rove was then fed to a Lakshmi Rieters' ring frame G 5/1 using a spindle speed of 12500 rps. Mercerization was carried out in a hank mercerization machine using 25% sodium hydroxide solution. After immersion for 120 s at room temperature, the skeins were stretched to 2% of their original length. The skeins were initially washed on the machine itself, neutralized with 2% sulphuric acid, thoroughly washed and then dried under atmospheric conditions.

All the yarns were tested for knot strength and loop strength on an Instron tensile tester (Model 4411) according to BS: 1932 procedure. Yarn-to-metal friction was measured on the Shirley yarn friction recorder winder according to ASTM D 3108 procedure. Yarn hairiness was recorded by Zweigles hairiness metre (Model G565). BSI test method\textsuperscript{8} was followed for measuring the snarling twist of ring- and rotor-spun yarns. Yarn elastic recovery was determined on a weighted ring yarn stiffness tester using the ring loop method\textsuperscript{9}.

Table 1 shows the results of tensile tests. Invariably, mercerized ring- and rotor-spun yarns show substantially higher values of knot strength and loop strength than their unmercerized counterparts. The trend is consistent in all yarns, though the magnitudes of changes are different between ring- and rotor-spun yarns. Expectedly, the knot strength ratio

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and loop strength ratio (Figs 1 and 2) of both unmercerized and mercerized yarns are also significantly higher than those of general knit wear yarns (0.85). This suggests that the mercerized ring and rotor yarns can survive severe bending and thus maintain their integrity during knitting. For both knotted and looped specimens, breaking extensions of both ring and rotor yarns show a significant decrease after mercerization. However, the loss in knot and loop breaking extensions of mercerized rotor yarns at different twists reflects no specific trend. Although rotor speed has little effect on breaking extension of unmercerized rotor yarns, there is a lesser decrease in breaking extension at higher rotor speeds due to the increased centrifugal force. This ultimately makes the yarn more compact which causes insufficient penetration of caustic liquor to axial fibres and consequently there is a decrease in the swelling of core fibres, resulting in lesser decrease in yarn breaking extension. The hairiness results (Fig. 3) show that the rotor-spun yarns are consistently less hairy than ring-spun yarns. The hairiness tends to decrease as the tex twist factor increases. Higher rotor speed also produces fewer hairs due to the decrease in friction time of yarn between the collecting groove and the exit. The lesser friction time at higher rotor speed would entail a smaller number of hairs raised from the nucleus of the yarn. Furthermore, regardless of yarn type, twist factor and rotor speed, the mercerized yarns have lesser hairiness than unmercerized yarns, as expected.

Yarn friction mainly affects yarn tension in all textile processes including knitting. It is also the main cause of fluff shedding from the yarn during knitting. Higher yarn-to-metal friction damages the yarn structure and, therefore, the component fibres of the yarn are easily shed from the yarn body. Hence, the yarn friction with the needles during knitting should be minimized to produce a low output tension. The mean values of yarn-to-metal friction are shown in Table 2. Invariably, the cotton rotor-spun yarns record significantly lower surface friction than their ring-spun counterpart. When these yarns are mercerized, the yarn-to-metal friction shows a reducing trend at all levels of twist. The reduction in yarn-to-metal friction arises due to the improved cross-sectional shape and laying of protruding fibres on the yarn surface, which ultimately makes the yarn surface smooth and free from folds and creases. For both the yarn structures, the lower yarn-to-metal friction corresponds to the higher twist factors because a great
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Fig. 1—Variation in knot strength ratio with tex twist factor [(a) 59.0 tex and (b) 29.5 tex]

Fig. 2—Variation in loop strength ratio with tex twist factor [(a) 59.0 tex and (b) 29.5 tex]
amount of twist leads to less relative contact with the contiguous metal surface than the low-twisted yarn. High rotor speed also tends to reduce yarn-to-metal friction. With increased yarn linear density, the yarn-to-metal friction shows an increasing trend due to greater proportional contact. Twist liveliness plays an important role in determining the performance of yarns during downstream processing. The results for snarling twist of cotton ring- and rotor-spun yarns are given in Table 2 from which it can be observed that the rotor-spun yarns have a lower tendency to snarl. For both ring-and rotor-spun yarns, the snarling twist increases with the increase in twist factor, and at the same time when yarn linear density decreases. On the other hand, the snarling tendency of both types of yarn tends to reduce after mercerization due to the relaxation of structural matrix of fibres in the yarn. Table 2 shows the elastic recovery of cotton ring and rotor yarns as a consequence of mercerization treatment. The trend is consistent in all the yarns, though the magnitudes of changes are different between yarns. The decrease in elastic recovery of mercerized yarns agrees with the common view that the mercerization reduces yarn breaking extension through permanent stretch by mercerization tension. Further, the yarns spun with different twist factors and rotor speeds respond differently to mercerization treatment.

The increased production cost due to mercerization is expected to generate limited commercial interest, even though the mercerization of cotton ring-and rotor-spun yarns with sodium hydroxide offers
significant increase in knot strength and loop strength and decrease in elastic recovery and knot and loop breaking extensions. The level of change in these yarn characteristics is more marked in rotor yarns and it increases when both twist factor and rotor speed decrease, and at the same time when yarn linear density increases. Cotton rotor-spun yarns are consistently less hairy than the ring-spun yarns. The hairiness decreases with increasing rotor speed and twist factor, and there is a similar behaviour with the decrease in yarn linear density. Hairiness also gets reduced on mercerization. Cotton rotor yarns exhibit less twist liveliness than ring-spun yarns, which however increases with the increase in twist factor. Mercerization is an effective means of reducing the snarling propensity of both types of yarn. The frictional coefficient of cotton rotor-spun yarn is significantly lower than that of ring-spun yarn and it reduces with the increase in twist factor or decrease in yarn linear density.

References
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