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The effect of Cordura fiber integration on the yarn quality properties of wool and wool/Lycra yarn

Abstract

Cordura fiber, which has high performance against tearing and abrasion, can be used to improve the tear strength and abrasion resistance of low-weight wool/lycra fabrics that can be suitable for daily wear. Thin wool fabric is very comfortable to wear, but lighter fabrics are more prone to appearance problems, since they are less able to resist the forces responsible for the distortions. This study aims to investigate the effect of Cordura fiber integration on the yarn quality properties of wool and wool/Lycra yarn. Cordura fiber was integrated into wool and wool/Lycra yarn structure with different fiber percentages and tested according to related the standard methods to evaluate yarn quality properties such as breaking force, breaking length (RKM), elongation at break, unevenness (CV%), yarn imperfection (thick, thin places and neps) and hairiness.

Keywords: cordura fiber, wool/lycra, yarn quality

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Introduction

Natural fibers, which are derived from a renewable resource, are getting considerable attention from researchers and academician due to their ecofriendly nature and sustainability. The increasing environmental concerns and depletion of oil resources have increased the importance of natural fibers. Natural fibers are an alternative resource to synthetic fibers like glass fiber, carbon fiber and have many advantages over synthetic fibers, including lower density, lighter weight, lower cost, biodegradability, abundant availability and ease of availability, lower energy requirements, and lower CO_2 emission. Natural fibers have been successfully used in a wide range of applications, from clothing and home textiles to automobiles, furniture, packaging and construction. Natural fibres can be obtained from plant fibers such as sisal, hemp, bamboo, flax, kenaf, jute, ramie, cotton as well as from animal source such as wool, silk and chicken feather fibers.

Wool is the most important animal based-natural fiber used in apparel and textile manufacturing. It is a fully renewable fiber and has distinct properties such as warmth retention, moisture absorption, elasticity, flame resistance, breathability, resilience softness. Wool fibres have been used as a textile raw material for apparel and home textiles for years. Recently, wool fiber has gained much more attention compared to manmade fibers in some industrial sectors, increasing the value of wool fiber. It is increasingly being used as an alternative metarial in the production of lightweight materials in aircrafts, ships, trains, and automobile upholstery.[1–4]

Wool is blended with other fibers to improve the processing performance of wool, the durability of the final products and reduce the total costs of production. Lycra, also known as spandex or elastane, is a synthetic fiber made of polyurethane known for its exceptional extensibility (up-to 400%). Presence of Lycra in the fabric provides better form fitting characteristic with improved comfort properties during use.[5] A wool/Lycra knitted fabric has been developed by CSIRO for the prevention of skin tears for the elderly people. The wool/Lycra fabric provides a layer of protection to the skin and is comfortable to wear 24 hours a day.[6,7] Wool/Lycra fabrics have been used for many different men's and women's wear, to provide freedom of movement in activity wear, to improve garment shape retention and wrinkle recovery in formal wear.[8,9] Wool stretch fabrics have been also developed for technical applications. Thin wool fabric is very comfortable to wear and ideal for blouses, dresses, shakes, skirts and trousers. However, lighter fabrics are more prone to appearance problems, since they are less able to resist the forces responsible for the distortions.[9]

Cordura, a kind of high-strength nylon fabric used in a wide range of products including luggage, backpacks, trousers, military wear, outdoor items and performance apparel, is widely used to provide reinforcement to the parts of the clothing that are most likely to be subject to aggressive localized abrasion. Cordura was developed by DuPont company in 1929, and is a registered trademark of Invista. The Invista nylon 6.6 fiber used in Cordura fabrics has a high melting point (254˚C), giving the fabric the ability to withstand high frictional heat while maintaining fabric integrity. Cordura yarn is tough and resistant to the most adverse outdoor conditions. Cordura yarn strength is twice stronger than regular nylon and polyester yarn and has better abrasion resistance and tearing strength abilities. Today, Cordura fiber is widely used in many application areas such as military clothing, shoes, boots, backpacks, workers' clothing, suitcases, tent cloth and musical instrument bags due to its advanced abrasion resistance, tear strength and flame retardancy properties.[10–12]

In this study, in order to overcome the poor tear and abrasion resistance in thin wool/Lycra fabrics, Cordura fiber, which shows high performance against tearing and abrasion, was integrated into wool and wool/Lycra yarn structure with different fiber percentages. All the yarn samples were tested according to related the standard methods to evaluate yarn quality properties such as breaking force, breaking length (RKM), elongation at break, unevenness (CV%), yarn imperfection (thick, thin places and neps) and hairiness. The assessment of these parameters is essential to obtain high quality yarn.

Experimental

Materials

In this study, wool, Cordura and Lycra fibers were used to produce yarns with different fiber content combinations through siro spinning

system. Siro-spun yarns are produced on a conventional ring frame by feeding two roving, which are simultaneously drafted into the apron area at a predetermined interval. The two strands are twisted together to form a two ply structure once they have passed the nip point of the front roller of the drafting system.[13]

Fiber properties used in this study are given in Table 1. Australian Merino wool fiber with 19.9 µm fineness, 0.53% oil content and 15.6% moisture content was used in the production of wool and wool blended yarn. The wool fiber used in this study has an average fiber length of 76.5 mm, 7.5% fibers shorter than 30 mm and 13.8% fibers shorter than 40 mm. The average fiber strength and fiber elengation were 12.9 g/tex and 29.4%, respectively. In the production of Cordura blended yarn, carded combed Cordura sliver having 3.2 dtex fiber fineness, 0.39% oil content, 2.2% moisture content was used. Cordura fiber has an average fiber length of 67.7 mm, 7.3% fibers shorter than 30 mm and 9.8% fibers shorter than 40 mm. It exhibited a tensile strength of 5 g/den and an elongation of 64%. Lycra fiber with a fineness of 44 dtex was provided from The Lycra Company.

Four different siro-spun yarn samples with a yarn count of Nm 70/2 (wool, wool/Lycra, wool/Cordura, wool/Cordura/Lycra) were produced with different fiber percentages as given in Table 2. As can be seen in Table 2 wool/Cordura/Lycra has the highest twist level (904 T/m), followed by wool/Lycra (772 T/m), wool/Cordura (755 T/m) and 100% wool yarn (749 T/m), respectively.

Table 1 Fiber properties used in this study

	Fiber fineness Microprojection ASTM D 2130)	Fiber length Hauteur (H, mm)	Short fiber % < 30 mm AL-meter (IWTO-17-85 E)	Short fiber % < 40 mm AL-meter (IWTO-17-85 E)	Fiber strength	Fiber elongation (%)
Wool	19.9 µ	76.5	7.50%	13.80%	12.9 g/tex	29.40%
Cordura	3.2 dtex	67.7	7.30%	9.80%	5 g/den	64.00%
Lycra	44 dtex					

Table 2 Yarn samples produced in this study

Yarn samples	Fiber	Percentage	Yarn count (Nm)	Twist (T/m) (CVm %)
Wool	Wool	100	70/2	749 (3.1)
Wool/Lycra	Wool	96	70/2	772 (2.67)
	Lycra	4		
Wool/Cordura	Wool	70	70/2	755 (1.3)
	Cordura	30		
Wool/Cordura/Lycra	Wool	68	70/2	904 (1.5)
	Cordura	28		
	Lycra	4		

Methods

Before the tests, all yarn samples were conditioned under standard laboratory conditions (20±2 °C and 65±2%).

Yarn breaking strength and elongation tests were carried out by using Uster Tensorapid 3 device. Unevenness, and imperfections values were determined by using Uster Tester 4. Yarn hairiness test was performed using Zweigle hairiness tester (S3). S3 value expresses the number of hairs longer than or equal to 3 mm.

Results and discussion

Mechanical properties

Yarn tensile properties including breaking force, breaking length (RKM) and elongation at break (breaking elongation) are given in Figures 1a–1c. Breaking strength and breaking elongation are two prime quality characteristics of any spun yarn that affect the processability of the yarn in subsequent processing.[14] Yarn breaking strength is the force required to break the yarn when a tensile force is applied along its length. As can be seen in Figure 1a, wool and wool/Lcyra yarn have a breaking force of 189 and 202 cN, respectively. Integration of Cordura fiber increased the breaking force to 344 cN for 70/30% wool/Cordura and 326 cN for 68/28/4% wool/Cordura/Lycra yarn.

Higher value of RKM is associated with better yarn quality. Cordura integrated blended yarn samples have higher RKM values compared to 100% wool yarn and wool/Lycra yarn (Figure 1b).

Yarn elongation at break is the percentage increase in length when the yarn breaks due to a breaking force applied along the main yarn axis.[15] Wool/Cordura/Lycra yarn exhibited the highest elongation rate of 27.16 %, which is attributed to the high elongation rate of Lycra and Cordura fiber. Cordura fiber has an elongation rate of 64% as given in Table 1. This is followed by the wool/Cordura yarn with an elongation rate of 24.13% (Figure 1c). When 96/4% wool/Lycra and 68/28/4% wool/Cordura/Lycra yarns are compared, the breaking elongation increased from 12.35% to 27.16% with the addition of Cordura fiber (28%) to the yarn structure.

Unevenness, imperfection and hairiness

Yarn unevenness (irregularity), which is the result of the variation in the number of fiber ends per unit length, is another important quality parameter of the yarn.

Figure 2 indicates that the addition of Cordura fiber provides a decrease in yarn unevenness, which may be due to the less short fiber content of the Cordura fiber (Table 1). High short fiber results in poor yarn strength and evenness, higher level of imperfection, higher yarn hairiness.[16] Yarn imperfections (thin places, thick places and neps) adversely affect the subsequent process such as spinning, winding, warping, weaving, knitting, colaration and the final application of the end product. The less imperfections in the yarn, the better the appearance and quality of the fabric. Imperfection index (IPI) expresses the sum of yarn thin places (–50%), thick places (+50%) and Neps (+200%) per kilometer.[17] Wool/Cordura yarn has lower IPI value as compared to other yarn samples, which is associated with the

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higher tensile strength of Cordura yarn. Fiber breakage has a major impact on imperfection and irregularity in the yarn.[14]

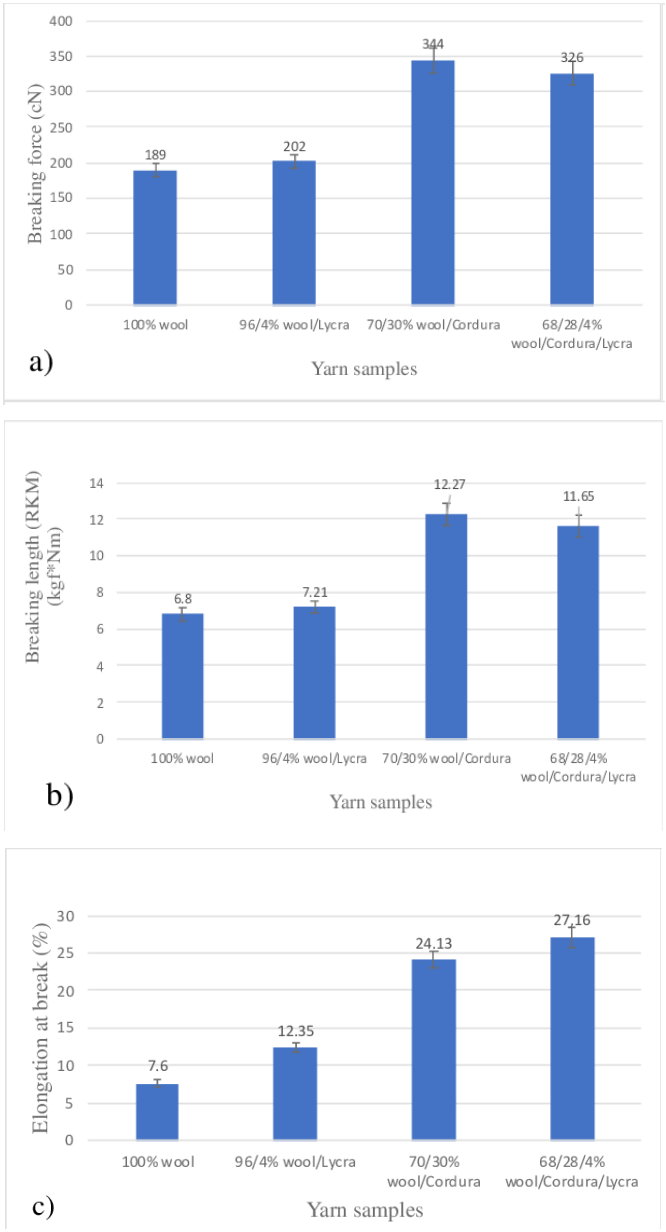

Figure 1 Mechanical properties of the yarn samples a) Breaking force (cN) b) Breaking length (RKM) (kgf*Nm) c) Elongation at break (%).

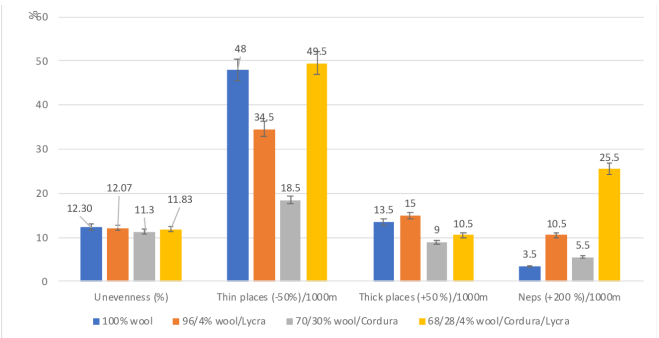

Figure 2 Unevenness, Imperfection of the yarn samples.

Wool/Cordura/Lycra yarn has the highest IPI compared to the other yarns. This may be arisen from its higher twist level (904 T/m) because thin and thick places are reduced up to a certain twist value and then started to increase.18

Hairiness (S3 value) of the yarn samples is represented in Figure 3. The S3 value is the number of hairs longer than or equal to 3 mm, which indicates undesirable hairiness. Hairiness is desirable to some extent for a pleasant handle, but a higher number of longer hairs may cause some problems such as yield losses during manufacturing processes, uneven appearance, pilling tendency, color differences in dyeing.19,20 The hairiness value of 100% wool yarn is 792, and with the addition of Lycra (96/4% Wool/Lycra), the hairiness decreased to 682. This is because yarn structure becomes compact with the the addition of Lycra.21,22

70/30% wool/Cordura yarn has a lower hairiness value (765) than 100% wool yarn. However, 68/28/4% wool /Cordura/Lycra yarn has a hairiness value of 943. The increase in hairiness value could be a result of high twist level of wool /Cordura/Lycra yarn (904 T/m). The results show that the addition of Cordura fiber into the wool yarn structure leads to a decrease in yarn hairiness up to a certain twist level.

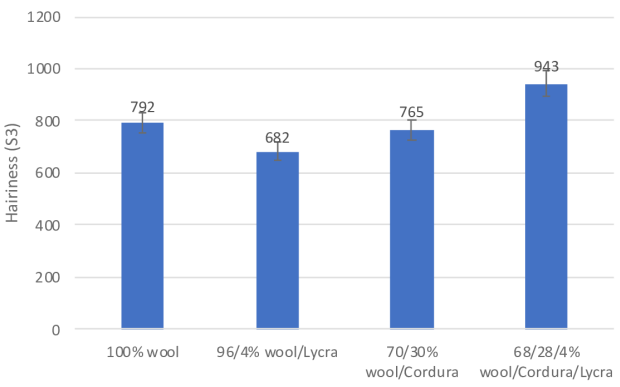

Figure 3 Hairiness of the yarn samples.

Conclusion

In this study, four different sirospun yarns with and without Cordura integration were produced to evaluate their yarn quality properties. Experimental results indicate that integration of Cordura fiber increased the breaking force (344 cN for 70/30% wool/Cordura, and 326 cN for 68/28/4% wool/Cordura/Lycra yarn), breaking length (12.27 kgf*Nm for 70/30% wool/Cordura, and 11.65 kgf*Nm for 68/28/4% wool/Cordura/Lycra yarn) and elongation at break (24.13% for 70/30% wool/Cordura, and 27.16% for 68/28/4% wool/Cordura/Lycra yarn).

The addition of Cordura fiber into the wool yarn structure leads to a decrease in yarn hairiness and imperfection index (IPI) up to a certain twist level. Wool/Cordura yarn has a lower IPI value and hairiness value as compared to other yarn samples, which is associated with the higher tensile strength of Cordura yarn. However, wool/Cordura/Lycra yarn has the highest IPI and hairiness value compared to the other yarns, which could be due to high twist level of wool /Cordura/Lycra yarn (904 T/m).

All these results obtained in this study revealed that the poor tensile strength and abrasion resistance of thin flannel wool and woolen Lycra fabrics can be eliminated by the use of Cordura-reinforced blended yarns.

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Conflicts of interest

Author declares that there is no conflict of interest.

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