TRANSLATION OF STRUCTURE AND STRENGTH PROPERTIES OF DIFFERENT SPUN YARNS ON FABRIC STRENGTH

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Introduction

Yarn properties are usually evaluated by the likely performance of the yarn in subsequent fabric manufacturing processes and fabric properties. The tensile strength of a fabric is recognized as one of the most important quality parameters of a fabric. The strength of a fabric not only depends on the strength of the constituent yarns, but also on the yarn structure and many other factors [1, 2]. The frictional forces between warp and weft, which are mainly dependent on the surface structure of yarns, influence the fabric strength to a greater extent [3]. There is one important aspect of the relationship between yarn structure and fabric strength, however, information in this topic is not adequate. Therefore, in this work an attempt has been made to study the translation of structure and properties of different spun yarns on fabric strength.

Experimental

A prototype sample loom was used for the preparation of fabric samples. Four different sets of plain-woven fabrics were prepared from the 20's Ne viscose staple yarns corresponding to ring, rotor, air-jet and open-end friction spinning systems. All the fabric samples were made using unsized warp yarns. In each set of fabric, the yarns representing to a particular spinning technology were used as warp and weft. However, due to the very poor strength of open-end friction spun yarn, it was not possible to produce a fabric using this yarn in warp. Therefore, the last set of fabric was prepared using ring and OE-friction spun yarns as warp and weft respectively. The ends per inch and picks per inch of the fabrics were 44 and 36 respectively.

The fabric specimens were subsequently tested for tensile testing in an Instron tensile tester using a testing speed of 500 mm/min. The specifications of the fabric specimen used in the strip test were as follows:

Total length of the strip: 150 mm.
Total width of the strip: 35 mm.
Distance between the two jaws: 75 mm.
Width of the strip: 25 mm (Excluding the raveled portion).

For calculating the ratio between strip strength of fabric per thread and single thread strength, the yarn samples prepared on different spinning technologies were also tested using Instron tensile tester using 75 mm gauge length and 500 mm/min extension rates.

Single thread pulling force from the fabric specimen was determined using Instron tensile tester at a cross-head speed of 500 mm/min. During the experiment, the upper jaw only gripped the upper portion of the pulling thread, whereas, the lower jaw gripped all the threads expect the lower portion of the pulling thread. Figure 1 illustrates a schematic representation of the experimental set up for single thread pulling force measurement.

Rothschild tensiometer-2000 was used to measure the input and out put tensions for determining the yarn-to-yarn coefficient of friction. A schematic diagram of the measurement of yarn-to yarn coefficient of friction is depicted in Figure 2. Amonton's law of friction was used to calculate the coefficient of friction from the values of input and output tensions. Three different levels of input tensions were taken and in each case the yarn withdrawal speed was 500 mm/min.

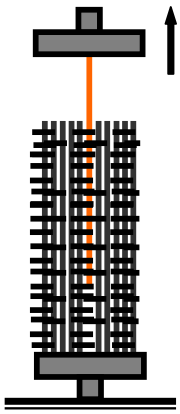
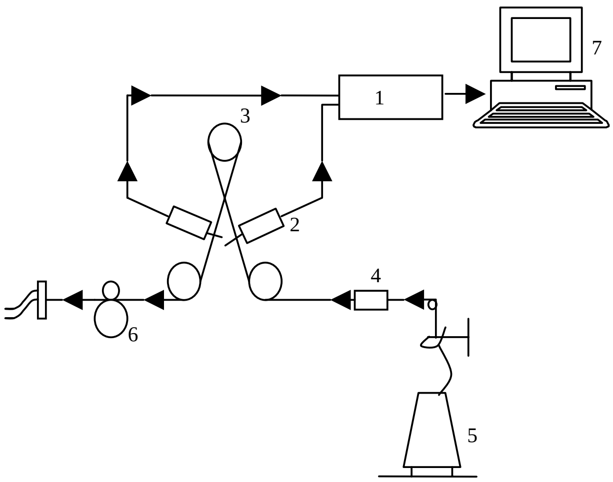


Figure 1. Single thread pulling from a fabric sample using Instron tester.



1 = electronic tensiometer, 2 = tension probe, 3 = movable pulley, 4 = tension compensator, 5 = yarn package, 6 = delivery roller, 7 = computer

Figure 2. Measurement of yarn-to-yarn coefficient of friction.

After the failure of fabric samples, each pair of broken ends corresponding to particular threads in the fabric were collected in glass slides. This was done by raveling out the transverse threads carefully from the failed fabric sample. After that, the percentage of rupture fibres at the stage of yarn failure in the fabric was determined using the tracer fibre technique.

The tracer fibres were mixed before opening operation in blow room in such a proportion, to have an average of 5 tracers of different colours in the cross-section of every yarn.To determine the proportion of broken and slipped fibres the slide containing the pair of broken ends was covered by another slide and benzyl alcohol solution was introduced drop by drop in between the slides. The slides were observed under a Projectina microscope using a magnification of 50. As the undyed viscose fibres are optically dissolved in benzyl alcohol solution the tracers of five different colours were clearly visible in the zones of yarn failure. A fibre was classified as broken if both the failed ends of yarn contain the same tracer fibre, i.e., of same colour and the sum of the lengths of both the tracer ends of same colour is equal to the original tracer length. A slipped fibre was classified if only one end of the broken yarn segments contains the tracer of particular colour.

After the tensile failure of single yarns, the proportion of broken fibres was also determined using the same technique.

Results and Discussions

The values of the ratio of strip strength per thread and single thread strength for fabric made from different spun yarn is given in Table1. It is noted that the ratio between the strip strength per thread and single thread strength is significantly higher in the weft direction compared to that of warp direction. It is also appreciated that when fabrics made from ring, rotor and air-jet spun yarns are compared, the ratio is notably higher for fabric made from air-jet yarn followed by rotor and ring yarns. A better ratio indicates a better fabric assistance or the transverse threads have better binding effect on the longitudinal threads. A higher roughness of yarn surface due to the presence of wrapper fibres in air-jet and rotor yarns causes a better utilization of strength in the fabric than the ring yarns. Furthermore, higher mean fibre extent and a fair degree of fibre alignment in the air-jet spun yarn with the aid of good fabric assistance increase the load bearing capacity by the fibres which in turn enhance more strength exploitation in the fabric. The role played by the surface structure of yarns in fabric assistance can be supported well by the values of the thread pulling force as well as the yarn-to yarn coefficient of friction, which are shown in Table II and Table III respectively. As far as the yarn-to yarn coefficient of friction is concerned, the Dref-II yarn has the maximum value followed by rotor, air-jet and ring yarns. Table IV shows the values of percentage of broken fibres in case of single yarns tensile failure and the yarn rupture inside the fabric. A higher percentage of fibre rupture when yarns break inside the fabric indicates that the mechanism of yarn failure is different inside the fabric as compared to the mechanism of single yarn failure and this resulted due to the interactive binding effect between warp and weft threads in side the fabric under the application of load.

Table I. Ratio of strip strength per thread and single thread strength.

Fabric made from	Warp direction	Weft direction
Ring yarns	1.08	1.15
Rotor yarns	1.29	1.41
Airjet yarns	1.43	1.57
Ring warp and Dref II weft yarns	1.22	1.48

Table II. Maximum thread pulling force, P (cN) and maximum distance at peak tension, X (mm) when the threads are being pulled out from the fabric.

Fabric made from	Warp direction		Weft direction	
	P (cN)	X (mm)	P (cN)	X (mm)
Ring yarns	85.3	7.5	103.6	9.1
Rotor yarns	109.8	11.8	138.1	15.2
Airjet yarns	99.2	10.7	115.7	12.9
Ring warp and Dref II weft yarns	98.8	10.5	145.4	16.3

Table III. Yarn to yarn coefficient of friction at different level of input tensions.

Type of yarns	Yarn to yarn coefficient of friction (μ) Input tension level		
	1 cN	2 cN	5 cN
Ring	0.28	0.26	0.21
Rotor	0.33	0.32	0.27
Airjet	0.33	0.31	0.26
Dref-II	0.34	0.32	0.28

Table 1V. Percentage of fibre rupture in single yarns and their failure within fabrics.

Yarns	Single yarn tenacity (cN/tex)	Percentage of broken fibres in single yarns	Percentage of broken fibres during yarn failure in fabrics	
			Warp direction	Weft direction
Ring	14.9	73.7%	75.5%	80.2%
Rotor	11.2	61.1%	64.7%	73.3%
Air-jet	10.8	55%	64.0%	70.8%
Dref-II	6.2	42.3%	-	54.4%

Conclusions

Ring spun yarn yields minimum value of the ratio between the strip strength per thread and single yarn strength, whereas for air-jet spun yarn this ratio is maximum. The values of yarn-to yarn coefficient of friction and peak value of thread pulling force is significantly lower for ring yarn as compared to other yarns. Percentage fibre rupture increases when yarns break inside the fabric. The weft wise performance of fabric strength is superior to the fabric strength in the warp direction. Therefore, an inference may be drawn that the surface structure of yarn play a major role in the fabric assistance and consolidates the fabric tensile properties.

References

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