Composite spun silk yarns – Yarn structures

Effects of yarn structures in composite spun silk yarns

The tensile properties of composite spun silk yarns and the compression properties of the fabrics were studied with a view to analyze the effects on yarn structure. Twin spun yarns, core spun yarns and doubled yarns were made by different spinning methods. It was then observed that the mechanical properties of composite yarns and fabrics varied according to the kinds of combined fibers. They were also considerably affected by the yarn structure, namely the number and direction of the twisting, even if the combination and the content of the fibers were constant. It was also found that the fabric made of the cotton/silk composite yarn might have a unique handling.

We studied the mechanical properties of the composite spun silk yarns and fabrics in previous papers (Matsumoto et al., 1986, 1987), and since then we have continued studying them. Our final aim is to improve the stiffness of the spun silk fabrics whose soft handle is said to be a fatal defect, and to better the nature of spun silk yarn. The composite yarns are core spun yarns made from both a filament yarn in the core and the spun silk fiber as the skin layer. But there is a limitation in the production when the components used are filament yarn and staple fiber. Therefore, further study is required for composite yarns made from the combination of the staple fibers.

We tried making different composite yarns using staple fibers as a constant, and then examined the tensile properties of the yarns and the compression properties of the fabrics.

Materials and Methods

1. Materials

Table 1 lists the mean length of staple fibers used in the composite yarns. The combinations used in the yarn were : polyester/silk I, cotton/ silk I and silk II/silk I. The composite yarns contained about 70% silk I by weight, which were the twin spun yarn, the core spun yarn and the doubled yarn. The single yarns were also made of the fibers, in order to compare with the composite yarns. The British yarn count of all the yarns was 10, and the twist factor and the twist direction are listed in Table 2.

Furthermore, these yarns as the weft (density =17 picks/cm) were woven across the polyester filament warp (50 d/36 f, density=64 ends/cm) in a plain weave.

Table 1. Fibers in composite yarns

Fiber	Mean fiber length (cm)
Silk I	11.80
Silk II	3.86
Polyester	3.14
Cotton	3.08

Table 2. Parameters of yarns

Yarn	Twist factor	Twist direction
Single yarn	3	Z
Twin spun yarn	3	Z
Core spun yarn	2/3	Z/Z
Doubled yarn	2/3	Z/Z

Twist (tpi) = Twist factor × (British yarn count)$^{1/2}$

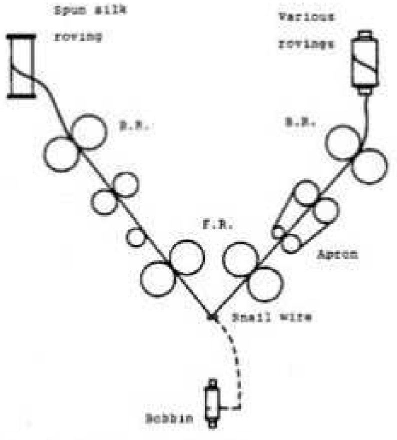

Fig. 1. Equipment for twin spun yarns. (F.R.=Front Roller, B.R.=Back Roller).

2. Making of composite yarn

In the spun silk ring spinning frame which is shown in Fig. 1, two rovings are drafted on each drafting zone and are then twisted together to form a yarn. The drafting part is equipped with an apron device for the short staple fibers, namely, polyester, cotton and silk II. This yarn is called the twin spun yarn.

As shown in Fig. 2, a single yarn is used in the core, tension is provided by a magnet tensor applied to the front roller to combine with a roving as the skin layer, and then they are twisted together. This yarn is called the core spun yarn.

Furthermore, the doubled yarn is combined by twisting together two single yarns.

The cross sectional structure of yarns will be referred to in detail in the latter part of this paper and some examples are shown in Fig. 8.

3. Methods

The stress-strain curves of the yarns were measured using the constant-rate of elongation tester (Instron type) when the test length was 27 cm, the extension speed was 10 cm/min, and the number of testing times per yarn was 100. The compression properties of the fabrics were measured by the rolling method utilizing rolling friction from a solid cylinder (Shinohara and

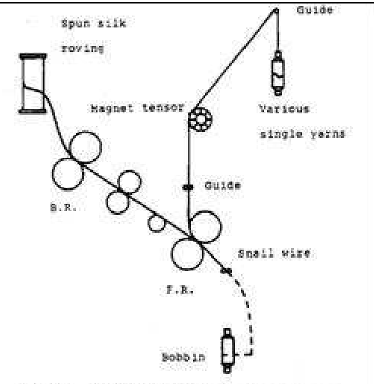

Fig. 2. Equipment for core spun yarns.

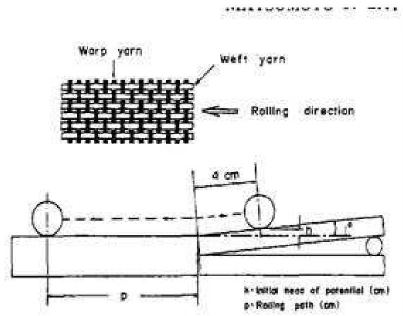

Fig. 3. Measuring apparatus for rolling method.

Go, 1961). As shown in Fig. 3, it is possible by this method to measure the rolling path when the solid cylinder rolls on the fabric at a constant initial velocity. The compressional modulus of fabric can be estimated from the size of the rolling path since the rolling path varies according to the stiffness of the fabric. The rolling path in the weft direction was measured using a sample that was 5 x 20 cm, and tested 10 times. And it was provided in the measurement that the angle between the slope and the horizontal plane of the sample was 1°, the length of the slope was 4 cm, and that the size of the roller, made of brass, was about 1.8 cm in diameter, 4 cm in length and 86.8 g in weight.

Results and Discussion

All the composite spun silk yarns used here were composed of silk I and the other staple fibers. Therefore, the produced yarns can be classified into three fibers, polyester, cotton and silk II. The yarns made from each of the fibers are single yarn, twin spun yarn, core spun yarn and doubled yarn. Using graphs let us tentatively connect the single yarn with a composite yarn by a broken line and connect the composite yarns with each other by a solid line. The vertical (y) axis varies according to each graph. The horizontal (x) axis of the graph is the arrangement of yarns, and it was set to cor respond with the number of twisting times because all twist directions were Z. As for the number of twisting times used to make a yarn, the single yarn was one, the twin spun yarn was one, the core spun yarn was two because the single yarn in the core had been twisted, and the doubled yarn was three for combining two single yarns.

Fig. 4 shows the count strength product from the produced yarns. The polyester/silk I composite yarn is smaller than the single polyester yarn, but the cotton/silk I composite yarn is larger than the cotton single yarn, and the silk II/silk I composite yarn is larger than the silk II single yarn. The strength of single yarns indicates a strength decrease in the following order, polyester, silk I, silk II and cotton. In general, the strength of a composite yarn is given by the sum of the strength generated by the two combined fibers. Thus, the composite yarns may be characterized as follows : In the case of polyester/silk I, a weak fiber of silk Iis added to a strong single yarn of polyester. In the case of cotton/silk I or silk II/silk I, a strong fiber of silk I is added to a weak single yarn of cotton or silk II. Using this explanation, it is possible to understand the variations of the strength which compared the composite yarn with the single yarn.

Furthermore, the strength of composite yarns tends to decrease in the following order, the twin spun yarn, the core spun yarn and the doubled yarn. When the number of twisting times in the same direction is increased in the making of composite yarns, it brings about many twists in the yarn. It is known that as yarn twist is increased, yarn strength rises to a maximum value at some optimum twist and then falls. The tensile behavior of twisted staple yarns can be explained by the effects of fiber obliquity with respect to the yarn axis combined with the effects of fiber slippage (Bogdan, 1956). Therefore, it is found that the tendency to decrease is clearly due to the effects of fiber obliquity in the yarn.

Fig. 5 shows the elongation of the produced

yarns. The comparison between the composite yarns and the single yarns, in the problem of elongation can be solved by a similar method to that used for yarn strength. It can also be observed that the elongation of composite yarns

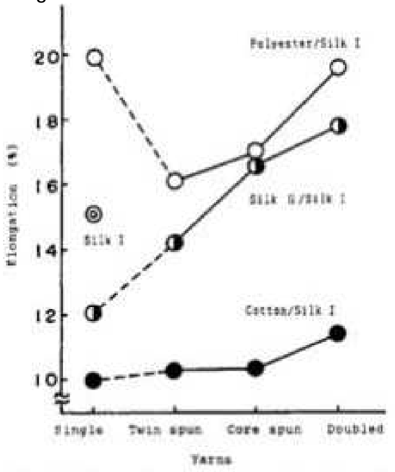

Fig. 5. Comparison with elongation in various yarns. (Composition=the other fibers 30%+silk I 70%).

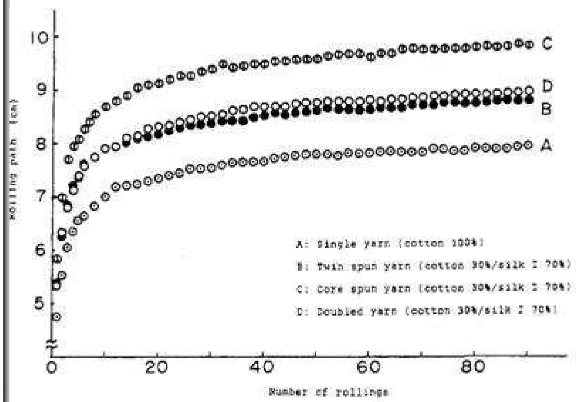

Fig. 6. Relation between rolling path and repeated rolling in fabrics.

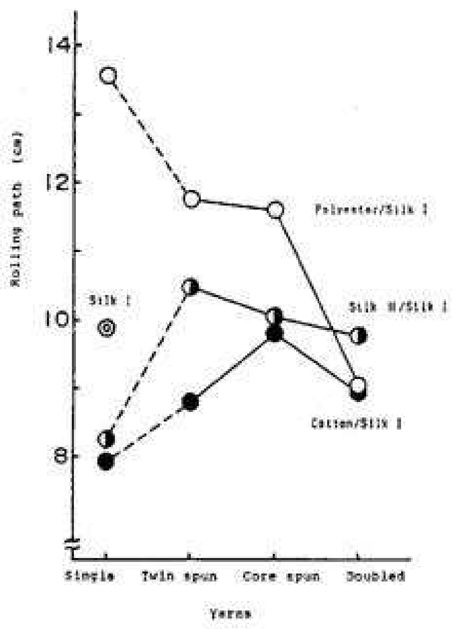

Fig. 7. Comparison with rolling path in various fabrics. (Composition= the other fibers 30% + silk I 70%).