Irregularities of Blended Yarns in Waste Silk Spinning System

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This paper deals with the irregularities of spun silk/polyester blended yarns resulting from the use of the waste silk spinning system. Staple fibers of silk and polyester were blended by sliver mixing in a drawing frame. The fiber length and the proportion of spun silk affecting the yarn irregularity were estimated. The fiber arrangement within a yarn cross-section was analysed. The experimental results were as follows: (1) The blend irregularities were considerably affected by both the proportion and the length of the silk staple fibers. (2) The silk fibers were located near the core in the cross-section of the blended yarn because they were both finer and longer than the polyester fibers in the blend.

Introduction

In the textile industry, many kinds of blend and composite yarns are produced in order to develop a new yarn with functional properties of fibers and to improve the properties of yarn and fabric. Usually, when the spun silk fibers are mixed with any kind of fibers for obtaining a feeling of high grade, they are cut up into a short length as they belong to the short staple sector and are blended by mixing sliver.

In the waste silk spinning system, a dressing machine enables to obtain a fringe made of fibers with a relatively uniform length. At the first stage of the dressing process, the fringe is designated as first draft. Generally, this draft contains the largest quantity of fibers with the longest length in the dressing process. Again, when the waste fibers recovered after the first stage of the dressing process are passed through the filling engine and the dressing machine, the second draft is obtained. However, both the values of length and quantity of fibers in the second draft are smaller than those of the first draft. By repeating this operation, it is possible to obtain silk staple fibers with a different length. The fiber length of the fourth draft, however, is longer than that characteristic of the short staple sector such as cotton fiber.

The mechanical and aesthetic properties of blended yarns are particularly important in terms of quality of textile products. Since these properties depend mainly on the irregularities
associated with fiber blending in the yarns, a large number of methods for evaluating the degree of fiber mixing in blended yarns have been developed (Coplan and Klein (1955), Bogdan et al. (1970), Krucinska (1988)).

However, information on the blend irregularity of spun silk is poorly documented.

An attempt was made to analyze blended yarns produced by using a waste silk spinning process. The effects of the proportion and the length of the silk fibers, and the method of mixing were examined. Furthermore, the fiber arrangement within a yarn cross-section was analyzed.

**Materials and methods**

The mean length of the silk staple fibers was 109 mm (first draft), 88 mm (second draft), 70 mm (third draft), and 57 mm (fourth draft), while that of the polyester staple fibers was 35 mm. The silk staple fibers were dyed red to facilitate the discrimination of the fibers within a yarn cross-section.

The hanks of slivers made from silk and polyester fibers were identical. The total sum of the number of slivers was 10 in the drawing process, and the nominal fiber content was modified by changing some of the silk and polyester slivers. The drawing frame was equipped with a sliver guide in the foreground of the back roller to prevent the interference of one type of fiber with another. The method of mixing slivers varied depending on the position of both slivers in a ratio of silk 50% / polyester 50%. After the sliver mixed in the first drawing was divided into 10 parts of identical length, a doubling action took place using the same drawing frame as in the second operation. Furthermore, the blended sliver was passed through a first and then a second roving frame, and then through a ring spinning frame. The English cotton count of yarn produced was 40 Ne, and the twist factor was 3 Ne⁻¹/₂ turns/inch.

The irregularities of a yarn, the coefficient of variation (CV %) and the spectrogram, were determined by using an Uster Tester 3 automatic evenness tester, in which the yarn speed was 25 m/minute and the testing time one minute.

The fiber arrangement within a yarn cross-section was observed as follows: (1) A yarn sample 3 cm long was embedded in a polyester resin and hardened. (2) The sample was cut off manually using a razor blade, and then a thin section was obtained. By random sampling, the total number of cross-sections was 6 in a yarn. (3) Photographs of the cross-sections were taken under a microscope.

The fiber arrangement was evaluated based on the migration index of Hamilton (1958). The procedure was as follows: (1) A yarn section was divided into five concentric zones corresponding to equal increments in radius. The resulting zones were numbered one to five, from the core to the surface. (2) The number of fibers of each component in each zone was counted and tabulated. The fiber frequencies were multiplied by an arithmetically equivalent correction value based on relative deniers and densities to obtain one component only. The fiber fineness and density were 1.2 denier and 1.48 g/c.c. for silk, and were 1.4 denier and 1.43 g/c.c. for polyester. Therefore, the value of the correction factor (C) was 1.25. (3) In each zone, the blend proportion was calculated from the number of fibers. An average blend proportion was obtained by calculating the sum of the number of fibers. (4) The migration index represents the overall core-to-surface distribution of a particular blend component by using a single numerical parameter. The index (M%) of each fiber was calculated by the following equations:
If $M = (F_{M_{a}} - F_{M_{u}}) / (F_{M_{u}} - F_{M_{i}}) \times 100\%$, and is negative;

whilst if $F_{M_{a}} > F_{M_{u}}$, $M = (F_{M_{a}} - F_{M_{u}}) / (F_{M_{u}} - F_{M_{o}}) \times 100\%$, and is positive.

where $F_{M_{a}}$ is the actual fiber moment, $F_{M_{u}}$ is the uniform moment, $F_{M_{i}}$ is the maximum inward moment, and $F_{M_{o}}$ is the maximum outward moment. The properties of the migration index are as follows (Hamilton, 1958):

(a) A migration index of zero corresponds to an even distribution of the component from core to surface, from which uniform distribution throughout the yarn section may reasonably be assumed. (b) A migration index of $\pm 100\%$ implies the complete separation of the component from the other fibers. Apart from such local mixing, the component in question lies exclusively at the yarn surface or core, respectively. (c) The migration index is positive or negative depending on outward or inward preferential migration. (d) The migration index of the second fiber component in a binary blend is equal in value, but opposite in sign, to the migration index of the component under consideration.

**Results and Discussion**

Fig. 1 shows the coefficient of variation (CV%) of yarn thickness plotted against the proportion of polyester fibers. The Uster CV% of the blended yarn increased with the in-

![Graph showing coefficient of variation (CV%) of yarn thickness against content of polyester.](image)
crease of the proportion of polyester fibers and the decrease in the mean fiber length of spun silk. Fig. 2 shows the wavelength with the maximum amplitude in the Uster spectrogram. The wavelength of the blended yarn increased with the increase of the proportion of polyester fibers. When the proportion of silk fibers was high, the blended yarn exhibited a maximum peak at a wavelength equal to about two times the mean fiber length of spun silk. However, when the proportion of polyester fibers was high, the wavelength of the blended yarn was longer than that equal to about two times the mean fiber length of polyester. It was considered that these variations were caused by the presence of short fibers of silk and polyester which affected the drafting wave because the roller gauge is long in a waste silk spinning system.

Figs. 3 and 4 show the CV % and the wavelength of the blended yarn plotted against the method used for mixing sliver. The nominal fiber composition was silk 50 %/polyester 50 %. In graphs, the symbols ○ and ● represent the positions of the silk and polyester slivers, respectively. The changes in the positions of both components did not show clear tendencies on the whole.
Table 1 lists the average blend proportion and the mean migration index for polyester fibers in the blended yarns, in which the yarn had a nominal composition of silk 50%/polyester 50%. It may be considered that all the average blend proportions for polyester fibers obtained from each zone of the yarn section were lower than the nominal blend proportion of 50% because testing was applied six times and the blend irregularity along the yarn length was considerable. On the other hand, all the mean migration indexes for polyester fibers gave positive values and corresponded to the outward position of polyester fibers in the yarn cross-section. However, the migration index decreased when the mean fiber length of spun silk was short. Compared with the blended yarn obtained in the first draft and shown in Fig. 5-(1), the blended yarn obtained in the fourth draft contained a larger number of polyester fibers near the core, as shown in Fig. 5-(2). It was considered that the fiber distribution was caused by differences in the fiber properties, such as dimension, specific gravity, etc. It may be necessary, therefore, to increase the staple length of polyester fibers in order to reduce the blend irregularities of the yarns produced by using the waste silk spinning process.

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References

Fig. 3 Change in coefficient of mass variation (CV) with sliver mixing (composition: silk 50% polyester 50%, A: silk, B: silk, C: silk, D: silk, E: silk, F: polyester, G: polyester, H: polyester, I: polyester). Figure 4 Variation of wavelength with sliver mixing (composition: silk 50% polyester 50%, A: silk, B: silk, C: silk, D: silk, E: silk, F: polyester, G: polyester, H: polyester, I: polyester). Figure 5 Yarn cross sections (composition: silk 50% polyester 50%, sliver mixing: F: polyester, G: polyester, H: polyester, I: polyester).
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松本陽一・土屋亀雄・鳥海浩一郎・原川和久：紡織工学における混紡糸のむら

糸中の繊維分布は、糸外観のみならずその機械的性質にも影響を及ぼす。そこで、紡紗工程を用いて作成した糸／ポリエステル混紡糸のむらを解析するために、繊維によるスライバ混合を用い、断面繊維長、含有率、および混合法の影響について検討した。

その結果、混紡糸のむらは断面繊維長、およびその含有率によって大きく影響される。また糸断面内において、断面繊維は糸中心近くに分布し易いが、ポリエステル短繊維は糸表面近くに多いことがわかった。これは、短繊維のもの粗さおよび長さによるものと考えられる。