Short Communications

Effect of filament pre-tension on the performance of solo-sirofil composite yarn

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In this study, solo-sirofil yarns under 5-30 cN filament pre-tension have been produced using modified EJM-128K ring spinning frame. The hairiness, breaking strength, breaking energy and yarn evenness have been tested under standard test conditions. It is observed that at 15 cN pre-tension of filament, solo-sirofil yarns show the best performance with lower hairiness, higher breaking strength & breaking energy, and better yarn evenness. The experimental results are helpful to understand the characteristics of the composite yarn produced by solo-sirofil system.

Keywords: Composite yarn, Filament pre-tension, Solo-sirofil, Yarn hairiness, Yarn strength, Yarn evenness

The composite yarn has the advantage of both the staple fibres and filaments to meet the market demand for high value-added products produced by combining both filaments with staple fibres. In general, the mechanical performance of the core yarn, such as strength, elasticity, durability, and dimensional stability, is carried by the filaments. However, the feeling performance, such as hand feeling and moisture, is determined by the staples. Various studies have been carried out to further develop the spinning techniques of composite yarn. Wu et al.1,3 explored the tensile properties of composite yarn, and concluded that the tensile properties of composite yarns mainly depend on the tensile properties of their filaments and that the torque of sirofil composite yarns is higher than composite yarns twisted from staple and filament yams. Pouresfandiari et al.4-6 explored the performance and mechanism of rotor-spun composite yarn, which indicated that the composite yarn can be produced with higher output and better quality. Compared with sirofil and rotor-spun composite yarns, solo-sirofil is one of the important new yarns.

The most significant advantage of solo-spun yarns over conventional ring-spun yarns is that the fibres are securely trapped within and between strands, and the hairiness of the yarn is thus reduced at a very high level due to the reduced fibre migration by the specially designed solo-spun roller7,8. However, its strength is reduced. By adding filament as the core yarn through combining sirofil system to solo-spun system, the strength and yarn evenness of the new composite yarn, called solo-sirofil, can be improved greatly9,10. According to our previous experiment, it is found that the characteristic of the solo-sirofil is critically affected by pre-tension of the filament. In this study, the hairiness, breaking strength and yarn evenness of solo-sirofil composite yarn have been investigated using polyester under different pre-tensions.

Pairs of solo-spun rollers (Fig. 1) and filament guide were fitted onto an EJM-128K ring spinning frame for solo-sirofil spinning process (Fig. 2). Parameters of solo-spun roller were thickness of teeth 0.2 mm, groove depth 0.3 mm and 0.4 mm (alternated), groove width 0.5 mm, and diameter of roller 13 mm. A cotton sliver (mean fibre length 25.4 mm, linear density 1.5 dtex, Micronaire value 3.43 and roving size 5.0 g/10 m) and 55D polyester filament as the filament yarn were used to produce 30tex solo-sirofil composite yarn. The twist factor was kept 415. The pressure of tongs mouth was kept 170 eN and the distance was 4.1 mm, while back zone

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Fig. 1—Physical figure of solo-spun roller

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drafting was 1.32. Pre-tensions of polyester were 5cN, 10cN, 15cN, 20cN, 25cN and 30cN separately.

The hairiness was tested at a testing speed of 30 m/min and test length of 10 m on a YG172 hair tester, and 1-9 mm hairiness per meter was measured. Breaking strength and breaking energy were determined at a test length of 500 mm, extension rate of 250 mm/min and pretension of 0.5 cN/tex on a YG061 tensile tester. Yarn evenness was tested by YG135G with the yarn speed of 400 m/min and the testing time of 1 min. All the tests were performed under a standard atmosphere of 20 ± 2 °C and 65 ± 2% RH.

Table 1 shows that at 15cN, the hairiness of 1-9 mm and 1-3 mm are found to be the lowest, while at 20cN, the hairiness of 4-9 mm (bad for fabric processing) is found to be the lowest. At 30cN, the yarns are found to be too hairy to be woven. Therefore, 30cN is eliminated in the following tests.

Table 1 also shows that breaking strength (cN/tex) of solo-sirofil first increases from 18.1 to 20.5 and then decreases to 17.7, as the pre-tension of filament increases from 5cN to 25cN. It is highest at 15cN, raised by 15.8% as compared to the lowest point. Breaking energy (cN×cm) also follows almost the same trend (Table 1), which first increases from 1035.9 to 1250, and then decreases to 1020. The highest point is obtained at 15cN, which is 22.5% raised than the minimum. It is inferred that 15cN pre-tension of filament is the critical point to the tensile property of solo-sirofil yarn.

It is observed that when pre-tension of filament increases from 5cN to 25cN, CV% and U% of solo-sirofil first decrease and then increase. Both CV% and U% remain at all their lowest point at 15cN; the yarn evenness remains at the best condition. CV% first decreases from 9.67 to 9.32, and then increases up to 9.97. CV% is almost the same i.e. 9.98 and 9.97 at 20 cN and 25 cN respectively. Unevenness achieves its lowest point at 7.37, which is 6.6% lower than the peak value (7.89).

Hearle and Bose indicated that the pattern of fibre migration within a yarn greatly influences the yarn properties, and the controlling fibre migration during spinning is an efficient way of controlling yarn properties. The drafted ribbon is divided to 2 – 5 fibre strands as they pass through the groove by the

<table>
<thead>
<tr>
<th>Tension of filament, cN</th>
<th>Hairiness 1-3 mm</th>
<th>Hairiness 4-9 mm</th>
<th>Breaking strength cN/tex</th>
<th>Breaking energy cN×cm</th>
<th>CV %</th>
<th>U %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1102.2</td>
<td>25.1</td>
<td>18.1</td>
<td>1035.9</td>
<td>9.67</td>
<td>7.63</td>
</tr>
<tr>
<td>10</td>
<td>1163.8</td>
<td>11.4</td>
<td>18.8</td>
<td>1030.0</td>
<td>9.43</td>
<td>7.39</td>
</tr>
<tr>
<td>15</td>
<td>1042.4</td>
<td>17.3</td>
<td>20.5</td>
<td>1250.0</td>
<td>9.32</td>
<td>7.37</td>
</tr>
<tr>
<td>20</td>
<td>1165.4</td>
<td>9.2</td>
<td>19.1</td>
<td>1115.5</td>
<td>9.98</td>
<td>7.89</td>
</tr>
<tr>
<td>25</td>
<td>1150.1</td>
<td>30.2</td>
<td>17.7</td>
<td>1020.0</td>
<td>9.97</td>
<td>7.84</td>
</tr>
<tr>
<td>30</td>
<td>1912.6</td>
<td>16.1</td>
<td>-</td>
<td>-</td>
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</tr>
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</table>
dividing effects of the solo-spun roller during spinning process. A few twists are first added to the fibre strands as they pass through the groove, and then most of the twists are added as they pass over the groove at the apex of the twist triangle zone (Fig. 3). During the spinning process, tension of the filament significantly affects the shape and height of twisting triangle. With the growth of filament tension, width of the twist triangle becomes narrower, which reduces the hairiness generated from the reversing or bending of fibres. However, if tension of filament is higher than a certain point, ends of some fibres would be pushed out of the twist triangle, and form hairs during speed revolutions under the influence of friction. Therefore, the twisting process deteriorates and results in a worse yarn evenness. As the amount of fibres contributed to the strength of yarns is reduced, the yarn strength decreases. According to the experiments discussed in this paper, the turning point is 15 cN when the composite yarn is 30tex/55D.

It is inferred from the study that when pre-tension of filament changes from 5cN to 25cN, the hairiness, breaking strength, breaking energy and yarn evenness of solo-sirofil composite yarn achieve best value at 15cN.

Acknowledgement

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