Air-jet texturing of draw-textured yarns

V K Kothari & V K Yadav
Department of Textile Technology, Indian Institute of Technology, New Delhi 110 016, India

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The possibility of feeding false-twist textured yam in air-jet texturing to obtain a yarn with higher bulk has been studied. Use of a modified false-twist textured feed yam for air-jet texturing results in a yarn of higher bulk, instability and tenacity but of lower elongation, initial modulus and linear density, as compared to air-jet textured yams produced from flat feed yams. The level of bulk can be further enhanced by post heat-setting the air-jet textured yams made from modified false-twist textured yams, but the resultant yams have higher instability and inferior tensile properties. Low interfilament friction, low skein shrinkage and higher bulk retraction are desirable in the modified false-twist textured yarn meant for air-jet texturing process.

Keywords: Air-jet texturing, False-twist textured yarn, Draw-textured yarn, Polyester yarn, Textured yarn

1 Introduction

Man has been using the natural fibres like cotton, wool and jute from very early days. Yams produced from these fibres have one thing in common, namely the surface fibres, which gives the fabrics made from these fibres a characteristic feel and appearance. Continuous filaments, on the other hand, are smooth and lustrous, and the fabrics produced from these have a slippery feel and poor comfort and aesthetic qualities. Filaments in this form are useful for certain applications, but for most of the end-uses a surface which is dull and more appealing to the human eyes is much more desirable if not essential. To impart in filament the yarns properties similar to those of natural fibre yarns, two different approaches were adopted. The first one was to duplicate the fibre exactly and the second one to duplicate the end product. In the first approach, the filaments were cut in staple form so as to make them compatible with the natural fibres. This, though gave desirable properties, increased the cost of production and lead to complications and problems during their conversion into fabric. It also did not take the advantage of the fact that when created, the fibres were already in a continuous yarn form, without the need for multi-step processing. The second approach was used keeping this in mind and air-jet texturing of continuous filament yarns was done for producing yarns with spun-like handle and appearance. A major drawback of such yarns in certain applications is the lack of stretch along with high bulk.

Modified texturing processes were introduced to produce textured filament yarns with spun-like character both in terms of appearance and physical properties. Piller has listed various modified texturing processes and defined 'hybrid texturing' as one of them. Demir and Wray have also made reference to two such patents. In this paper, air-jet texturing of false-twist textured yarns has been described and the properties of the resultant yarns have been presented. The effects of using coning oil during false-twist texturing and post-heat setting on air-jet texturing have also been reported.

2 Materials and Methods

2.1 Materials

Two polyester partially-oriented yams (POYs) of 100/36 and 126/34 deniers having circular cross-section and semi-dull lustre were used for the study. Draw ratios kept at draw-texturing machine and air-jet texturing machine were 1.6 and 1.632 respectively, resulting in drawn yarn denier of 62/36 and 80/34 respectively.

False-twist draw-textured yams were produced on the Himson-Rieter Scrugg SDS 700 C draw-texturing machine. Two types of modified stretch yarns were produced. Type A yarns were produced with coning oil applied during winding and Type B yarns were produced without coning oil. POY 126/34 was used...
to produce both Type A and Type B yarns, while POY 100/36 was used to produce only Type B yarns. The following draw-texturing variables were kept at constant level:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/Y ratio</td>
<td>1.92</td>
</tr>
<tr>
<td>Primary heater temp</td>
<td>195 ± 2°C</td>
</tr>
<tr>
<td>Secondary heater temp</td>
<td>160 ± 2°C</td>
</tr>
<tr>
<td>Stabilizing overfeed</td>
<td>7.97%</td>
</tr>
<tr>
<td>Winding underfeed</td>
<td>1.13%</td>
</tr>
<tr>
<td>Throughput speed</td>
<td>464 m/min</td>
</tr>
<tr>
<td>Oiling roller speed</td>
<td></td>
</tr>
<tr>
<td>Type A</td>
<td>15 rpm</td>
</tr>
<tr>
<td>Type B</td>
<td>0 rpm</td>
</tr>
<tr>
<td>Friction disc type</td>
<td>Positorg with polyurethane disc in 1-7-1 configuration</td>
</tr>
</tbody>
</table>

Single-end air-jet textured yarns were produced on Eltex AT/HS air-texturing machine and were divided in the following categories:

**Category 1**—Non-heat stabilised yarns produced from POY directly after drawing at 120°C hot-pin temperature.

**Category 2**—Non-heat stabilised yarns produced from draw-textured yarn (Type A and Type B).

**Category 3**—Post-heat stabilised yarns produced from draw-textured yarn (Type A and Type B).

During the preparation of Category 2 and Category 3 yarns, pretension was applied to feed yarns before feeding to the jet. A pretension of 42 gf was applied to Type B yarns of POY 126/34 and 100/36 denier, while a pretension to 55 gf was applied for Type A yarn of POY 126/34 denier.

The texturing conditions on the air-jet texturing machine were as follows:

**Texturing nozzle type:** Hemjet with T110 core

**Winding speed:** 300 m/min

**Water application:** 1 litre at 1 bar water pressure

**Overfeed to air jet:** 25%

**Air pressure:** 10 bar

**Mechanical stretch:** 4.7%

**Heat stabilising temp:** 200°C (for Category 3)

**Winding tension:** 2 eN

**Winding under feed:** 0.7%

To calculate the physical bulk of air-jet textured yarns and to know the properties of feed yarns in Category 1 entering the jet, drawn yarn samples of each POY were also produced at hot-pin temperature of 120°C and winding speed of 300 m/min.

### 2.2 Crimp Properties

Crimp and bulk properties of false-twist textured yarns were tested according to the ASTM Test Method D4031-95a (ref. 3). A skein of 5000 denier was prepared and then placed on a stand with a measuring scale in mm and the length $L_a$ was measured after 15 s of the application of a light load of 7.5 gf (1.5 mgf/den) which was left on the skein throughout the test. A heavy load of 500 gf (100 mgf/den) was then applied for 30 s and the length $L_b$ was measured. Skein without the heavy load was then placed in a hot-air oven maintained at 120±2°C for 5 min. After that, the skein was allowed to cool down in a standard laboratory atmosphere and the length $C_a$ was measured. Heavy load was again applied for 30 s to measure the length $L_b$, and the length $C_c$ was measured after 30 s of the removal of heavy load. The following measures of the crimp and bulk properties were then calculated using the following relationships:

\[
\text{Crimp contraction (CC), } \% = \frac{L_a - C_a}{L_a} \times 100
\]

\[
\text{Skein shrinkage (SS), } \% = \frac{L_b - L_a}{L_a} \times 100
\]

\[
\text{Bulk shrinkage (BKS), } \% = \frac{C_b - C_a}{C_a} \times 100
\]

\[
\text{Crimp recovery (CR), } \% = \frac{L_b - C_b}{L_b - C_a} \times 100
\]

Four skeins per sample were tested. For each sample, a minimum lapsed time of 72 h between material processing and testing was maintained.

### 2.3 Tensile Properties

Tensile properties of yarns were determined in accordance with the ASTM Test Method D2256-95a (ref. 4). Instron tensile testing machine (Model 4301) working on CRE principle and fitted with pneumatic jaws and a load cell of 1 kgf was used. All measurements were made at 250±3 mm gauge length with a pretension of 0.06 gf/den. Jaw speed of 300 mm/min was used. Ten readings per sample were taken to obtain the averages of tensile properties.

### 2.4 Physical Bulk

Physical bulk of air-jet textured yarns was measured using the modified Du Pont method suggested by Sengupta et al. Cylindrical package was wound under a fixed tension level of 2 eN at a winding speed of 300 m/min for 30 min. The physical
bulk of the textured yarn is given by the following relationship:

Physical bulk (%) = \frac{\text{Density of parent yarn package (g/cm}^3\text{)} \times 100}{\text{Density of textured yarn package (g/cm}^3\text{)}}

2.5 Instability

A method suggested by Du Pont was used for the instability measurement of air-jet textured yarns. A basic load of 0.01 gf/den is applied to the yarn and a mark is made at 100 cm distance from the clamp. Yarn is then subjected to a heavy load of 0.5 gf/den for 30 s. The permanent extension in the length of the yarn, measured 30 s after the heavy load has been removed, is taken as a measure of instability. Ten readings were taken from a sample package to estimate instability and between each successive readings, nearly 5 m yarn was unwound from the package and discarded.

3 Results and Discussion

3.1 Effect of Air-Jet Texturing of False-Twist Textured Yarns

Table 1 shows the various properties of air-jet textured yarns and the tensile properties of different feed yarns. Figs 1 and 2 show the stress-strain curves of feed yarns and air-jet textured yarns produced from 126/34 and 100/36 denier POY respectively. It is observed from Table 1 that air-jet texturing of false-twist textured yarns results in higher bulk and instability (except in case of Type A feed yarn), lower yarn linear density, higher tenacity and lower initial modulus and elongation, compared to air-jet textured yarns of Category 1 produced from the flat filaments directly. Higher bulk per unit linear density is obtained which means a light fabric of better cover could be produced from such yarns. Higher tenacity and lower linear density obtained along with higher bulk is probably due to an open structure formed by the texturing jet. Since the yarns are mechanically stabilized at a stretch of 4.7%, the loosely formed structure is straightened out, giving a lower linear density. Increase in tenacity is due to the increase in the number of load bearing elements.

It has been observed that the texturability of Type A feed yarn was poor. This is probably due to the increased cohesion between filaments because of coning oil which is applied during false-twist texturing to prevent filamentation in further processing. This is contrary to the requirement of air-jet texturing technology, where it is desirable to have lower cohesion and inter-filament friction for better texturing. Because of the increased cohesion it was

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<table>
<thead>
<tr>
<th>Feed yarn type</th>
<th>Yarn category*</th>
<th>Physical bulk</th>
<th>Instability</th>
<th>Increase in linear density</th>
<th>Tenacity gf/den</th>
<th>Breaking elongation %</th>
<th>Initial modulus gf/den</th>
</tr>
</thead>
<tbody>
<tr>
<td>126/34</td>
<td>I</td>
<td>292</td>
<td>2.1</td>
<td>13.21</td>
<td>2.34</td>
<td>29.6</td>
<td>24.6</td>
</tr>
<tr>
<td></td>
<td>2A</td>
<td>228</td>
<td>1.7</td>
<td>6.01</td>
<td>2.96</td>
<td>21.8</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>317</td>
<td>2.3</td>
<td>8.02</td>
<td>2.81</td>
<td>25.2</td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>288</td>
<td>1.7</td>
<td>6.71</td>
<td>2.76</td>
<td>19.8</td>
<td>15.9</td>
</tr>
<tr>
<td></td>
<td>3B</td>
<td>288</td>
<td>1.5</td>
<td>7.27</td>
<td>2.87</td>
<td>23.0</td>
<td>14.5</td>
</tr>
<tr>
<td></td>
<td>DY</td>
<td>100</td>
<td>--</td>
<td>0</td>
<td>3.43</td>
<td>29.4</td>
<td>84.7</td>
</tr>
<tr>
<td>100/36</td>
<td>I</td>
<td>234</td>
<td>0.7</td>
<td>11.79</td>
<td>2.27</td>
<td>19.6</td>
<td>31.4</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>284</td>
<td>1.0</td>
<td>6.15</td>
<td>2.98</td>
<td>18.6</td>
<td>20.2</td>
</tr>
<tr>
<td></td>
<td>3B</td>
<td>311</td>
<td>1.6</td>
<td>11.69</td>
<td>2.04</td>
<td>16.5</td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td>DY</td>
<td>100</td>
<td>--</td>
<td>0</td>
<td>2.86</td>
<td>12.1</td>
<td>91.3</td>
</tr>
</tbody>
</table>

*Yarn category: I—Air-jet textured yarn from POY, B—False-twist textured yarn without coning oil, 2A—Air-jet textured yarn from false-twist textured yarn with coning oil, 2B—Air-jet textured yarn from false-twist textured yarn without coning oil, 3A—Air-jet textured post heat-set yarn made from false-twist textured yarn with coning oil, 3B—Air-jet textured post heat-set yarn made from false-twist textured yarn without coning oil, and DY—Drawn yarn
necessary to use high feed yarn tensions for air-jet texturing of Type A yarns. In case of Type A yarn of 126/34 denier POY, a tension of 55 gf was necessary compared to 42 gf for Type B yarns. As a result, in case of Type A yarns made from 126/34 denier POY, a reduced bulk is obtained due to inability of the individual filaments to separate and form loops to the same extent. Thus, it has resulted in a compact structure with more straight filaments giving a higher tenacity and initial modulus and a lower instability, linear density and elongation, compared to air-jet textured yarn from Type B feed yarn.

3.2 Effect of Heat-Setting on the Properties of Air-Jet False-Twist Textured Yarns
It is observed from Table 1 that post heat-setting increases the physical bulk, instability and linear density and reduces the tenacity, elongation and initial modulus. Only exception is the Type 3B yarn made from 126/34 denier POY where a reverse trend is observed. A possible explanation for this discrepancy is given subsequently.

Table 2 lists the various crimp properties of false-twist textured yarns. Heat setting the air-jet false-twist textured yarns will have two-fold effect:

- Shrinking of individual filaments due to residual shrinkage remaining in the filaments. Extent of this shrinkage is given by skein shrinkage (%).
- Development of crimp, resulting in increased bulk. This is given quantitatively by bulk shrinkage (%) which is similar to bulk retraction (%).

Both these will have a counteracting effect on the bulk of air-jet textured yarns. Former will tend to reduce bulk due to compacting of core. On the other hand, the later will tend to increase bulk by creating more air volume for a given mass due to crimp development. The effect due to skein shrinkage will

<table>
<thead>
<tr>
<th>Feed Yarn Denier</th>
<th>Crimp Shrinkage (%)</th>
<th>Skein Shrinkage (%)</th>
<th>Bulk Shrinkage (%)</th>
<th>Crimp Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>126/34</td>
<td>30.8</td>
<td>20.8</td>
<td>18.7</td>
<td>91.2</td>
</tr>
<tr>
<td>310/36</td>
<td>14.4</td>
<td>11.1</td>
<td>11.9</td>
<td>91.9</td>
</tr>
</tbody>
</table>
have precedence over the effect due to bulk shrinkage, as much higher shrinkage forces (tensions) would be involved in skein shrinkage compared to bulk shrinkage. As a result, in the case of Type 3B yarn made from 126/34 denier POY, there is more of a compact core due to high skein shrinkage. This is reflected in lower bulk, instability and linear density, and increased tenacity and initial modulus.

However, in the case of Type 3B yarn made from 100/36 denier POY, due to the low skein shrinkage, there may be little compacting of core, but that is more than compensated by high bulk shrinkage of the false-twist textured yarn, resulting in increased bulk. This is further supported by an increase in instability and linear density and a decrease in tenacity, elongation and initial modulus.

4 Conclusions

Air-jet texturing of false-twist textured yarn results in a higher bulk along with higher tenacity, lower elongation, lower initial modulus, higher instability and lower linear density, as compared to the air-jet textured yarn from flat feed yarns. It is essential to make crimp out of phase with each other for texturing to take place. This is achieved in present study by applying a tension to the feed yarn before it is fed to the jet.

False-twist textured yarn with a lower skein shrinkage and a higher bulk shrinkage (retraction) could be used to obtain a high bulk in the yarn by post heat-setting the air-jet textured yarn produced from them. Such yarns would have an added advantage of a very low residual shrinkage which provides a better dimensional stability to the fabrics produced from them.

Coning oil applied during false-twist texturing plays a crucial role. This should be chosen keeping in mind the requirement of air-jet texturing, viz. reducing inter-filament and metal-to-filament friction.

References

1. Piller B, Melland Textilber, 60 (2) (1979) 140, E 128.