Core coverage in DREF-III friction-spun yarns

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The appearance of DREF-III friction-spun core yarns has been studied subjectively in respect of the coverage of core by the sheath fibres. It is observed that the core coverage increases with the increase in sheath component, irrespective of the form of core. However, it is not possible to hide the core completely even with a very high sheath content of 85%.

Keywords: Core coverage, Core-spun yarn, DREF-III spun yarn, Friction spinning, Polyester/viscose yarn

1 Introduction

Core/sheath structures essentially consist of two components. The core component makes a major contribution towards the tensile properties of the yarn while the sheath, acting as a cover, mainly influences the yarn surface characteristics like feel, comfort and appearance. Such structures can be produced in a number of ways, such as by using a modified ring frame\(^1^7\), ordinary ring/fancy doubler\(^2^8\), open-end rotor spinning technique\(^9\), air-vortex system\(^10^, 11\), I. C. S. technique\(^12^-15\), and friction spinning systems\(^16^-19\).

Friction spinning is the latest addition to this. Out of the two different systems, viz. DREF-II and DREF-III, in this field the DREF-III system is more versatile since core and sheath can be controlled independently to allow the selective combination and placement of different materials for functional, economic and aesthetic reasons.

Whatever may be the spinning system, the core coverage by the sheath fibres is an important aspect. Many industrial and household applications of these structures require the application of special finishes, coatings and dyes which, for appearance sake, make it essential to hide the core completely below the sheath fibres. In this regard, some attempts have already been made at Southern Regional Research Center by Sawhney et al.\(^5, 6\) to produce an almost totally covered yarn with 33% polyester core and 67% cotton sheath on a modified ring spinning frame giving an appearance of 100% cotton spun yarn. For friction-spun yarns, Louis et al.\(^20\) have pointed out the appearance of noticeable sections on the yarn surface where the wrapper fibres are not able to cover the core fibres completely. It has also been reported that the complete cover of the core with sheath fibres is obtained only when the sheath component is very high\(^21\). However, the studies regarding visual appearance of these yarns are limited\(^22\).

Equally important is the measurement of core coverage. The literature lacks information in this field. One method of measuring the core coverage is the objective assessment which is based on the optical differentiation between the core and the dyed wrapper fibres as suggested by Sawhney et al.\(^5, 6\). In this method, the yarn/fabric surface is scanned by the image analyzing computer system and the fraction of total scanned area of the yarn/fabric that comprises bare or uncovered core is computed. The other method of assessing the core coverage is the visual examination which is a subjective assessment of the appearance of the yarn surface where either core or sheath is dyed. Obviously, a great deal of experience and considerable skill are required for this. Moreover, the results obtained by this method may not be reproducible due to the subjective errors introduced in judging the appearance.

In spite of this, visual appearance remains an important
aspect as it ultimately affects the acceptability of the yarn in the market. For wider acceptance in the market and to improve upon the worldwide volume of market for friction-spun yarns, limited at present, it is essential to study the visual appearance of these yarns particularly in terms of core coverage.

The present work was, therefore, aimed at studying the appearance of DREF-III friction-spun core yarns by subjective assessment in respect of coverage of core by the sheath fibres.

2 Materials and Methods

2.1 Materials
Polyester multifilament yarn and polyester staple fibres were selected for core while viscose rayon fibres were selected for the sheath component. In order to facilitate the judgement of core coverage, different colours were used for the core (purple) and the sheath (golden) components. Table 1 shows the detailed specifications of the materials used.

2.2 Methods

2.2.1 Preparation of Yarn Samples
Polyester and viscose rayon fibres were processed separately through a Lakshmi Rieter blowroom line and carded on an MMC card. The card slivers were given two passages of drawing on a Lakshmi Rieter draw frame (LR DO/2S model) to produce finished slivers of 3.0 ktex.

For the preparation of the yarn to be incorporated as core, a part of the polyester sliver was converted into roving on a Texmaco Howa simplex machine. The roving was then spun into yarns of different linear densities (Table 2), using the same twist factor (2.9) but two different twist directions (Z and S) on a Texmaco ring frame. The linear density of each of these yarns was adjusted to get the desired percentage of core in the DREF-III core-spun yarn.

Sixteen (16) yarn samples of 59.0 tex (Table 2) having different forms of core (drafted fibres, ring-spun yarns and multifilament yarns) and varying core/sheath ratios ranging from 15:85 to 80:20 were spun on the DREF-III spinning machine. Owing to certain constraints related to spinning limitations (frequent interruptions in yarn formation process particularly for normal drafted core), the core/sheath ratio for the three different forms of core could not be matched for all combinations. However, for all the yarns, five slivers of viscose rayon fibres (dyed in golden colour) were fed to opening roller drafting unit so as to form the sheath and the roller drafting unit was utilized for feeding polyester (dyed in purple colour) as core in different forms viz. staple fibres, spun yarns and multifilament yarns. For staple fibre core, a sliver was drafted in the normal way while for spun and multifilament yarns, the feeding was done at the back of the front pair of drafting rollers. The drum spinning speed and delivery rate were maintained at constant levels of 4000 rpm and 200 m/min respectively.

2.2.2 Subjective Assessment of Core Coverage

For the visual appearance of the core coverage or the subjective assessment of the golden colour (sheath fibres) content on the surface of the yarns, each of the yarn samples was wrapped manually over a small size white paper card to form a 3 in × 2 in strip. Each of the strip was photographed to have an enlarged view of the wraps (strip). To avoid confusion during the assessment, only eight photographs were selected out of

![Table 1—Raw material specifications](image)

<table>
<thead>
<tr>
<th>Material</th>
<th>Length (mm)</th>
<th>Fineness (dtex)</th>
<th>No. of filaments</th>
<th>Individual filament fineness (dtex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscose rayon fibre</td>
<td>51</td>
<td>1.67</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Polyester fibre</td>
<td>51</td>
<td>1.56</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Polyester filament</td>
<td>-</td>
<td>88.89</td>
<td>34</td>
<td>2.61</td>
</tr>
</tbody>
</table>

![Table 2—Yarn samples with corresponding spinning conditions](image)

<table>
<thead>
<tr>
<th>Yarn ref. no. (tex)</th>
<th>Linear density</th>
<th>Core/sheath ratio</th>
<th>Core type</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>59.0</td>
<td>50:50</td>
<td>Normal fibres</td>
</tr>
<tr>
<td>S2</td>
<td>59.0</td>
<td>60:40</td>
<td>Normal fibres</td>
</tr>
<tr>
<td>S3</td>
<td>59.0</td>
<td>70:30</td>
<td>Normal fibres</td>
</tr>
<tr>
<td>S4</td>
<td>59.0</td>
<td>80:20</td>
<td>Normal fibres</td>
</tr>
<tr>
<td>S5</td>
<td>59.0</td>
<td>40:60</td>
<td>S-twisted ring yarn (23.6 tex)</td>
</tr>
<tr>
<td>S6</td>
<td>59.0</td>
<td>50:50</td>
<td>S-twisted ring yarn (29.5 tex)</td>
</tr>
<tr>
<td>S7</td>
<td>59.0</td>
<td>60:40</td>
<td>S-twisted ring yarn (35.4 tex)</td>
</tr>
<tr>
<td>S8</td>
<td>59.0</td>
<td>70:30</td>
<td>S-twisted ring yarn (41.3 tex)</td>
</tr>
<tr>
<td>S9</td>
<td>59.0</td>
<td>80:20</td>
<td>Z-twisted ring yarn (23.6 tex)</td>
</tr>
<tr>
<td>S10</td>
<td>59.0</td>
<td>40:60</td>
<td>Z-twisted ring yarn (29.5 tex)</td>
</tr>
<tr>
<td>S11</td>
<td>59.0</td>
<td>50:50</td>
<td>Z-twisted ring yarn (35.4 tex)</td>
</tr>
<tr>
<td>S12</td>
<td>59.0</td>
<td>60:40</td>
<td>Z-twisted ring yarn (41.3 tex)</td>
</tr>
<tr>
<td>S13</td>
<td>59.0</td>
<td>15.5</td>
<td>Multifilament yarn</td>
</tr>
<tr>
<td>S14</td>
<td>59.0</td>
<td>30:70</td>
<td>Multifilament yarn</td>
</tr>
<tr>
<td>S15</td>
<td>59.0</td>
<td>45:55</td>
<td>Multifilament yarn</td>
</tr>
<tr>
<td>S16</td>
<td>59.0</td>
<td>60:40</td>
<td>Multifilament yarn</td>
</tr>
</tbody>
</table>

* Linear density
Fig. 1—Typical photographs showing the appearance of DREF-III spun core yarns [a – sample S1, b – sample S4, c – sample S7, d – sample S8, e – sample S9, f – sample S12, g – sample S13, and h – sample S16]
the sixteen samples. Selection was made in such a way that the set of eight photographs included the samples having the lowest and the highest sheath content for each type of core used.

These photographs were shown to a panel of judges comprising students, laboratory technicians and faculty members. Each judge was asked individually to rank the photographs from 1 (most golden) to 8 (least golden). These ranks were utilized to calculate coefficient of concordance which produced a value $W$, indicating the level of agreement among the judges.

### 3 Results and Discussion

The appearance of core-spun yarns is significantly affected by the uniformity and the degree of core coverage. This can be observed from the set of photographs (Fig. 1) of the various DREF-III core-spun yarns produced with different levels of core/sheath ratio and three different forms of core.

Table 3 shows the rank orders assigned by the judges to these photographs in respect of their appearance taking golden colour content as the attribute for judgement. All the judges expressed the same view that the purple component is not completely covered by the golden one. In order to know whether or not there was a general consensus of opinion among the judges as a whole and to have confidence in this subjective evaluations, the coefficient of concordance was determined using the following relationship:

$$W = S / \left[ M^2 \left( n^3 - n \right) \right] / 12$$

where $S$ is the sum of squares of the differences of the rank sums and the mean of the rank sums; $m$, the number of judges; and $n$, the number of samples.

In the present study, for a mean rank sum of 54, the value of $S$ is 3944 (Table 4) and the coefficient of concordance is 0.652 which indicate a close agreement among the twelve judges. A test of significance was applied to this value making use of $F$-distribution. For this, the calculated value of $W$ was modified using the following relationship:

$$W' = \frac{(S - 1)}{\left[ M^2 \left( n^3 - n \right) \right] / 12 + 2}$$

This value of $W'$ was used to find out the value of $F$ by the following relationship:

$$F = \frac{(m - 1) W'}{1 - W'}$$

The calculated value of $F$ was compared with the tabulated value of $F$ from a table of variance ratio with two estimates ($\gamma_1$ and $\gamma_2$) of degrees of freedom. The two estimates ($\gamma_1$ and $\gamma_2$) were calculated as follows:

$$\gamma_1 = \frac{[(n - 1) - 2]}{m}$$

$$\gamma_2 = \frac{(m - 1) \gamma_1}{12}$$

$$= \frac{6.83}{12}$$

$$= 0.569$$

$$= 75.2$$
The calculated value of $F$ exceeds the tabulated value of $F$ ($F_{	ext{tabulated}} = 3$) for $\gamma_1 = 6.83$ and $\gamma_2 = 75.2$ at 1% level of confidence. This confirms that the close agreement among the judges is not due to chance. The very high probability associated with the observed value of $W$ enables us to reject the null hypothesis that the judges' ratings are unrelated to each other. The final ranking considering the rank totals may, therefore, be made as shown in Table 4.

When these final ranks are plotted with percentage sheath content (Fig. 2) without considering the form of core, it is observed that a sample with a minimum sheath content is placed at the lowest rank (8). An increase in the sheath proportion, irrespective of the form of core, improves the core coverage as shown by the improvement in final rank; one with the highest sheath content (85%) receives the top rank (1). This confirms that the core coverage is mainly decided by the sheath proportion, whatever may be the form of core.

4 Conclusion
Core coverage increases with the increase in sheath component, irrespective of the form of core. However, it is not possible to hide the core completely even with a very high sheath content of 85%. The coefficient of concordance was 0.65, showing a general consensus among the judges.

References