Influence of Spinning Processing Parameters on Yarn Cross-Sectional Area
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Abstract
In the recent days every textile technologist requires the production of yarn with higher quality and high yarn realization which can be made possible if the textile technologist takes the improvement steps on the machine as well as processing parameters. Now everybody is looking for encouraging the yarn quality by improving processing parameters. Generally the yarn quality parameters are affected by the physical structure of the yarn. The yarn cross-section shape is the very important yarn physical parameter which has a dominant effect on the physical structure of the yarn. In the past days no such studies have been conducted on the yarn cross-section studies due to the various limitations of the yarn cross-section measuring or testing instruments. Here author studied four factors are affecting the yarn cross-section i.e. twist multiplier, Roving hank, spinning system and doubling technique.

Introduction
Up till now very limited studies have been conducted on the yarn cross-section shape and which is mainly due to the difficulty and inaccuracy in the measurement of the yarn cross-section shape. It is found that the yarn cross-section shape plays very important role in deciding the fabric appearance as well as it has dominant effect on the yarn quality parameters as stated by Arindam Basu [1] so it fills important to test the yarn cross-sectional shape and its area. The conventional method discussed in the study by Gunay Melih et al [2] and Hamilton J.B. [3] for direct yarn cross-section measurement method which gives the approximate value, so far in this study the yarn cross-sectional area has been accurately measured by the instrument developed by Prof. Narkhedkar R.N. et al [5]. The instrument developed by the author it is possible to measure the yarn cross-sectional area without cutting the yarn so far there is no disturbance is provided to the fibres in the yarn cross-section. There are many parameters of cross section which affect the physical and mechanical properties of the yarns such as: surface area, perimeter, equivalent diameter, large diameter, small diameter, convexity, stiffness, eccentricity, and hydraulic diameter.

Material and method
In this study for testing the yarn cross-sectional area the testing instrument fabricated by author was used. For testing the effect of various processing parameters on the yarn cross-sectional area three different cotton counts viz. 20s Ne, 30s Ne and 40s Ne are used. The mentioned three yarn counts are spun with three twist multipliers each i.e. 3.6, 4.2 and 4.8.

Results and Discussion:
1. Effect of Twist Multiplier –
For testing the effect of twist multipliers the yarn samples have been produced for three different twist multipliers such as: 3.6, 4.2 & 4.8 each for three combed cotton counts like 20s, 30s & 40s then the change in yarn cross-sectional area have been calculated by average radius method as well as by the novel method and these values are as given following table 1.

<table>
<thead>
<tr>
<th>Twist Multiplier</th>
<th>20s</th>
<th>30s</th>
<th>40s</th>
<th>20s</th>
<th>30s</th>
<th>40s</th>
<th>20s</th>
<th>30s</th>
<th>40s</th>
<th>20s</th>
<th>30s</th>
<th>40s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yarn Count Ne</td>
<td>3.6</td>
<td>4.2</td>
<td>4.8</td>
<td>3.6</td>
<td>4.2</td>
<td>4.8</td>
<td>3.6</td>
<td>4.2</td>
<td>4.8</td>
<td>3.6</td>
<td>4.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Average Yarn Radius (mm)</td>
<td>0.11407</td>
<td>0.10005</td>
<td>0.09107</td>
<td>0.10019</td>
<td>0.08909</td>
<td>0.07937</td>
<td>0.08058</td>
<td>0.020401</td>
<td>0.019242</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yarn C/S Area By Avg. Radius (mm²)</td>
<td>0.040884</td>
<td>0.031451</td>
<td>0.026059</td>
<td>0.03154</td>
<td>0.024938</td>
<td>0.019793</td>
<td>0.07192</td>
<td>0.019242</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yarn C/S Area By Novel Method (mm²)</td>
<td>0.03799</td>
<td>0.02892</td>
<td>0.024894</td>
<td>0.03154</td>
<td>0.023513</td>
<td>0.018454</td>
<td>0.0594</td>
<td>0.010078</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Yarn C/S Area W. r. t. Different Counts and Twist Multipliers
Above Table 2 and figure 1 reflects that, for both the materials there is significant difference in yarn cross-sectional area for the different twist multipliers it is interpreted by ‘P’ values which are less than 0.05 which is due to the variation in fibre packing density affected by the twist. It also confirms that there is significant difference in yarn cross-sectional area calculated by two different methods for a particular count, T.M. & material it is due to the fact that, in the conventional average radius method the radius calculated may not be the perfect one, but the novel method considers all possible yarn radii and calculates accurate yarn cross-sectional area.

It is also found that, as the twist multiplier increases there is reduction in yarn cross-sectional area, for coarser counts there is only 13% to 20% reduction due to higher number fibres in cross-section, while the reduction is increased to 20% to 35% in case of fine counts due to higher compactness offered by the less number of fibres in yarn cross-section.

2. Effect of Roving Hank Fed and different spinning systems –

For testing the effect of fed roving hank 30s Ne cotton count both for the 0.7s Ne and 1.16s Ne roving hank was produced and the yarn with two spinning systems viz. compact spinning system and regular spinning system was produced with hank fed as 0.7s Ne and the cross-sectional area calculated by both the testing methods are as given in following Table 3.
The above table 3 and figure 2 confirms that, even the count produced is same i.e. 30s Ne the yarn cross-sectional area produced by the course roving i.e. 0.7s Ne is larger than that of produced from the finer roving hank i.e. 1.16s Ne this fact is true for both the testing methods this is due to the fact that the courser roving gives more spreading during the drafting in the drafting system while the web spreading is less for finer roving hank. The statistical analysis as given in the table 4 it is found that, the ‘p’ value for two different roving hanks fed is 0.03172 is less than 0.05 which proves that there is significant difference between the yarn cross-sectional area produced from the two different roving hanks but both the testing methods calculates nearly same yarn cross-sectional area.

The above table 4 reflects the statistical analysis of the yarn cross-sectional areas calculated by both of the methods as well as by the compact spinning system and regular spinning system. From this statistical analysis it is proved that there is no significant difference between the yarn cross-sectional areas calculated by both of the testing methods but since the ‘P’ value for different spinning systems is 0.03379 which is less than 0.05, the yarn produced by using two spinning systems viz. compact spinning system and regular spinning system shows significantly different cross-sectional area this is because in the compact spinning system during the drafting the material web is not allowed to spread and maximum number of fibres area bounded in the yarn body resulting to the increase in fibre density of the yarn while in case of the yarn produced by using regular spinning system the drafting web is spreads during drafting and the fibre packing density is reduces as compared to the yarn produced by the compact system even the yarn count produced by both of the system is same i.e. 30s Ne.

### Table 4 Statistical Analysis

<table>
<thead>
<tr>
<th>Analyzed For</th>
<th>'P' Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Different roving hanks</td>
</tr>
<tr>
<td>Between Method</td>
<td>0.127874</td>
</tr>
<tr>
<td>Between different roving hank fed</td>
<td>0.031718</td>
</tr>
</tbody>
</table>

3. **Effect of Doubling Techniques**

In this study 2/60s Ne double yarn has been produced with three different doubling techniques such as: Ring doubler, TFO & SIRO then those samples are tested by both the measuring techniques. The results are as given in table 5.

### Table 5 Yarn C/S Area W. R. T. Different Doubling Techniques

<table>
<thead>
<tr>
<th>Doubling System</th>
<th>Average Yarn Radius (mm)</th>
<th>Yarn C/S Area By Avg. Radius (mm²)</th>
<th>Yarn C/S Area By Novel Method (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ring doubler</td>
<td>0.15179</td>
<td>0.072392</td>
<td>0.062475</td>
</tr>
<tr>
<td>TFO</td>
<td>0.16809</td>
<td>0.088775</td>
<td>0.076049</td>
</tr>
<tr>
<td>SIRO</td>
<td>0.13416</td>
<td>0.056527</td>
<td>0.051414</td>
</tr>
</tbody>
</table>
Among the all doubling techniques TFO gives larger yarn cross-section as compared to the other two techniques and SIRO yarn is produced with lest yarn cross-sectional area which is due to the principle of twist on twist.

Above table 5 and figure 4 reflects that, there is no significant difference in yarn cross-sectional area calculated by two different methods for a particular doubling technique it is interpreted by ‘P’ value 0.053 which is greater than 0.05 this is because of increase in linear density of the yarn. It is also found that, the different doubling techniques produce yarns of significantly different cross-sections it is interpreted by ‘P’ value 0.0179 which is less than 0.05 which are due to the variation in the yarn twisting techniques.

Conclusions

Conventional method of calculating the yarn cross-sectional area gives the area of circle corresponding to the any radius taken but the novel method developed by us gives the correct yarn cross-sectional area irrespective of the any one radius. By this novel method correct, fast and easily yarn cross-sectional area can be calculated due to the soft ware interference.

It is found that the yarn cross-sectional area is reduces as the yarn twist multiplier increases. For the courser counts the reduction in yarn cross-sectional area with the increase in twist multiplier is less as compared to the finer counts.

Even the count produced is same i. e. 30s Ne the yarn cross-sectional area produced by the course roving is larger than that of produced from the finer roving hank this fact is true for both the testing methods. By the statistical analysis it is found that, the ‘p’ value for two different roving hanks fed is less than 0.05 which proves that there is significiant difference between the yarn cross-sectional area produced from the two different roving hanks but both the testing methods calculates nearly same yarn cross-sectional area.

By the statistical analysis of the yarn cross-sectional areas calculated by both of the methods as well as by the compact spinning system and regular spinning system it is proved that there is no significant difference between the yarn cross-sectional areas calculated by both of the testing methods but since the ‘P’ value for different spinning systems is less than 0.05, the yarn produced by using two spinning shows significantly different cross-sectional area even the yarn count produced by both of the system is same i.e. 30s Ne.

Among the three doubling techniques TFO gives larger yarn cross-section as compared to the other two techniques and SIRO yarn is produced with lest yarn cross-sectional area. The statistical analysis reflects that, there is no significant difference in yarn cross-sectional area calculated by two different methods for a particular doubling technique which is interpreted by ‘P’ value which is greater than 0.05.

References: