How does open-end processing variables effect imperfections for different yarn count?

by

Sh. Muhammad Nawaz*, Nisar Ahmad Jamil**, Muhammad Iftikhar *** and Bilal Farooqi

Abstract

Open end-processing variables effect upon imperfections under different yarn count were studied. The results for thin thick places and neps indicate that effect of yarn count and rotor diameter were highly significant while effect of draw-off navel type was only significant.

Introduction

The productivity of yarn formation has increased 3-5 times by open-end spinning as compared to ring spinning system. Direct winding of the spun yarn to form a cheese of 3-5 kg is an additional benefit. The qualitative properties of open-end yarn are much better than carded short staple cotton with the exception of lower mean strength (Wirth, 1975). As far as economics is concerned, open-end spinning does not need the roving and winding machine. Because of better uniformity, number of drawing operations is also lowered and it produced equally good yarn from lower grade cotton. The profit margin is higher as compared to ring spinning system with other bonus advantages of less space and labour requirements.

Rotor spinning gives a new boom to the cotton processing. Yarn produced is more uniform, fuller, aerated and regular in strength. Hence it is planned to carry out research work pertaining to the optimum rotor diameter, draw-off nozzle for various counts for Pakistani cotton. Present investigation will suggest optimal open-end machine setting for the best quality yarn production. Simpson and Patureau (1979) mentioned that any factor that increased the twisting torque at the yarn formation point, for example fast rotor speed, large diameter rotors, and grooves in the yarn takeoff navel, produced yarns with poor fibre orientation and short term variability. They further reported that yarn spun with a coarsely grooved draw-off navel have more imperfection and unevenness than those spun with a finely grooved draw-off navel. Manohar et al. (1983) reported that Uster U% thin and thick places and appearances of the yarn are broadly unaffected by the rotor diameter. He further reported that nep level in the yarn increases steeply with the increase in rotor diameter. Ahmed (1989) mentioned that increase in short fibre content cause the increase neps in the card web which further increases the neps in the yarn spun.

The open-end cotton yarns are superior in short term regularity to carded ring spun cotton yarns and there is complete absence of pronounced drafting wave type of irregularity that is the characteristic of the latter. Hence thick thin places may be the result of poor sliver quality, high short fibre percentage, insufficient fibre opening and dirt accumulation in rotor. Similarly Haque (1998) concluded that the main cause of imperfection in the spun yarn is substantial variation in the number of fibres in the yarn cross section along the length. As the yarn becomes finer the number of fibres in the cross section decreased and the yarn imperfections increase.

Materials and methods

The present technological study on the effect of multiple open-end processing variables upon the yarn quality was initiated in the Department of Fibre Technology, University of Agriculture, Faisalabad and carried out at Shafi Spinning Mills, Sheikhupura Road, Faisalabad.

The representative lint cotton samples of the cotton variety MNH-93 were collected from the running stock for its evaluation. These physical characteristics were estimated by High Volume Instruments (HVI)-900 SA), a fibre testing system manufactured by M/s. Zellweger Ltd., Switzerland. Specimen lint samples recorded span length with its mean value of 1.03 inch and CV as 0.85%, fibre uniformity ratio with its mean value 48.13% and CV as 1.35%, fibre micronaire with its mean value 4 with CV as 2.74%, fibre maturity percentage with its mean value 82.12% and with CV as 0.76%, fibre bundle strength with its mean value 84.15 x 1000 lb (in) 2 with CV as 0.53%, fibre elongation percentage with its mean value 7.3% and CV as 2.88%, cotton colour with its mean value of 67.92 and CV as .72%, trash percentage with its mean value 10.31% and trash count with its mean value 8.2% and CV as 5.21%.

Raw cotton was processed at the blow room, carding and drawing section. The drawing sliver of 0.12 hanks was fed to the open-end machine (Model SE 8, Schlafhorst, Germany). Following are the coding of the variables of the open-end machine for the current study.

| Rotor Diameter | D1=33 mm | D2=40 mm |

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**Draw-off navel type**

N1 = Spiral grooved path with built-in four notches. (KN4R4)

N2 = Built-in four coarsely grooved notches (KN4)

N3 = Built-in finely grooved spiral path (Spiral)

**Yarn Count**

C1 = 10s

C2 = 16s

C3 = 20s

The yarn samples thus fabricated were evaluated for the following parameters.

**Imperfections (thin, thick places & neps)**

Equipment employed was Uster Evenness Tester (UT3), which simultaneously measures the imperfections viz thin, thick places and nepes per thousand meters of yarn. The sensitivity setting for the determination of imperfections was - 50% for thin places, +50% for thick places and +200% for nepes.

**Analysis of data**

The data thus obtained was analysed statistically using three-factor factorial completely randomised design (CRD) for the interpretation of data. Duncan’s new Multiple Range (DMR) was applied for individual comparison of means among the various yarn characteristics as suggested by Faqir (2000) using M. Stat Micro-computer package as devised by Freed (1992).

**Results and discussion**

Open End is a very rapidly developing spinning technique for the production of coarse and medium count yarns. This is so because of its higher productivity, better product quality and profitability. In view of such factors the present research work was initiated to study the effect of multiple Open-End processing variables i.e., yarn count, rotor diameter and draw-off navel type upon the yarn quality. The resultant data presented in these tables is discussed here character-wise along with statistical manipulation.

**Thin places**

The statistical analysis of variance and comparison of individual mean for yarns thin places is shown in table 1a and 1b respectively. The results indicate that the effect of yarn count (C) and rotor diameter (D) were highly significant, while the effect of draw-off navel type was only significant. In case of interactions, the interaction DxNxC was highly significant. However, the interaction DxN was only significant, while the interactions DxC and NxC remained non-significant.

Duncan’s multiple range test (table 1b) for the comparison of individual mean for draw-off navel type revealed highest number of yarn thin places (1.8/km) for N2 (KN4, coarsely grooved) followed by 1.43/km for N1 (KN4R4) and 1.2/km for N3 (spiral, finely grooved). It was evident from the result that N2 and N3 were significantly different. However, N1 was non-significant from both N2 and N3. The result showed that the imperfections increased with the use of coarsely grooved navel and reduced with the use of finely grooved navel type. This finding got full support from the work of Simpson and Patureau (1979) who concluded that yarn spun with a coarsely grooved draw-off navel have more imperfections than those spun with finely grooved draw-off navel.

As regards yarn count the result revealed that the highest value of yarn thin places was 3.1/km for C3(20s) followed by 1.26/km for C2 (16s) and 0.06/km for C1 (10s). The result showed that C1,C2 and C3 significantly differed from each other. It was evident from the result of table 1b that as the yarn count became finer the imperfection increased. Yarn imperfection decreased as the yarn count decreased. Therefore, it was concluded that yarn count and imperfection had a direct relationship. Our present result concluded that yarn spun with a coarsely grooved draw-off navel have more imperfections than those spun with finely grooved draw-off navel.

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>1</td>
<td>1.344</td>
<td>1.344</td>
<td>1.6026</td>
<td>0.0096**</td>
</tr>
<tr>
<td>N</td>
<td>2</td>
<td>5.489</td>
<td>2.744</td>
<td>3.2715</td>
<td>0.0437*</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>140.022</td>
<td>70.011</td>
<td>1.6570</td>
<td>0.0000**</td>
</tr>
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<td>5.756</td>
<td>2.878</td>
<td>3.4305</td>
<td>0.0378</td>
</tr>
<tr>
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<td>0.278</td>
<td>0.331</td>
<td>NS</td>
</tr>
<tr>
<td>NC</td>
<td>4</td>
<td>6.444</td>
<td>1.61</td>
<td>1.9205</td>
<td>0.1162**</td>
</tr>
<tr>
<td>DNC</td>
<td>4</td>
<td>22.444</td>
<td>5.611</td>
<td>6.6887</td>
<td>0.0001**</td>
</tr>
<tr>
<td>Error</td>
<td>72</td>
<td>60.400</td>
<td>0.839</td>
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<td>Total</td>
<td>89</td>
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</table>

Note: ** = Highly significant
* = Significant
NS. Non-significant

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**Table-1b**

**Comparison of individual means for thin places**

<table>
<thead>
<tr>
<th>Navel type</th>
<th>Thin</th>
<th>Count</th>
<th>Thin</th>
<th>Rotor dia</th>
<th>Thin</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>1.43 AB</td>
<td>C1</td>
<td>0.06 A</td>
<td>D1</td>
<td>1.6 B</td>
</tr>
<tr>
<td>N2</td>
<td>1.8 B</td>
<td>C2</td>
<td>1.26 B</td>
<td>D2</td>
<td>1.35 A</td>
</tr>
<tr>
<td>N3</td>
<td>1.2 A</td>
<td>C3</td>
<td>3.1</td>
<td></td>
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</tr>
</tbody>
</table>

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**Table-1 c**

**Comparison of interactions means DxNxC for thin places**

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Any two means not sharing a letter in common differ significantly at α= 0.05
is substantial variation in the number of fibres in the yarn cross section along the length. As the yarn becomes finer the number of fibres in the cross section decreased and the yarn imperfections increased Wirth (1975) remarked that the open-end yarn are more regular, have fewer thick and thin places and have far better weaving and knitting properties. Sheikh (1991) noted that the weakest points in yarn are more important with respect to further processing than a high mean tensile strength. The term yarn fault also indicates particularly big thick places and thin places. These can be characterized to a first approximation by their diameters and length.

As regards rotor diameter table 1b shows that the highest value of yarn thin places was 12.6/km for D2 (40mm) followed by 10.9/km for D1 (33mm). The result revealed that D1 and D2 significantly differed from each other. It was evident from the result that as the rotor diameter increased the yarn imperfection increased. It mean rotor diameter and yarn imperfection had a direct relationship. Manohar et al. (1983) reported that Uster U% imperfections and appearance of the yarn are broadly effected by rotor diameter. Barella et al. (1983) reported that rotor diameter effect yarn imperfections both linearly and quadratically. Booth (1983) defined thick places as fault length of approximately the fibre staple length, having a cross-section of 50% increase over the average value, and thin places as a fault length of approximately the fibre staple length having a cross section approximately 50% less than the average value.

Table 1c depicted the interaction of yarn count, navel type and rotor diameter (CxNxD). Under count 10 density maximum thin places 0.4/km were recorded at the combination of KN4R4 x 33mm and all the rest of the combination gave minimum thin places with a value of 0.0/km. Under count 16 density maximum thin places 1.6/km were recorded for four combinations i.e. KN4R4 x 33mm, KN4 x 33mm, KN4 x 40 mm and spiral x 40 mm and the minimum thin places 0.4/km were recorded at the combination of KN4R4 x 40mm. Under count 20 density maximum thin places 5.2/km were recorded at the combination of KN4 x 33mm and the minimum thin places 2.4/km were recorded at four combinations i.e. KN4R4 x 33mm, KN4 x 40 mm, spiral x 33mm and spiral x 40 mm. KN4 navel produced yarn with maximum thin places for 33 mm rotor diameter. All navel types produce yarn with minimum thin places for both diameters for coarse counts. Overall the worst combination was C3xN2xD1 (20x KN4 x 33mm) with the mean value as 5.2/km.

**Thick places**

The statistical analysis of variance and comparison of individual mean for yarn thick places was shown in table 2a and 2b respectively. The result indicated that the effect of yarn count (C) and rotor diameter (D) were highly significant, while the effect of draw-off navel type was only significant. In case of interactions, the interaction NxC was highly significant. However, the interaction DxNxC and DxN were only significant, while the interaction DxC remained non-significant.

Duncan’s multiple range test (table 2b) for the comparison of individual mean for draw-off navel type revealed that highest yarn thick places (12.87/km) were recorded for N2 (KN4, coarsely grooved) followed by 12.13/km for N1 (KN4R4) and 10.33/km for N3 (spiral, finely grooved). It was evident from the results that N1 and N2 are significantly different from N3. While N1 and N2 are non-significant with respect to each other. The result showed that the thick places increased with the use of coarsely grooved navel and reduced with the use of finely grooved navel type. This finding got the full support from Simpson and

**Table 2a**

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F. value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
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<td>64.178</td>
<td>6.771</td>
<td>6.7714</td>
<td>0.0012**</td>
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<td>5.3787</td>
<td>5.3787</td>
<td>0.0167*</td>
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<tr>
<td>C</td>
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<td>66.2649</td>
<td>66.2649</td>
<td>0.0000**</td>
</tr>
<tr>
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<td>31.244</td>
<td>3.2966</td>
<td>3.2966</td>
<td>0.0427*</td>
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<tr>
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<td>3.244</td>
<td>0.3423</td>
<td>0.0342</td>
<td>NS</td>
</tr>
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<td>NC</td>
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<td>60.378</td>
<td>6.3705</td>
<td>6.3705</td>
<td>0.0002**</td>
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<td>DNC</td>
<td>4</td>
<td>32.111</td>
<td>3.3880</td>
<td>3.3880</td>
<td>0.0135*</td>
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</table>

Error was 72, 9.478 and Total was 89, 2443.556.

Note: ** = Highly significant
* = Significant
N.S. Non-significant

**Table 2b**

<table>
<thead>
<tr>
<th>Navel type</th>
<th>Thick Count</th>
<th>Thick Rotor dia</th>
<th>Thick</th>
</tr>
</thead>
<tbody>
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<td>12.13 B</td>
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</tr>
<tr>
<td>N2</td>
<td>12.87 B</td>
<td>12.73 B</td>
<td>D2</td>
</tr>
<tr>
<td>N3</td>
<td>10.33 A</td>
<td>15.8 C</td>
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**Table 2c**

<table>
<thead>
<tr>
<th>D1</th>
<th>D2</th>
<th>D1</th>
<th>D2</th>
<th>D1</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>5.6 A</td>
<td>5.7 A</td>
<td>13.6 D</td>
<td>17.6 E</td>
<td>11.2 CD</td>
</tr>
<tr>
<td>N2</td>
<td>6 AB</td>
<td>8.4 ABC</td>
<td>12.8 CD</td>
<td>12 CD</td>
<td>19.6 E</td>
</tr>
<tr>
<td>N3</td>
<td>5.7 A</td>
<td>9.6 ABCD</td>
<td>10.4 CD</td>
<td>10 BCD</td>
<td>13.6 D</td>
</tr>
</tbody>
</table>

Note: Any two means not sharing a letter in common differ significantly at α = 0.05.
As regards to the yarn count the result revealed that the highest value of yarn thick places was 15.8/km for C3 (20s), followed by 12.73/km for C2 (16s) and 6.8/km for C1 (10s). The result showed that C1, C2 and C3 significantly differed from each other. It was evident from the result of table 2b that as the yarn count became finer the imperfection increased. Yarn imperfection decreased as the yarn count decreased. Therefore, it was concluded that yarn count and imperfection had a direct relationship. Our present result showed C3 count had the highest value of imperfection, which was the finest from the rest of the counts. Previously similar result was reported by Haque (1998), who concluded that the main cause of imperfection in the spun yarn is substantial variation in the numbers of fibres in the yarn cross section along the length. As the yarn becomes finer the number of fibres in the cross section decreased and the yarn imperfections increased.

As regards rotor diameter table 2b shows that the highest value of yarn thick places was 1.35/km for D2 (40mm) followed by 1.6/km for D1(33mm). The result revealed that D1 and D2 significantly differed from each other. It was evident from the result that as the rotor diameter increased the yarn imperfection increased. It means rotor diameter and yarn imperfection had a direct relationship. Manohar et. al. (1983) reported that Uster U%, imperfections and appearance of the yarn are broadly effected by rotor diameter. Barella et. al. (1983) reported that rotor diameter effect yarn imperfections both linearly and quadratically. Haranhalli (1990) concluded that thick and thin places might be the result of poor sliver quality, high short fibre percentage, insufficient fibre opening and dirt accumulation in rotor. Booth (1983) defined thick places as a fault length of approximately the fibre staple length, having a cross-section of 50% increase over the average value, and thin places as a fault length of approximately the fibre staple length having a cross-section approximately 50% less than the average value.

Table 2c depicted the interaction of yarn count, navel type and rotor diameter (CxNxD). Under count 16s maximum thick places 9.6/km were recorded at the combination of spiral x 40 mm and the minimum thick places 5.6/km were recorded at the combination of KN4R4 x 40 mm. Under count 16s maximum thick places 17.6/km were recorded at the combination of KN4R4 x 40 mm and the minimum thick places 10.0/km were recorded at the combination of spiral x 40 mm. Under count 20s maximum thick places 19.6/km were recorded at the combination of KN4 x 33mm and the minimum thick places 11.2/km were recorded at the combination of KN4R4 x 33mm. KN4R4 navel produced yarn with minimum thick places for both rotor diameters. KN4 navel produced yarn with maximum thick places for 33mm rotor diameter, while KN4R4 navel produced yarn with maximum thick places for 40 mm rotor diameter. Overall best combination was C1xN1xD1 (10s x KN4 x 33mm) and the worst combination was C3xN2xD1 (20s x KN4 x 33mm) with their respective mean values as 5.6/km and 19.6/km.

**Neps**

The statistical analysis of variance and comparison of individual mean for yarn neps was shown in table 3a and 3b respectively. The result indicated that the effect of yarn count (C) and rotor diameter (D) were highly significant, while the effect of draw-off navel type was only significant. In case of interactions, the interactions DxNxC and DxC were highly significant. However, the interactions DxD and NxC remained non-significant.

### Table-3a

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F-value</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
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<td>48,400</td>
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<tr>
<td>C</td>
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<td>16,933</td>
<td>4.1583</td>
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<tr>
<td>D</td>
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<td>250,867</td>
<td>125,433</td>
<td>252,933</td>
<td>62.1119**</td>
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<td>Total</td>
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</tr>
</tbody>
</table>

Note: ** = Highly significant  * = Significant  N.S. = Non-significant

### Table-3b

<table>
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<tr>
<th>Navel type</th>
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<th>Count</th>
<th>Neps</th>
<th>Rotor dia</th>
<th>Neps</th>
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<td>2.6 A</td>
<td>D1</td>
<td>4.4 A</td>
</tr>
<tr>
<td>N2</td>
<td>5.6 B</td>
<td>C2</td>
<td>4.4 B</td>
<td>D</td>
<td>5.8 B</td>
</tr>
<tr>
<td>N3</td>
<td>4.2 A</td>
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<td>8.3 C</td>
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### Table 3c

<table>
<thead>
<tr>
<th>Comparison of interaction means DxNxC for neps</th>
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</thead>
<tbody>
<tr>
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<td>N1</td>
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<tr>
<td>N2</td>
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<td>N3</td>
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</tbody>
</table>

Note: Any two means not sharing a letter in common differ significantly at α= 0.05.
Duncan’s multiple range test (table 3b) for the comparison of individual mean for draw-off navel type revealed that highest yarn neps (5.6/km) were recorded for N2 (KN4, coarsely grooved) followed by 5.53/km for N1 (KN4R4) and 4.26/km for N3 (spiral finely grooved). It was evident that N1 and N2 were significantly different from N3, while N1 and N2 were non-significant with respect to each other. The result showed that the imperfection increased with the use of coarsely grooved navel and reduced with the use of finely grooved navel type. This finding got full support from Simpson and Patureau (1979) who also concluded that yarn spun with a coarsely grooved draw-off navel have more imperfections than those spun with finely grooved draw-off navel.

As regards yarn count the result revealed that the highest value of yarn neps was 8.33/km for C3 (20s) followed by 4.4/km for C2 (16s) and 2.6/km for C1 (10s). The counts C1, C2 and C3 significantly differed from each other. It was evident from the result of table 1b that as the yarn count became finer the imperfections increased. Therefore, it was concluded that yarn count and imperfection had a direct relationship. Our present result showed C3 count had the highest value of imperfections, which was the finest from the rest of the counts. Previously similar result was reported by Haque (1998) who concluded that the main cause of imperfection in the spun yarn is substantial variation in the numbers of fibres in the yarn cross section along the length. As the yarn becomes finer the number of fibres in the cross section decreased and the yarn imperfections increased. Douglas (1989) also concluded that the yarn imperfection depends upon yarn count.

As regards rotor diameter table 1b showed that the highest value of yarn neps was 5.86/km for D2 (40mm) followed by 4.4/km for D1 (33mm). The result revealed that D1 and D2 significantly differed from each other. It was evident from the result that as the rotor diameter increased the yarn neps also increased. It means rotor diameter and yarn neps had a direct relationship. Present result got support from Kampen et al. (1979) who reported that the proportion of wrapper fibres come down with increased rotor diameter but the number of wraps per unit length increases, therefore, there is an increase number of neps in Uster. Likewise Manohar et al. (1983) reported that Uster U% imperfections and appearance of the yarn are broadly effected by Rotor diameter. Barella et al (1983) reported that rotor diameter effects yarn imperfections both linearly and quadratically.

Table 3c showed the interaction of yarn count, navel type and rotor diameter (CxNxD). Under count 10s maximum neps (4.4/km) were recorded at the combination of KN4R4 and 33mm rotor diameter and the minimum neps (1.6/km) were recorded at the combination of spiral x rotor dia 33 mm. Under count 16s maximum neps (5.2/km) were recorded at the combination of KN4 x 40mm and the minimum neps (2.8/km) were recorded at the combination of spiral x 40mm. Under count 20s maximum neps (12.8/km) were recorded at the combination of KN4R4 x 40mm and the minimum neps (4.0/km) were recorded at the combination of KN4R4 x 33mm. Spiral navel produced yarn with minimum neps for 33 mm rotor diameter, while KN4R4 and KN4 navel produced yarn with minimum neps for 40mm rotor diameter. KN4 navel produced yarn with maximum neps for 33mm rotor diameter, while KN4R4 navel produced yarn with maximum neps for 40mm rotor diameter. Overall best combination was (C1xN3xD1) and the worst combination was achieved while using 33mm O.E. rotor with spiral navel for 10s carded yarn (C3xN1xD2) (20s x KN4R4 x 40 mm) with their respective mean values as (1.6/km and 12.8/km).

**Literature cited**


