Effect of fiber blending ratios of cotton/polyester yarns on retained splice diameter

H İ Çelik and H K Kaynak
Gaziantep University, Faculty of Engineering, Textile Engineering Department, 27310 Gaziantep / Turkey
Email: hcelik@gantep.edu.tr

Abstract. The most important performance parameters of splicing are obtaining adequate strength and appearance at the splice point for all processing requirements. The diameter of spliced portion effects not only appearance of the splice joints but also physical characteristics such as packing density, strength, specific volume of the yarn. In this study, the effect of cotton/polyester fiber blend ratios on spliced portion diameter at different slicing air pressures was investigated. For this aim, three yarn samples 100% cotton, 80-20% CO-PES and 50-50% CO-PES were produced with 40/1 Ne. Each yarn samples was spliced at three different pressures; 4 bar, 5 bar and 6 bar. The diameters of spliced portion and retained yarns were measured by using ImageJ program and the results were analyzed statistically.

1. Introduction

Yarn winding is the process of transferring yarn from bobbins to packages to facilitate in the subsequent processes of warping, weaving and knitting. In this process, both the yarn ends are joined together to provide the continuity of the yarn package and several yarn faults; neps, thin place, thick place are removed. Thus, more uniform yarn mass distribution and higher yarn evenness properties are obtained. The yarn ends are joined together by applying a blast of compressed air into a profiled device called a splicing chamber. The most important performance parameters of splicing are obtaining adequate strength and appearance at the splice point for all processing requirements. The diameter of spliced portion effects not only appearance of the splice joints but also physical characteristics such as packing density, strength, specific volume etc. Yarn diameter is an important property which affects the physical properties of the end products. Variations in yarn diameter cause undesirable effects such as imperfections in the knitted or woven fabric and difficulties in weaving preparation stages.

In literature some studies have been performed on the effect of splicing parameters such as splicing length, duration of splicing air blast, and splicing air pressure on strength and appearance of the spliced yarns [1-13]. Gürkan et al. have been investigated the effect of both fiber characteristics and splicing parameters on retained spliced diameter [11, 12]. In these studies, yarn samples with different types of cotton fibers have been produced and applied splicing process.

In literature, there is very limited study on effect of yarn blending ratio on spliced portion diameter at different slicing air pressures [14]. With the development in technology and human life standards, the consumer demands from a product increases day by day. In order to satisfy the requirements, the fiber blends are used with different ratios to benefit from the specific characteristic of fibers. Each
fiber has its own specific mechanical and chemical properties. The fiber characteristic properties such as length, bending, resilience, elasticity etc. determines the yarn properties. It is claimed that since the splicing process is based on the snarling of the fibers in yarn structure because of pressurized air, the splice joint diameter and spliced yarn strength will be affected by the fiber characteristics.

In this study, it is aimed to investigate the effect of fiber blend ratio on spliced portion diameter at different slicing air pressures. For this aim, three yarn samples 100% cotton, 80-20% CO-PES and 50-50% CO-PES are produced with 40/1 Ne. Each yarn samples are spliced at three different pressures; 4 bar, 5 bar and 6 bar. The images of the yarn samples are acquired. The diameters of spliced portion and retained yarns are measured on the images of the spiced yarns.

2. Material and Method

2.1 Material

For this study, 40/1 Ne cotton-polyester (CO/PES) ring spun yarn samples of 100% cotton and with two different blending ratios; 80/20% CO-PES and 50/50% CO-PES are produced (Table 1). The spliced yarns are produced by using these sample yarns under three different splicing pressures; 4 bar, 5 bar and 6 bar. Other splicing machine parameters are kept constant. Thus, totally 9 different spliced yarn samples are produced.

| Sample       | Fiber Content       | U (%) | CVm (%) | Thin Place (-50%/km) | Thick Place (+50%/km) | Neps (+200%/km) | H      |
|--------------|---------------------|-------|---------|----------------------|-----------------------|----------------|--------|
| 100% CO      | 100% Cotton         | 10.82 | 13.65   | 3.3                  | 35.8                  | 83.3           | 5.68   |
| 80-20% CO-PES| 80-20% Cotton-Polyester | 12.23 | 15.46   | 18.3                 | 136.7                 | 163.3          | 5.48   |
| 50-50% CO-PES| 50-50% Cotton-Polyester | 11.56 | 14.63   | 6.7                  | 102.5                 | 146.7          | 4.96   |

2.2 Method

The yarn samples given in Table 1 are applied air splice process by using Leopfe YarnMaster Machine. Three different air pressure; 4 bar, 5 bar and 6 bar are applied for each yarn sample. The diameter of the parent yarns and splice portion are measured by means of image frames. The image frames of the spliced yarn samples are acquired by using scanner with 1200 dpi resolution. The diameter of the parent yarn and spliced portion are measured by using ImageJ program. In this program, known length of the scale in pixel is set to a unit such as; cm, mm. In this, study pixel-mm conversion is used. For each pressure value, 5 spliced yarn samples are produced. From each spliced yarn sample, 10 diameter measurements are taken. The average diameters of the spliced portion and the corresponding parent yarns are calculated by using 50 readings of each sample. The percent of the increase in the splice joint diameter is calculated with following equation.

$$\Delta D(\%) = \frac{D_s - D_p}{D_p} \times 100$$

where,
- $D_s$: is the diameter of spliced portion,
- $D_p$: is the diameter of parent yarn,
- $\Delta D$: is the change in diameter of the spliced portion with respect to the diameter of parent yarns in percentage.
3. Result and Discussion

The yarn diameter increases due to the splice process are given with respect to the splice pressure in Figure 2. The highest and the lowest increases are obtained with 50-50% CO-PES sample at 4 bar and 6 bar splice pressures respectively. As polyester ratio of the yarn content is increased, the diameter of the splice portion has increased with respect to the diameter of parent yarn at 4 and 5 bar splice pressures. This situation reverses for 6 bar splice pressure. For 6 bar pressure, the diameter increment ratio of the splice portion decreases when the polyester content of the yarn sample is increased. The yarn sample 100% CO has got a concave upward trend as the splice pressure is increased. The yarn sample 80-20% CO-PES has got a concave downward trend in accordance to the pressure increase. The diameter increment of the sample 50-50% CO-PES is decreasing as the splice pressure is increased.

It is required that the yarn diameter increase should be at minimum level in term of appearance performance of the splice process. When only the appearance performance of the splice process is taken into account, it can be said that the most appropriate splice pressures for each yarn samples; 100% CO, 80-20% CO-PES and 50-50% CO-PES are 5 bar, 6 bar and 6 bar respectively.
In order to determine the statistical significance of the effects of splice pressure and yarn blend on spliced yarn diameter ANOVA was performed. For this aim the statistical software package SPSS 21.0 was used to interpret the experimental data. All test results were assessed in 95% confidence interval.

**Table 2.** ANOVA for yarn diameter.

| Source          | Sum of Squares | df | Mean Square | F       | Sig. | Partial Eta Squared |
|-----------------|----------------|----|-------------|---------|------|---------------------|
| Corrected Model | 1.911^a        | 8  | 0.239       | 18.93   | 0.0  | 0.256               |
| Intercept       | 13.488         | 1  | 13.488      | 1068.962| 0.0  | 0.708               |
| Pressure        | 0.497          | 2  | 0.248       | 19.68   | 0.0  | 0.082               |
| Yarntype        | 0.120          | 2  | 0.060       | 4.767   | 0.0  | 0.021               |
| Pressure*Yarntype | 1.294        | 4  | 0.324       | 25.64   | 0.0  | 0.189               |
| Error           | 5.565          | 441| 0.013       |         |      |                     |
| Total           | 20.964         | 450| 0.013       |         |      |                     |
| Corrected Total | 7.476          | 449|             |         |      |                     |

^a R Squared = 0.256 (Adjusted R Squared = 0.242)
According to ANOVA results, splice pressure and yarn type has statistically significant effects on spliced yarn diameter (p=0.000<0.05, p=0.009<0.05). Table 3 and 4 represents the multiple comparison test results for splice pressure and yarn type.

Table 3. Multiple comparison results for splice pressure.

| Tukey HSD | Bar | Bar | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | Lower Bound | Upper Bound |
|----------|-----|-----|-----------------------|------------|------|-------------------------|-------------|-------------|
|          | 4.00| 5.00| 0.0313*               | 0.01297    | 0.043| 0.0008                 | 0.0502      | 0.1118      |
|          |     | 6.00| 0.0807*               | 0.01297    | 0.000| -                      | -           | -           |
|          | 5.00| 4.00| -0.0313*              | 0.01297    | 0.043| 0.0618                 | 0.0008      | 0.0799      |
|          |     | 6.00| 0.0494*               | 0.01297    | 0.000| 0.1112                 | 0.0502      | 0.1112      |
|          | 6.00| 4.00| -0.0807*              | 0.01297    | 0.000| 0.0799                 | 0.0189      | 0.0189      |
|          | 5.00|     | -0.0494*              | 0.01297    | 0.000| -                      | -           | -           |

*The mean difference is significant at the 0.05 level.

Table 4. Multiple comparison results for blend type.

| Tukey HSD | Yarn Type | Yarn Type | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | Lower Bound | Upper Bound |
|----------|-----------|-----------|-----------------------|------------|------|-------------------------|-------------|-------------|
|          | 100% CO   | 50-50% CO-PES | -0.0338*            | 0.01297    | 0.0  | -                      | -           | -           |
|          | 80-20% CO-PES | 50-50% CO-PES | 0.0338*            | 0.01297    | 0.0  | 0.0033                 | 0.0033      | 0.0033      |
|          | 50-50% CO-PES | 100% CO    | 0.0017               | 0.01297    | 0.9  | -                      | -           | -           |
|          | 80-20% CO-PES | 100% CO    | -0.0017              | 0.01297    | 0.9  | 0.00322                | 0.00322     | 0.00322     |
|          | 80-20% CO-PES | 50-50% CO-PES | 0.0017               | 0.01297    | .99  | -                      | -           | -           |

* The mean difference is significant at the 0.05 level.

According to multiple comparison test results for splice pressure, each pressure level (4, 5, 6 bar) has statistically different effects on spliced yarn diameter, in 95% confidence interval. On the other hand, 50-50% CO-PES and 80-20% CO-PES blend types have statistically similar effect on the diameter of spliced yarn. But 100% CO yarn statistically differs from 50-50% CO-PES and 80-20% CO-PES blend types.
4. Conclusion
In this study, the effect of cotton-polyester fiber blending ratio on splice portion appearance performance was investigated. It can be said that the optimum splice pressure for the most appropriate splice appearance changes with respect to the fiber content of the yarn. For 4 and 5 bar splice air pressures, as polyester ratio of the yarn content was increased, the diameter of the splice portion also increased with respect to the diameter of parent yarn. For 6 bar air pressure, the splice joint diameter decreases with the increase in polyester content of the yarn samples.

According to statistical analysis results, it can be revealed that the splice pressure and yarn fiber content have statistically significant effects on spliced yarn diameter. On the other hand, it can also be concluded that each pressure level has statistically different effects on spliced yarn diameter. With respect to the fiber blend ratio, 50-50% CO-PES and 80-20% CO-PES blend types have statistically similar effect on the diameter of spliced yarn. But 100% CO yarn statistically differs from 50-50% CO-PES and 80-20% CO-PES blend types.

Acknowledgement
Authors thank to Kara Holding textile mill for supplying yarn samples and to Gür İplik company for producing spliced yarns.

References
[1] Das A, Ishtiaque S M, Parida J R 2005 Effect of fiber friction, yarn twist, and splicing air pressure on yarn splicing performance Fibers and Polymers 6 1 pp 72–78
[2] Hassen M B, Jaouachi B, Sahnoun M, Sakli F 2008 Mechanical properties and appearance of wet-spliced cotton/elastane yarns The Journal of The Textile Institute 99:2 pp 119–123
[3] Jaouachi B, Hassen M B, Sahnoun M, Sakli F 2010 Evaluation of wet pneumatically spliced elastic denim yarns with fuzzy theory The Journal of The Textile Institute 101 2 pp 111–119
[4] Webb C J, Waters G T, Thomas A J, Liu G P, Thomas E J C 2009 Optimising splicing parameters for splice aesthetics for a continuous filament synthetic yarn The Journal of The Textile Institute 100:2 pp 141–151
[5] Webb C J, Waters G T, Liu G P, Thomas C 2009 The influence of yarn count on the splicing of simple continuous filament synthetic yarns Textile Research Journal 79 3 pp 195–204
[6] Das A, Ishtiaque S M, Parmar S K 2012 Study on spliced yarns of different spinning technologies. Part I: tensile characteristics The Journal of The Textile Institute 103 3 pp 244–255
[7] Das A, Ishtiaque S M, Parmar S K 2012 Study on spliced yarns of different spinning technologies. Part II: structural characteristics The Journal of The Textile Institute 103 3 pp 256–268
[8] Cheng K P S, Lam H L I 2000 Strength of pneumatic spliced polyester/cotton ring spun yarns Textile Research Journal 70 3 pp 243–246
[9] Cheng K P S, Lam H L I 2000 Physical properties of pneumatically spliced cotton ring spun yarns Textile Research Journal 70 12 pp 1053–1057
[10] Cheng K P S, Lam H L I 2003 Evaluating and comparing the physical properties of spliced yarns by regression and neural network techniques Textile Research Journal 73 2 pp 161–164
[11] Ünal P G, Özdíl N, Taşkın C 2010 The effect of fiber properties on the characteristics of spliced yarns part I: prediction of spliced yarns tensile properties Textile Research Journal 80 5 pp 429–438
[12] Ünal P G, Özdíl N, Taşkın C 2009 The effect of fiber properties on the characteristics of spliced yarns: part II: prediction of retained spliced diameter Textile Research Journal 80 17 pp 1751–1758
[13] Webb C J, Waters G T, Thomas A J, Liu G P, Thomas C 2007 The use of the Taguchi design of
eperiment method in optimizing splicing conditions for a Nylon 66 yarn, The Journal of
The Textile Institute 98:4 pp 327–336

[14] Moqee A, Jabb A, Hussain T, Ali Z, Haq Z U 2013 Influence of splicing parameters on
retained splice strength, elongation and appearance of spliced cotton/flax blended yarn
Indian Journal of Fiber & Textile Research 38 March pp 74–80