The effects of core material parameters on the mechanical properties of double core and single core spun yarns

T Bedez Ute¹ and H Kadoglu¹
¹Ege University, Department of Textile Engineering, İzmir, Türkiye

tuba.bedez@ege.edu.tr

Abstract
Comfort and aesthetic appearance are the basic features that consumers expect from their clothes. For improving body movement comfort in apparel, elastic core-spun yarns can be used to produce elasticity of the woven and knitted fabrics. In this study, the effects of elastane linear density on the mechanical properties of double core and single core yarns, spun with different core materials, were investigated. According to statistical evaluations, significant differences were found between yarn properties.

1. Introduction
Consumers want to feel comfortable as well as they want their clothes to look good. While improving the aesthetic appearance of the garments is of interest to fashion designers, it is the focus of textile engineers to enhance comfort. For improving body movement comfort in apparel, elastic core-spun yarns can be used to produce elasticity of the woven and knitted fabrics. In these yarns, elastane as the core is covered with staple fibres. On the other hand, bagging which is a three dimensional fabric deformation, is an undesirable appearance of fabrics [1]. The lack of dimensional stability or recovery after prolonged or repeated pressure on the fabrics causes bagging deformation [2]. In recent years, double core yarns have begun to be produced, especially for denim jeans to overcome the mentioned problem.

Core-spun yarns consist of at least two different components; a staple sheath and a filament core [3]. While, double-core (dual-core) yarns made of three components; an elastic polyurethane filament (such as Lycra®, Creora® or Inviya® I-300) and a multifilament (such as Lycra® T400®) are used in the core, covered by a staple sheath. Double-core yarns are used for high quality denim fabrics [4].

Many researchers have been focused on core-spun and elastic yarns’ properties [5-7]. Sarıoğlu and Babaarslan investigated the fatigue behavior of rigid core-spun yarn structure containing PET textured filament yarn (PET DTY) with respect to different filament fineness and yarn count [8]. Celik and Kaynak examined the effects of elastane draw ratio on air permeability of denim woven fabrics [9]. Ertaş et al [10] analyzed the effect of the density changes in the use of the double-core threads used in denim fabrics. Telli et al, focused on the usage of core and double-core yarns containing tungsten for electromagnetic shielding [11]. Qadir et al. investigated the effects of elastane linear density and draft ratio on the physical and mechanical properties of single core-spun yarns. According to literature survey, elastic material parameters of the double core spun yarns have not be investigated previously.

2. Experimental
In this study, the effects of elastane linear density and elastane type on the properties of double core and single core yarns, spun with different core materials, were investigated. The performance characteristics of the two most widely used elastane types in the market, expressed as elastan A and
elastane B, have also been examined. For this purpose 44 dtex, 78 dtex and 117 dtex elastane filaments were used in the production of elastic core spun yarns. Elastic core spun yarns containing single core will be referred to as "soft core" in this article. Besides, 55 dtex polyester (PES) or 55 dtex elastomultiester (EME) filaments were used for accompanying elastane in double core spun yarn production. Additionally, PES or EME containing core spun yarns produced without using elastane will be referred to as "rigid core". Sheath material was cotton for all yarn types.

Yarns were spun in the same yarn count and twist coefficient (Ne 18, α 4,2) on a ring spinning frame. Yarn samples were conditioned under standard atmospheric conditions, thereafter basic yarn characteristics such as evenness, imperfections, hairiness, breaking strength and breaking elongation, were tested. Yarn uniformity, the IPI values and yarn hairiness were measured on Uster Tester 5, tensile properties were measured with Uster Tensorapid 4.

|                    | Rigid core material | Elastik Core material | Elastan dtex | Yarn unevenness CVm (%) | Number of thin places (-50%) | Number of thick places (+50%) | Number of nep (+200%) | Yarn hairiness (H) |
|--------------------|---------------------|-----------------------|--------------|-------------------------|------------------------------|-------------------------------|---------------------|-------------------|
| Single core yarn   | PES                 | -                     | 10,91        | 0,00                    | 20,00                        | 17,50                         | 5,69                |
|                    | EME                 | -                     | 10,20        | 0,00                    | 8,75                         | 12,50                         | 5,82                |
|                    | - Elastan A 44      | 10,68                 | 0,00         | 13,75                   | 16,25                        | 6,22                          |
|                    | - Elastan A 78      | 10,51                 | 0,00         | 9,38                    | 10,63                        | 5,97                          |
| Soft core yarn     | -                  | Elastan A 117         | 10,56        | 0,50                    | 10,50                        | 5,05                          | 6,13                |
|                    | - Elastan B 44      | 10,62                 | 0,00         | 6,25                    | 10,63                        | 5,79                          |
|                    | - Elastan B 78      | 10,15                 | 0,00         | 8,75                    | 9,38                         | 6,23                          |
|                    | - Elastan B 117     | 10,68                 | 0,00         | 18,75                   | 12,50                        | 6,45                          |
|                    | EME                 | Elastan A 44          | 9,97         | 0,00                    | 6,25                         | 11,88                         | 5,54                |
|                    | EME                 | Elastan A 78          | 9,24         | 0,00                    | 2,50                         | 8,75                          | 5,04                |
|                    | EME                 | Elastan A 117         | 8,85         | 0,00                    | 4,38                         | 6,88                          | 5,41                |
|                    | EME                 | Elastan B 44          | 9,47         | 0,00                    | 7,00                         | 11,00                         | 5,64                |
|                    | EME                 | Elastan B 78          | 9,90         | 0,00                    | 8,75                         | 5,63                          | 5,94                |
|                    | EME                 | Elastan B 117         | 9,59         | 0,00                    | 6,88                         | 6,88                          | 5,81                |
|                    | PES                 | Elastan A 44          | 10,24        | 0,00                    | 15,00                        | 15,00                         | 5,88                |
| Double core        | PES                 | Elastan A 78          | 10,22        | 0,00                    | 13,13                        | 13,75                         | 5,86                |
|                    | PES                 | Elastan A 117         | 9,68         | 0,00                    | 6,25                         | 9,38                          | 5,67                |
|                    | PES                 | Elastan B 44          | 10,72        | 0,00                    | 17,50                        | 16,88                         | 5,72                |
|                    | PES                 | Elastan B 78          | 10,40        | 0,00                    | 16,25                        | 14,38                         | 5,65                |
|                    | PES                 | Elastan B 117         | 9,81         | 0,00                    | 9,38                         | 10,63                         | 5,82                |

Test results, given in Table 1, were evaluated statistically with SPSS software. With the aim of determining the statistical importance of the differences between the yarn characteristics, ANOVA (Analysis of variance) was performed. F values were obtained from analysis of variance and their statistically significance were evaluated (p>0,05).

3. Results
The effects of elastane type, elastane linear density and different core materials on the properties of core spun yarns on the yarn evenness, yarn hairiness, breaking strength and elongation results are given in Figure 1.
Figure 1. Yarn unevenness, yarn hairiness, breaking strength and elongation values of the single and double core spun yarns.

According to test results and statistical evaluations, it is found that yarn evenness decreases with the increase of elastane thickness. Dual core spun yarns have lower yarn unevenness values than single core spun yarns, including both soft core and rigid core spun yarns. These are thought to be caused by the decrease in the amount of sheath cotton fibre. Dual core yarns produced with 117 dtex elastane A and B have the lowest unevenness values whereas dual core spun yarns produced with 44 dtex elastane or rigid core spun yarns had the highest unevenness values. Yarns containing elastane A showed lower unevenness values than the yarns containing elastan B, in general. Soft core yarns produced with only elastane have the highest Uster CV% values whereas, dual core yarns produced with EME and elastane yarns showed the lowest unevenness values compared to others.

In terms of yarn hairiness, as a result of higher fibre movement, soft core yarns have higher hairiness values than rigid core and double core spun yarns. EME containing double core yarns showed lower hairiness values than PES containing yarns. It is found that the effect of elastane thickness on yarn hairiness was not statistically significant in general.

It is found that the breaking strength and yarn unevenness of the core spun yarns were decreased while breaking elongation values increase with the increase of the elastane thickness. For 44 dtex and 78 dtex fineness, elastane A caused higher elongation but lower breaking strength compared to elastane B. On the other hand, 117 dtex elastane B showed statistically the highest elongation values for both PES and EME containing double core spun yarns (Table 2) and also single cored elastic yarns.

Table 2. Student-Newman-Keuls (SNK) post-hoc results for yarn elongation at break (effect of elastane)

| 1st core material | 2nd core material-PES | 2nd core material-EME |
|-------------------|-----------------------|-----------------------|
| (rigid core)      |                       |                       |
| Elastane B-44dtx  | 8,12                  | Elastane A-44dtx      | 10,25 |
| Elastane B-78dtx  | 10,23                 | Elastane A-78dtx      | 10,27 |
| Elastane A-44dtx  | 10,50                 | Elastane B-44dtx      | 10,41 |
| Elastane A-78dtx  | 11,08                 | Elastane A-117dtx     | 11,64 |
| Elastane A-117dtx | 12,58                 | Elastane B-78dtx      | 11,65 |
| Elastane B-117dtx | 13,20                 | Elastane B-117dtx     | 12,81 |

Sig. 1.0 1.0 0.32 1.00 1.00 1.00 Sig. <0.058 0.174 0.151
Double core yarns have been observed to have higher elongation values, independent of the elastane brand and thickness, than single core yarns. In terms of hard core materials, PES containing double core yarns have higher elongation and strength values than EME containing double core yarns, in general.

Table 3. Student-Newman-Keuls (SNK) post-hoc results for yarn elongation at break (effect of rigid core material)

|          | 44 dtex  | 78 dtex  | 117 dtex |
|----------|----------|----------|----------|
|          | 1        | 2        | 3        | 1        | 2        | 3        | 1        | 2        | 3        |
| Elastane A |          |          |          |          |          |          |          |          |          |
| Soft core | 8,74     | 8,24     | 9,50     |          |          |          |          |          |          |
| EME       | 10,25    | 10,27    | 11,64    |          |          |          |          |          |          |
| EME       | 10,50    | 11,08    |          |          |          |          |          |          |          |
| Sig.      | 1,00     | 1,00     | 1,00     | 1,00     | 1,00     | 1,00     |          |          |          |
| Elastane B |          |          |          |          |          |          |          |          |          |
| Soft core | 8,84     | 8,69     | 11,12    |          |          |          |          |          |          |
| PES       | 9,52     | 10,23    | 12,81    |          |          |          |          |          |          |
| EME       | 10,41    | 11,65    | 13,20    |          |          |          |          |          |          |
| Sig.      | 1,00     | 1,00     | 0,59     |          |          |          |          |          |          |

According to Table 3, soft core yarns produced with only elastane had statistically significantly lower breaking elongation values than elastic double core spun for both elastane A and B for all elastane thicknesses. On the other hand PES containing double core yarns have the highest elongation values when elastane A is used whereas EME containing double core yarns have the highest elongation values when elastane B is used.

4. Conclusion

Nowadays, consumers are increasingly demanding products with improved elasticity as well as reduced bagging problems. For this reason, double core yarns, especially for denim jeans, are of interest. In this study, the effects of elastane linear density and elastane type on the properties of double core and single core yarns, spun with different core materials, were investigated. It is found that the type core materials and the thickness of the materials have significant effects on yarn properties.

Acknowledgments

We would like to present our thanks to the Scientific and Technological Research Council of Turkey-TÜBİTAK, Project number: 116M687 for its financial support. A special thanks to Mesut Çelik from Orta Anadolu Tekstil for yarn spinning.

References

[1] Şengöz N G 2004 Bagging in textiles Textile Progress 36 1 pp 1-64
[2] Uçar N Realff M L Radhakrishniah and P Ucar M 2002 Objective and subjective analysis of knitted fabric bagging Textile Research Journal 72 11 pp 977-982
[3] Technical Document 2006 Producing Core-Spun Yarns Containing Lycra® Elastane Fiber Invista February
[4] http://www.tekstilteknik.com.tr/fashionable-dual-core-yarnsperefectly-spliced-wound/ (Available on 25.06.2017)
[5] Su C and Yang H 2004 Structure and Elasticity of Fine Elastomeric Yarns Textile Research Journal 74 12 pp 1041-1044
[6] Su C I Maa M C and Yang H Y 2004 Structure and performance of elastic core-spun yarn Textile Research Journal 74 7 pp 607-610
[7] Babaarslan O 2001 Method of Producing a Polyester/Viscose Core-Spun Yarn Containing Spandex Using a Modified Ring Spinning Frame Textile Research Journal 71 4 pp 367-371
[8] Sarıoğlu E and Babaarslan O 2017 Fatigue behaviour of core-spun yarns containing filament by means of cyclic dynamic loading *Autex 2017 Greece*

[9] Çelik H İ and Kaynak H K 2017 An investigation on effect of elastane draw ratio on air permeability of denim fabrics *Autex 2017 Greece*

[10] Ertaş O G Ünal B Z and Çelik N 2016 Analyzing the effect of the elastane-containing dual-core weft yarn density on the denim fabric performance properties *The Journal of The Textile Institute* 107, 1 pp 116–126

[11] Telli A Daşan Y Babaarslan O and Karaduman S 2017 Usage of Core and Dual-Core Yarns Containing Tungsten for Electromagnetic Shielding *Advance Research in Textile Engineering* 21 p1013

[12] Qadir M B Hussain T Malik M Ahmad F and Jeong S H 2014 Effect of elastane linear density and draft ratio on the physical and mechanical properties of core-spun cotton yarns *The Journal of The Textile Institute* 105 7 pp 753-759