Effect of process variables on the properties of dual-core yarns containing wool/elastane

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REZUMAT – ABSTRACT

Efectul variabilelor de process asupra proprietăților firelor cu miez dublu care conțin lână/elastan

Denimul, cu un număr mare de utilizatori, indiferent de vârstă, sex și statut social, a fost unul dintre cele mai importante produse pentru sectorul îmbrăcăminte. Cererea de țesătură denim s-a diversificat odată cu schimbarea stilului de viață al consumatorului. Producătorii de denim dezvoltă tehnici și materiale de producție alternative prin aplicarea de noi cercetări pentru a se adapta cerințelor consumatorilor. Unul dintre materialele alternative utilizate în structura țesăturilor denim este firul cu miez dublu. Firul cu miez dublu este fabricat cu mașina de filat cu inele modificată, pentru a beneficia de proprietățile miezului dublu. În acest studio este investigată influența unor parametri de producție, cum ar fi: nivelul de torsiune, etirarea lanai și etirarea elastanului asupra proprietăților firelor cu miez dublu care conțin lână/elastan. Rezultatele au arătat că nivelul de torsiune este un parametru important pentru valorile neuniformității, pilozității, tenacității și alungirii firelor cu miez dublu. În plus, etirarea lanai este un parametru semnificativ pentru valorile pilozității și alungirii la rupere. De asemenea, s-a observant că variația nivelului de etirare al elastanului afectează valorile tenacității și alungirii firelor cu miez dublu.

Cuvinte-cheie: filat cu miez, fir cu miez dublu, fir de lână, elastan, țesătură denim

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The denim, having a large customer base irrelevant of age, gender and social status limitation, has been one of the most important products for thegarment sector. Denim fabric demand has diversified with the changing consumer's sense of life day by day. The denim manufacturers develop alternative production techniques and materials by turning towards new researches in order to adapt to consumer demands. One of the alternative materials, which are used in denim fabric structure, is the dual-core yarns. The dual-core yarn is manufactured through the modified ring-spinning machine in order to benefit at the same time from the properties of two core components. In this study the influence of some production parameters such as twist level, wool draft and elastane draft on the properties of dual-core yarns containing wool/elastane is investigated.The results indicated that the twist level is significantly effective parameter for the unevenness, hairiness, tenacity and elongation values of dual-core yarns. In addition, wool draft is significantly effective parameter for hairiness and breaking elongation values. It was also observed that variation of elastane draft level affects tenacity and elongation values of dual-core yarns.

Keywords: core-spun, dual-core yarn, wool yarn, elastane, denim fabric

INTRODUCTION

Denim fabric has become a crucial part of fabric production sector since it has been used extensively by people of all ages, classes and genders. Moreover, customers' requirement for the aesthetic and functional performance of denim is increasing with each passing day, which has led to the use of different types of materials and finishing treatments.

Stretch denims are products used for function and at the same time fashion as well. The stretch property is gainedwith core spun wefts which contain elastane filament in denim fabric structure. Core-spun yarn spinning is a process defined as the twisting the staple fibres around the core yarn, which is either filament or staple spun yarn [1]. The produced yarn has the sheath-core structure. Elastane filament is a manufactured filament in which the filament-forming substance is along chain synthetic polymer comprised of at least 85% by weight of segmented polyurethane [2].

Core spun yarns containing elastane which has low modules, gain easy stretch properties to the denim fabrics. However denim fabric consumers also demand the high recovery power and low fabric growth besides easy stretch properties. In order to meet the consumer demand another core yarn which has high tension modules compare to the elastane, is required. Hereby, PET, PA, T400, PBT etc. and elastane are usually used together as the core part in order to benefit from the properties of two different core components at the same time. For the production of this kind of multi-component core-spun yarn, PET, PA, T400, PBT etc. (1st core) and elastane (2nd core) are fed separately to the drafting unit of ring spinning machine and this system is called dual-core method [3].

There are limited studies about dual-core yarns in the literature. Material contentand production parameters are two important factors which affect the performances of dual-core spun yarns [4–8]. In order to give different performance characteristics to denim

fabrics, various core spun yarns can be used in denim fabric structure. In this study, dual-core spun yarns which consist of wool yarn as the first core and elastane filament as the second core were produced to benefit tactile and thermal effects of wool fibers and stretch effects of elastane filament at the same time, with a novel approach. The purpose of this study was to examine the influence of production parameters such as twist level, wool draft and elastane draft on the various properties of thisnovel dual-core spun yarns.

MATERIALS AND METHODS

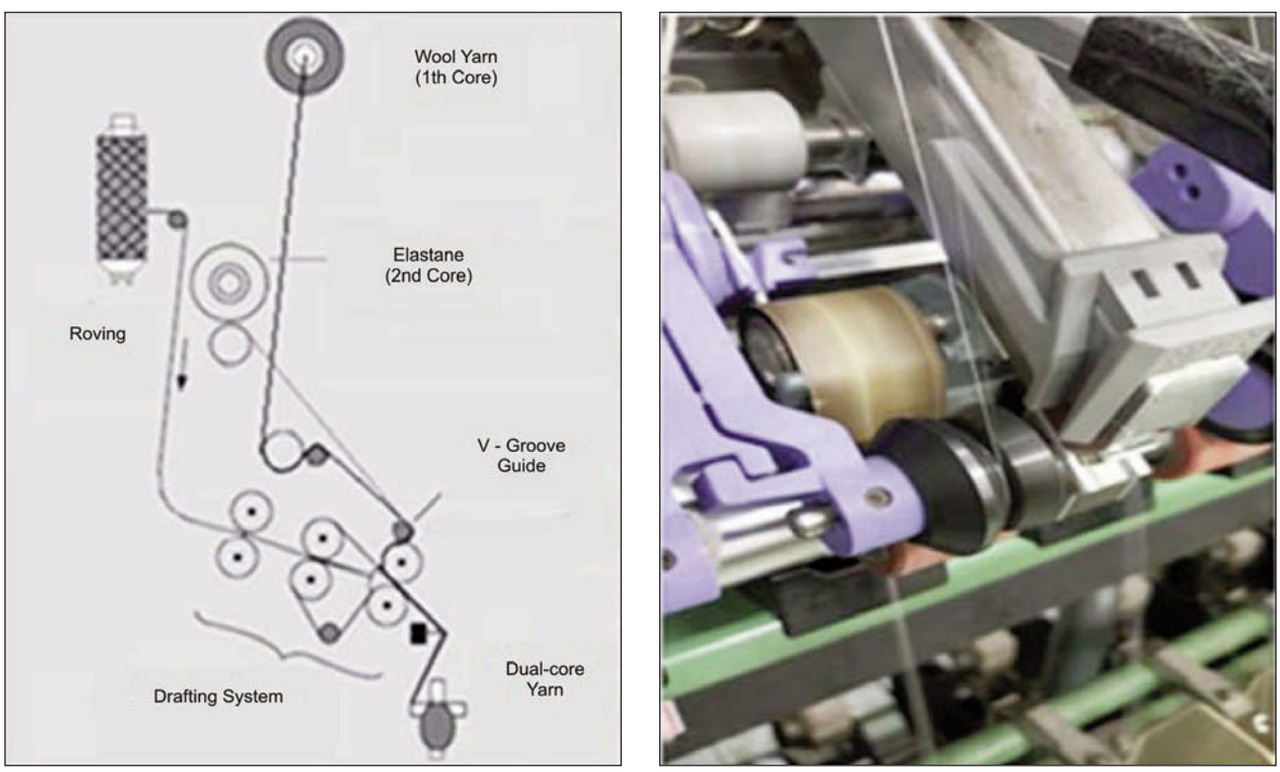
27 different types of dual-corespun yarns were produced in modified ring frame machine by passing a Nm 80/1 wool yarn (S-twist with 800 T/m) and a 78 dtex elastane filament through the front rollers which form the core and cotton fibers through normal roller drafting system which form the outer cover of yarn known as sheath as seen in figure 1.

Scanning electron microscope (SEM) images were taken in order to better visualize the morphological structure of the dual-core yarns. The surface morphology of the dual core yarn was studied employing a ZEISS EVO scanning electron microscope (SEM) in VP mode operating with an accelerating voltage of 25 keV. The core (wool yarn and elastane filament) and cover (cotton fibers) parts of dual-core yarn can be seen in figure 2. Codes and production parameters of the dual-core yarn samples were summarized in table 1.

It was investigated the effects of production parameters on the yarn unevenness, hairiness, tenacity, and elongation values of dual-core yarn samples. Yarn unevenness and hairiness were measured on Uster Tester 5 with the testing speed of 400 m/min throughout 1 minute. Yarn tenacity and breaking elongation were determined on UsterTensorapid 4 Tester. For each yarn sample, five tests were performed and the averages were reported. The tests, samples were conditioned at least for 24 hours in an atmosphere of 20±2°C and 65±2% relative humidity in order to adjust humidity balance.

RESULTS AND DISCUSSIONS

The obtained results of dual-core yarns were evaluated statistically for significance in differences using



a *b*

Fig. 1. (a) Schematic diagram of dual-core yarn production method and (b) Drafting system-V groove guide

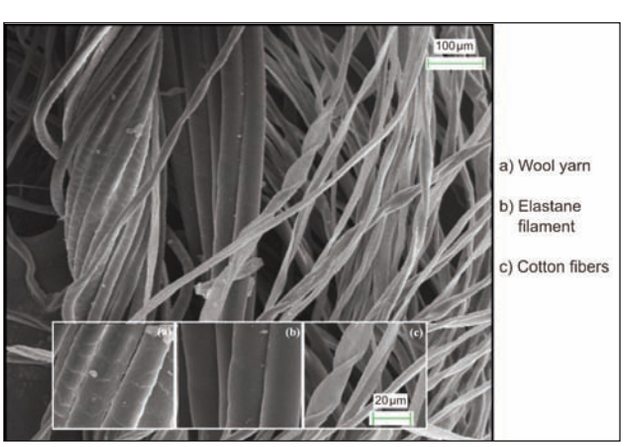


Fig. 2. SEM image of the dual-core spun yarn

Table 1

Yarn code	Twist level [T/m]	Wool draft	Elastane draft
1	585	1.01	3.3
2	585	1.01	3.5
3	585	1.01	3.8
4	585	1.03	3.3
5	585	1.03	3.5
6	585	1.03	3.8
7	585	1.05	3.3
8	585	1.05	3.5
9	585	1.05	3.8
10	670	1.01	3.3
11	670	1.01	3.5
12	670	1.01	3.8
13	670	1.03	3.3
14	670	1.03	3.5
15	670	1.03	3.8
16	670	1.05	3.3
17	670	1.05	3.5
18	670	1.05	3.8
19	750	1.01	3.3
20	750	1.01	3.5
21	750	1.01	3.8
22	750	1.03	3.3
23	750	1.03	3.5
24	750	1.03	3.8
25	750	1.05	3.3
26	750	1.05	3.5
27	750	1.05	3.8

three-way replicated analysis of variance (ANOVA) and the means were compared by conducting Student Newman-Keuls (SNK) tests at a level of 0.05 using SPSS statistical package. Table 2 shows the SNK test results for unevenness hairiness and tensile

Table 2

	CVm [%]	Hairiness [H]	Tenacity [cN/tex]	Elongation [%]
Twist level				
585 T/m	14.87a	8.26a	7.65a	10.35a
670 T/m	14.56ab	7.61b	7.88b	10.48ab
750 T/m	14.16b	6.62c	8.05b	10.73b
Wool draft				
1.01	14.72a	7.61a	7.75a	10.14a
1.03	14.55a	7.50a	7.90a	10.46b
1.05	14.31a	7.38b	7.93a	10.95c
Elastane draft				
3.3	14.46a	7.46a	7.64a	10.03a
3.5	14.46a	7.50a	7.82a	10.64b
3.8	14.66a	7.53a	8.12b	10.89b

properties of dual-core yarn samples. In the interpretation of SNK results, abbreviations a, b, c, d, and e represent factor level; factor levels that have the same letters are not different from each other at a significance level of 0.05 (table 2).

Figure 3 shows the mean values yarn unevenness values of dual-core yarns produced with different twist level, wool draft and elastane draft. According to ANOVA test results, only the twist level (P_T=0,023) was significant factor for yarn unevenness.

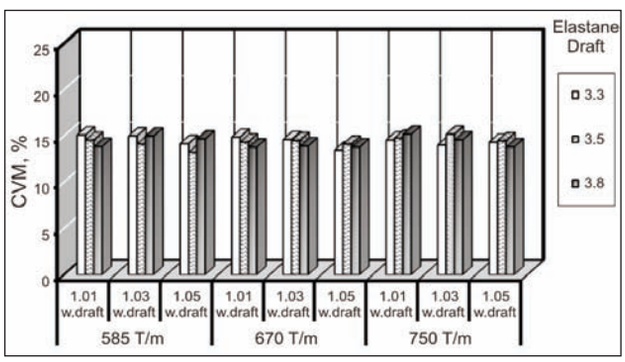


Fig. 3. Yarn unevenness versus twist level for comparable 1.01, 1.03, and 1.05 wool draft with 3.3, 3.5, and 3.8 elastane draft

From the SNK test results the differences between yarn unevenness values for 585 and 750 T/m twist level were found to be statistically significant. It was observed that there is decreasing trend in the unevenness values of yarn samples as twist level increases. This can be explained by the fact that the staple fiber may not accurately cover the filament due to low twist level as explained in earlier studies [9,10].

Figure 4 shows the average UsterHairiness (H) values of dual-core yarns produced with different twist level, wool draft and elastane draft. According to ANOVA test result, the twist level (P_T=0.000) and wool draft (P_W=0.001) were found to be statistically significant for the UsterHairiness (H) values of yarn samples. In addition the intersections of twist level/wool draft (P_{T*W}=0.000), wool draft/elastane draft (P_{W*E}=0.000), twist level/elastane draft (P_{T*E}=0.000) and the triple intersection of all factors (P_{T*W*E}=0.000) were found to be statistically significant for Uster Hairiness (H).

From the SNK test results, the differences between UsterHairiness (H) values of yarns for all twist level were found to be statistically significant. SNK test results showed that an increase in twist level from 585 T/m to 750 T/m resulted in an improvement in UsterHairiness (H). This is caused by the decreasing amount of free fiber ends and/or fiber loops protruding from a yarnbody with increasing twist level.

In addition, the difference between UsterHairiness (H) values for 1.05 wool draftand the other wool draftswas found to be statistically significant. From the results, it was observed that there is decreasing trend in the hairiness values of yarn samples as wool draft increases.

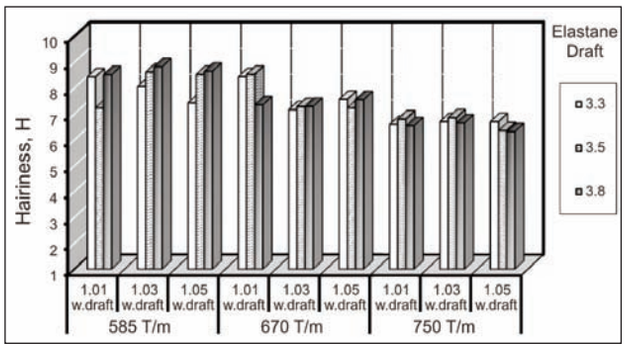


Fig. 4. Hairiness (H) versus twist level for comparable 1.01, 1.03, and 1.05 wool draft with 3.3, 3.5, and 3.8 elastane draft

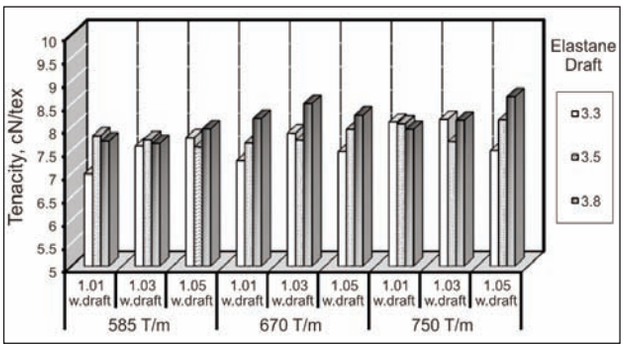


Fig. 5. Tenacity (cN/tex)versus twist level for comparable 1.01, 1.03, and 1.05 wool draft with 3.3, 3.5, and 3.8 elastane draft

Figure 5 shows the average tenacity (cN/tex) values of dual-core yarns produced with different twist level, wool draft and elastane draft. According to ANOVA test results, both the twist level ($P_T = 0.003$) and elastane draft ($P_E = 0.000$) were significant factors for the tenacity of yarn samples.

From the SNK test results (table 2), the difference between tenacity values for 750 T/m and the other twist levels was found to be statistically significant. It was observed that there is increasing trend in the tenacity values of yarn samples as twist level increases. The reason of this situation is the fact that the cohesion between the cores (wool/elastane) and sheath cotton fibers increases with the increase in twist level. These results are supported by previous studies on core-spun yarns [10, 11].

In addition, the difference between tenacity values for 3.8 elastane draft and the other elastane drafts was found to be statistically significant. From the results, it was observed that there is increasing trend in thetenacity values of dual-core yarn samples as elastane draft increases. This can be explained by the stress-induced crystallisation phenomenon of the elastane filament with increasing draft value. Su et al. have explained this phenomenon by the fact that when elastane with higher draw ratio is fed in production, the originally folded and twisted soft segments in the elastane filament are straightened allowing harder segments to form a crystal lattice by the effect of hydrogen bonding [12]. Moreover, similar to previous studies [13], the increase in the tenacity values with increasing elastane draft can also be associated with the decreasing elastane ratio which also means increasing sheath fibers' percentage in dual-core yarn structure.

Figure 6 shows the average breaking elongation values of dual-core yarns produced with different twist level, wool draft and elastane draft. According to ANOVA test results, the twist level ($P_T = 0.032$), elastane draft ($P_E = 0.000$) and wool draft ($P_W = 0.000$) were significant factors for breaking elongation (%) of yarn samples. The intersections of, wool draft/elastane draft ($P_{W*E} = 0.000$), twist/elastane draft ($P_{T*E} = 0.001$) and the triple intersection of all factors

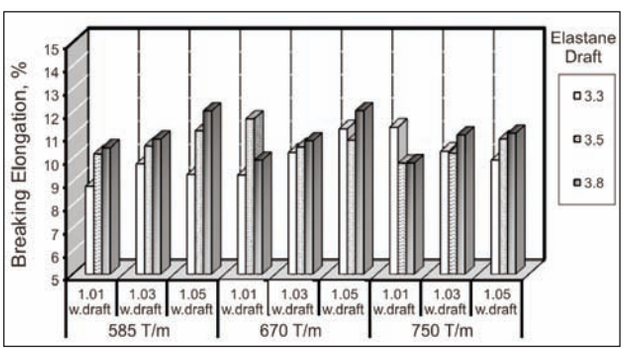


Fig. 6. Elongation (%) versus twist level for comparable 1.01, 1.03, and 1.05 wool draft with 3.3, 3.5 and 3.8 elastane draft

($P_{T*W*E} = 0.000$) were also found to be statistically significant for breaking elongation.

From the SNK test results, the difference between breaking elongation values for 585 and 750 T/m twist levels was found to be statistically significant. It was observed that there is increasing trend in the breaking elongation values of yarn samples as twist level increases. The reason of this case is the fact that the sheath fibers are wrapped better around each other with increasing twist level.

In addition, the differences between breaking elongation values of yarns for all wool drafts were found to be statistically significant. This increase in wool draft from 1.01 to 1.05 resulted in an improvement in breaking elongation.

From the SNK test results, the difference between breaking elongation values for 3.3 elastane draft and the other elastane drafts was found to be statistically significant.It was observed that there is increasing trend in breaking elongation values of yarn samples as elastane draft increase. This may be explained by the fact that the chance of fibers slipping in the dual-core yarn increases, as staple fibers in dual-core yarn increase with increasing elastane draft. Wu et al. (2003) and Lin et al. (2011) found similar results in their studies [14, 15].

CONCLUSION

This study demonstrates that various properties of dual-core yarns are significantly affected by twist

level, wool draft and elastane draft as outlined in the followings:

The unevenness of dual-core yarns is only affected by twist level factor. Experimental results showed that there is decreasing trend in the unevenness values of yarn samples as twist level increase.

The hairiness of dual-core yarns is affected twist level and wool draft. The hairiness values decrease while twist level of dual-core yarns increases. The best hairiness values are obtained from dual-core yarn samples produced with 750 T/m twist level. Furthermore, experimental results show that there is decreasing trend in the hairiness values of yarn samples as wool draft increases.

The tenacity of dual-core yarns is affected by twist level and elastane draft factors. Experimental results show that there is increasing trend in the tenacity values of yarn samples as twist level and elastane draft increase.

The elongation of dual-core yarns is affected by twist level, wool draft and elastane draft factors. Experimental results show that there is increasing trend in the tenacity values of yarn samples as twist level and elastane draft increase. The elongation values increase while wool draft of dual-core yarns increases. The best elongation values are obtained from dual-core yarn samples produced with 1.05 wool draft.

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