DEVELOPMENT AND CHARACTERIZATION OF COTTON ELASTIC YARNS TO IMPROVE WEAR COMFORT OF BI-ELASTIC THIN FABRICS

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ABSTRACT

Clothing is our second skin, beyond the aesthetic function it primarily has the protective function. One cannot speak about clothing design without mentioning comfort and we may even say that they are not dissociable. The clothing design, in conceptual sense, cannot be successful if it does not take into account the comfort component. Among the many comfort dimensions, the sensorial and ergonomic dimensions of comfort which influence the sensory perception and the ability of a garment to "well fit", are largely determined by the elastic properties of the yarns and fabrics. The present work, relates to the development of cotton elastic yarns for bi-stretch woven fabrics, designed for high-quality women's fine shirting. The yarns were manufactured by the conventional core-spinning method, using different filaments in the core and cotton fibres as sheath. The physical-mechanical properties of the yarns were evaluated to assess their performance ability to improve bi-stretch fabrics wear comfort.

Keywords: *elastic yarns, comfort, function by design*

1. INTRODUCTION

The current trend towards the production of function-focused fibrous products led to an increasing need to regard clothing design, as a process of creating products that satisfies a functional requirement with an aesthetic effect. This trend is making the design task more complex and challenging, not only to designers, but also to engineers and researchers in the textile and garment fields.

From this design for function perspective, comfort is one of the most important aspects of clothing, mainly for next to skin garments, such as trousers and shirts. Considered a multidimensional property, comfort can be divided into four broad groups: psycho-aesthetic, thermo-physiological, ergonomic and sensorial comfort [1]. Apart from the psycho-aesthetic dimension of comfort, which is related to the aesthetic appeal and the fashion trends, the other three dimensions of comfort are determined by the characteristics and constructional properties of the fibrous materials. These dimensions determine products' wear comfort [2].

Fabrics' stretch is among the properties that largely influence wear comfort [3-7]. Dependent on fabrics' elasticity and extensibility, it primarily influences the ability of a garment to fit and allow freedom of movements- ergonomic comfort- and the mechanical sensations induced to the skin -sensorial comfort.

Imparting stretch to woven fabrics involves the use of elastic filaments or elastic yarns. Core-spinning is one of the techniques to produce elastic yarns, where stretch is conveyed to the yarn by the elastic core which retracts after removing the stress, compacting and bulking the sheath.
Filament and fibre properties together with spinning parameters define the yarn structure, which plays a major role in the resulting fabric comfort [9]. Several works have been carried

out to study the effect of filament / fibre characteristics and process variables on the structure and performance properties of elastic core-spun yarns [4-6; 10-13]. The effects of fibre and elastic filament properties and of spinning variables, namely draft ratio, twist factor and elastane feed angle, on yarn properties and structure were investigated. From the results obtained in these studies, core filament linear density, elastane content, draft ratio and twist factor were considered as the major variables influencing the properties of elastic core-spun yarns.
The present paper, reports the work that has been done in the development of fine cotton elastic yarns for bi-stretch woven fabrics, designed for high-quality women's shirting. The yarns were manufactured by the conventional core-spinning method, using different filaments in the core and cotton fibres as sheath. The effect of fiber properties-spinning parameters on the elastic yarn properties was evaluated to select the best combination to impart bi-stretch fabrics wear comfort.

2. EXPERIMENTAL

In this study, core-spun cotton elastic 60/1Ne yarns with different filaments in the core were developed and their physical-mechanical properties evaluated. These yarns will be employed as warp and weft yarns in shirting fabrics.
The company Somelos Mix-Fios Têxteis S.A manufactured the yarns in conventional core-spun ring spinning systems.
The yarns' sheath is composed by raw white cotton US Pima. The yarns' core varies in the type of filament, namely, Lycra®[1], ROICA™[2], T400®[3] and PBT[4], and in the filament linear density, 22dtex, 33dtex and 44dtex.
Six 60/1Ne yarns were developed with different percentages of cotton and elastic filament content, draft ratio and twist factor. The technical specifications used to produce the core-spun elastic yarns are shown in Table 1.

Table 1. Technical specifications for the yarns 60/1 Ne developed

Tech Specs	Yarn 1	Yarn 2	Yarn 3	Yarn 4	Yarn 5	Yarn 6
Composition	67% Cotton 33% T400® 22 dtex	91% Cotton 9% ROICA™ 22 dtex	89% Cotton 11% Lycra® 44 dtex	78% Cotton 22% PBT 22dtex	86% Cotton 14% Lycra® 44 dtex	86% Cotton 14% Lycra® 44 dtex
Twist factor Twist direction	4,20 Z	4,20 Z	4,20 Z	4,20 Z	6,35[1] Z	4.20 Z
Draft ratio	1,08	3,33	4,00	1,08	3,33	3,33
Post-treatment/ conditioning	None[2]	Steamed P0[3]	Steamed P0[3]	None[2]	Steamed P0[3]	Steamed P0[3]
Observations	[1] Twist increased to give a crepe effect [2] Heat treatment performed on fabrics (in dry state at 60-120ºC and in wet state at 60-100ºC) [3] Steaming Conditions: temperature 75ºC; 80% moisture; time 15 min					

[1] Lycra® is an elastomeric filament (polyurethane) with high stretch and recovery properties.

[2] ROICA™ is an elastomeric filament with high stretch and recovery properties.

[3] T400® is a two-component filament from Lycra® (Elastomultiester (EME) fibre). When exposed to heat, each component shrinks to a different degree, producing a helical crimp.

[4] PBT is a Polybutylene Terephthalate multi-filament textured yarn with high crimp.

After production, the physical-mechanical properties of the developed core-spun yarns were characterized and compared.
All the tests were carried out under standard atmospheric conditions (temperature 20ºC±2 and relative humidity 65%±2). The yarn linear density was determined according to standard NP EN ISO 2060, the crimp was measured in the Crimp Tester, according to standard NF 07101/07311, using a pre-tension of 5,9 cN and the mechanical properties were evaluated according to NP EN ISO 2062 (in Hounsfield dynamometer unit, with pre-tension of 5 cN and force applied at a constant speed of 500 mm/min).

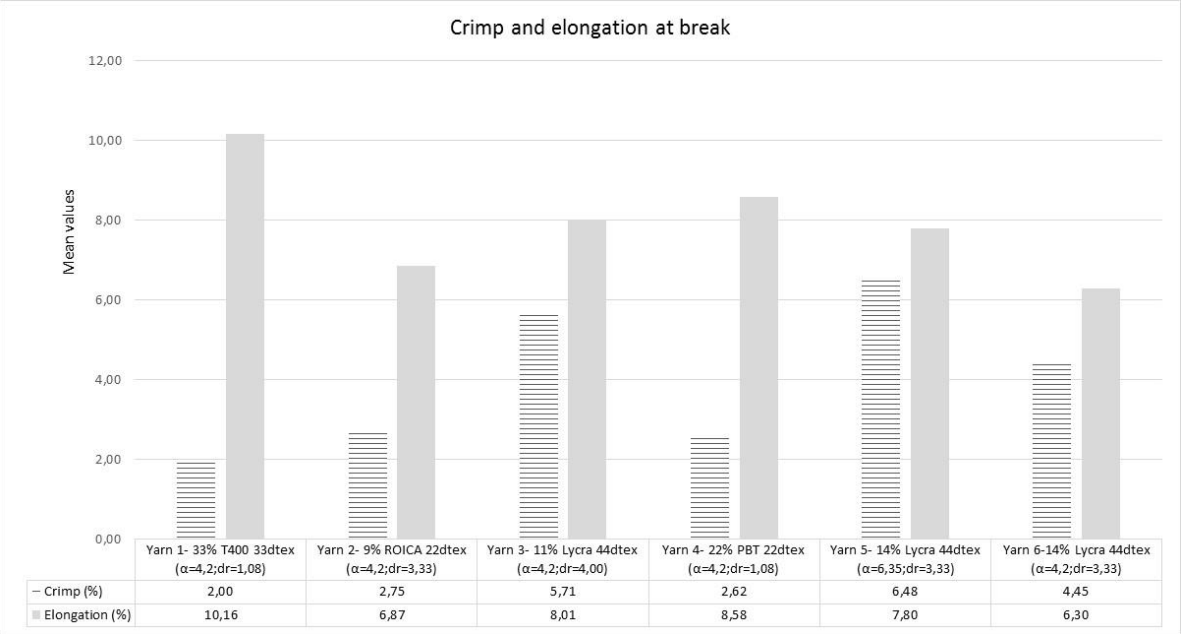
3. RESULTS AND DISCUSSION

Elastic and extension abilities of the developed yarns are the main target of the work. Therefore, the analysis was primarily focused of the on yarns' crimp and elongation parameters, as they provide relevant information on yarns' behaviour when submitted to low loading conditions and at break. Table 2 presents the relevant properties considered for the six yarns developed.

Table 2. Characteristics of developed 60/1 Ne core-spun elastic yarns

Properties (mean values)	Yarn 1	Yarn 2	Yarn 3	Yarn 4	Yarn 5	Yarn 6
Linear density (Ne)	57,60	58,45	58,43	56,70	57,78	58,85
Crimp (%)	2,00	2,75	5,71	2,62	6,48	4,45
Breaking Strength (N)	2,27	2,13	1,85	2,11	1,73	1,80
Elongation (%)	10,16	6,87	8,01	8,58	7,80	6,30
Tenacity (N/tex)	0,23	0,22	0,19	0,21	0,18	0,19

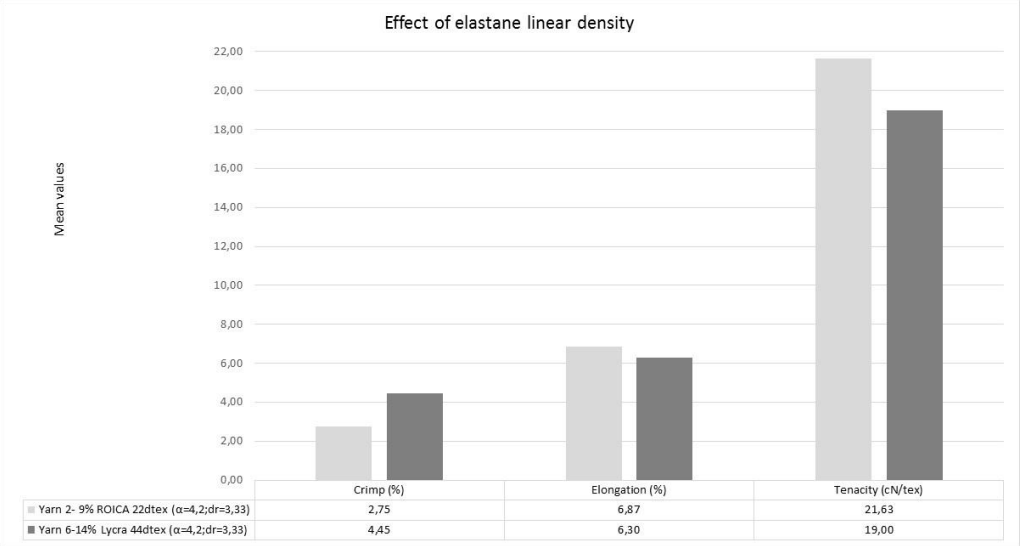
The comparative study carried out showed that the yarns with a higher content of core elastane filament, Yarn 1 (with 33% of T400®) and Yarn 4 (with 22% of PBT), are the ones with the highest elongation and simultaneously, the lower crimp mean values. Due to the inherent characteristics of these filaments (whose elastic behaviour derive, respectively, from differential shrinkage of the components and from heat-set crimp (texturizing)), crimp will only be promoted in fabric state (through a heat treatment) to convey fabric stretch ad recovery properties. Figure 1 illustrates the elastic and extension ability of the developed yarns.



	Yarn 1- 33% T400 33dtex (α=4,2;dr=1,08)	Yarn 2- 9% ROICA 22dtex (α=4,2;dr=3,33)	Yarn 3- 11% Lycra 44dtex (α=4,2;dr=4,00)	Yarn 4- 22% PBT 22dtex (α=4,2;dr=1,08)	Yarn 5- 14% Lycra 44dtex (α=6,35;dr=3,33)	Yarn 6-14% Lycra 44dtex (α=4,2;dr=3,33)
Crimp (%)	2,00	2,75	5,71	2,62	6,48	4,45
Elongation (%)	10,16	6,87	8,01	8,58	7,80	6,30

Figure 1. Elastic and extension ability of the developed 60/1 Ne yarns

The effect of elastane linear density on yarns' properties is depicted on Figure 2, comparing Yarns 2 and 6. By keeping spinning parameters (draft ratio and twist factor) constant, it is apparent that the yarn with the thinner filament core (Yarn 2- 22 dtex ROICA™) demonstrates a significantly lower crimp. This indicates that a weaker elastic behaviour (recovery after stress removal) is expected in fabric state. The elongation and tenacity of both yarns is not significantly different.



	Crimp (%)	Elongation (%)	Tenacity (cN/tex)
Yarn 2- 9% ROICA 22dtex (α=4,2;dr=3,33)	2,75	6,87	21,63
Yarn 6-14% Lycra 44dtex (α=4,2;dr=3,33)	4,45	6,30	19,00

Figure 2. Effect of elastane core filament linear density on the properties of 60/1 Ne elastic yarns

The effect of spinning parameters, on yarns' properties was assessed using two draft ratios-3,33 and 4,00 and two twist factors-4,20 and 6,35, and led to the development of three elastic yarns with a 44dtex Lycra® core filament (Yarns 3, 5 and 6). Figure 3 illustrates the results obtained for the evaluated properties.
Yarns 3 and 5 show the highest crimp values (respectively, 5,71% and 6,48%) and the highest elongation values (respectively, 8,01% and 7,80 %). These yarns correspond, respectively, to the ones with highest draft ratio (4,00) and twist factor (6,35).

The effect of draft ratio on the elastic and extension ability of the yarns can be evaluated on Yarns 3 and 6. Produced with the same twist factor (4,20), the reduction in the draft ratio (from 4,00 to 3,33), promoting an increase in yarn's elastane content (11% to 14%), led to a significant decrease of crimp and elongation values. This can be explained by the lower draft ratio used in Yarn 6, which led to lower retraction force of the sheath fibres and hence to lower elastic and extension ability.
When comparing Yarns 6 and 5, the effect of twist factor can be evaluated. By increasing the twist factor (from 4,20 to 6,35), the crimp and elongation values significantly increased. Furthermore, the tenacity of the yarn with higher twist factor, decreased.
Moreover, as decreasing the draft ratio increased the elastane percentage, it resulted in lower yarn elongation.

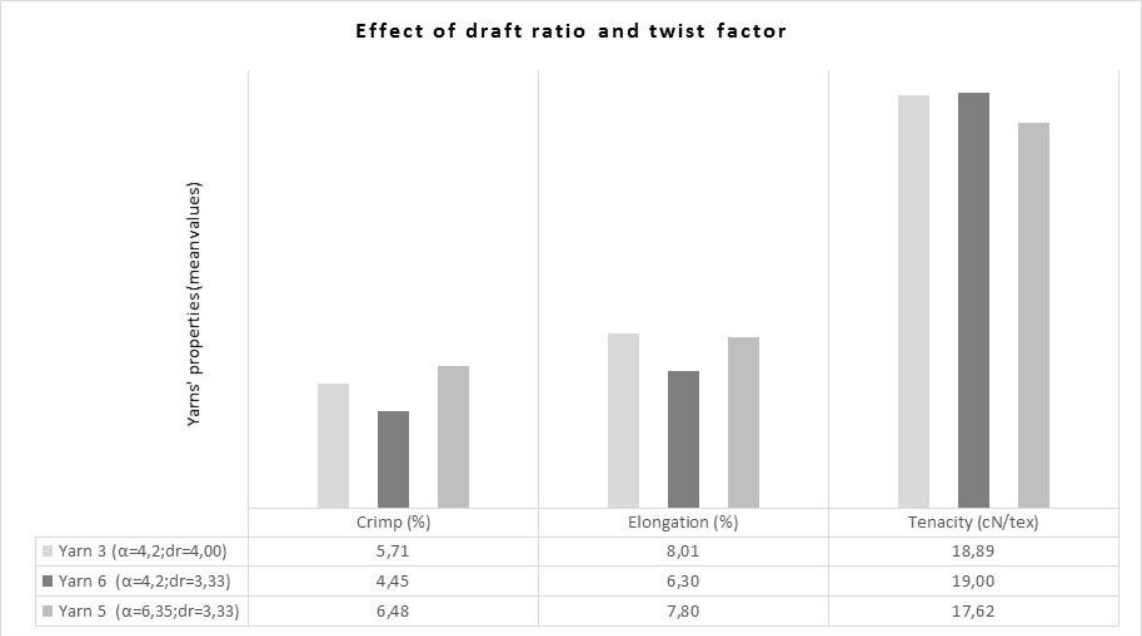


Figure 3. Effect of draw ratio *(dr)* and twist factor *(α)* on the properties of the developed 60/1 Ne yarns

4. CONCLUSIONS

In this paper we present the characteristics of the cotton core-spun elastic yarns, designed and developed to impart stretch and recovery properties to high quality lightweight bi-elastic fabrics for women shirting, therefore wear comfort.
From the obtained results, the influence of spinning parameters (draw ratio twist and factor) on yarns' crimp and elongation is confirmed.
Considering that the yarns with higher crimp provide better elastic properties to the fabrics, Yarns 3 (89% Cotton/11% Lycra® 44 dtex) and 5 (86% Cotton/14% Lycra® 44 dtex) have been selected to design and develop bi-elastic fabrics, from both aesthetic and functional viewpoints.
Furthermore, Yarns 1 (67% Cotton/33% T400) and 4 (78% Cotton/22% PBT), which demonstrated the highest elongation, will be heat-treated to impart crimp and also woven to assess their ability to promote fabrics stretch and recovery properties.
The elastic behaviour of these fabrics, now in production, will be studied to evaluate and select the fibre-spinning conditions that maximize the transference of yarns 'properties to the fabrics.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

[1] Li, Y, The Science of Clothing Comfort, Textile Progress, vol. 31, Nº 1, 2002
[2] U.C. Hipler, P. Elsner, Biofunctional textiles and the skin, vol 33, Karger Pub., 2006
[3] Broega, A. C.; Cabeço-Silva, M. E. The Comfort Performance of Wool Light Fabrics Based on Subjective, Objective Evaluation, 8th Autex Conference, Autex Conference Proceedings, ed Cittá Studio di Biella Biella, Italy, Jun 2008.
[4] Qadir, T. Hussain, M. Malik. Effect of Elastane Denier and Draft Ratio of Core-Spun Cotton Weft Yarns on the Mechanical Properties of Woven Fabrics, Journal of Engineered Fibers and Fabrics, 2014,Volume 9, Issue 1, p23-31.
[5] A. Das, R. Chakraborty, Sudies on elastane-cotton spun stretch yarns and fabrics: Part I- Yarn characteristics, Indian Journal of Fibre and Textile Research, 2013, vol 38, p237243.
[6] Ortlek, G. H. Ulku, S. Effects of spandex and yarn counts on the properties of elastic core-spun yarns produced on murata vortex spinner, Textile Research Journal, 2007, 77, p432–436.
[7] Roshan Shishoo, Textiles in Sports, The Textile Institute, 2005.
[8] Y. Elmogahzy, Yarn Engineering, Indian Journal of Fibre and Textile Research, 2006, vol31, p150-159.
[9] Ching-Iuan Su, Meei-Chyi Maa, Hsiao-Ying Yang, Structure and Performance of Elastic Core-Spun Yarn, Textile Research Journal, 2004,vol. 74 No. 7, p607-610.
[10] B. Adeli, A.A.Ghareaghaji, M.Shanbeh," Structural Evaluation of Elastic Core-Spun Yarns and Fabrics under Tensile Fatigue Loading", Textile Research Journal, 2011,Vol.80,No.1, Issue.2p137-147.
[11] Ching-Iuan Su, Hsiao-Ying Yang, Structure and Elasticity of Fine Elastomeric Yarns, Textile Research Journal, 2004, vol 74, nº12, p1041-1044.
[12] A. Babay, H. Helali & S. Msahli, Study of the mechanical behavior of the elastic-core-spun yarns, The Journal of The Textile Institute, 2014,105, 7, p701-710
[13] Hatice Kubra Kaynak, Optimization of stretch and recovery properties of woven stretch fabrics, Textile Research Journal, 0(00) 1–11 (published online February 25, 2016)

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