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Developing a rheological model for predicting stress relaxation behavior of cotton-covered elastane core-spun yarns

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This study aims at providing a new approach to develop a rheological model predicting the stress relaxation behavior of cotton-covered elastane core-spun yarns. The yarns have been manufactured with various counts and elastane drafts. According to a yarn's tensile and relaxation dataset, the model integrated three components characterizing different tensile curves' zones. The model validation is established for the whole yarn's range. Besides, this model fitted well the experimental data with a significant correlation coefficient. Also, it is important to highlight that most of the rheological parameters have almost the same values for various elastane drafts, yarn counts, and imposed deformation levels. Those reproducible results allow us to simulate the elastic core-spun yarn behavior under different constraints and to identify some mechanical parameters relevant to simulate and predict the end product's properties.

Keywords: Cotton, Elastic core-spun yarns, Elastane draft, Mechanical behavior, Rheological model, Stress relaxation, Yarn count

1 Introduction

Elastic core-spun yarn is understood as a cross-sectionally structured composite yarn in which the core strand is wrapped by staple[1]. Usually, an elastic core-spun yarn consists of covering elastane fibres, such as Lycra, Spandex, Creora, and Dorlastan®, with a cut of natural, artificial or synthetic fibres[2,3]. For denim fabrics, the elastic core-spun yarn is produced on a ring spinning machine to be used as weft yarns.

This core spinning process allows producing elastic core yarns via an elastane feeder ensuring a defined and constant draft value[4-6]. Physical and mechanical properties, such as tenacity, comfort, durability, and functional properties are improved with the utilization of such yarns in the end product[7]. Thus, the insertion of elastane filament in yarn core confers new characteristics, not only to yarn properties, but also to the fabrics' behavior.

Owing to the ever-growing use of this type of yarn for all kinds of applications, the demands on the mechanical properties of these yarns have become more and more varied. For this reason, several works have been carried out to investigate the effect of some parameters on the mechanical properties of the elastic core-spun yarns. Babay *et al.*[8] showed that the yarn's elasticity was highly improved with the elastane filament. Therefore, the elastane draft is crucial to the yarn's strength and elongation. Also, some researchers showed that the elastane draft and yarn counts had a significant impact on the mechanical properties of the elastic core-spun yarns[9,10]. Muhammad *et al.*[11] proved that the elastane ratio and the linear density had a significant contribution to the mechanical properties of elastic core-spun yarn, such as yarn's tenacity and elongation. Emine and Pinar[2] showed that the core-sheath ratio and the filament linear density affected the ring core-spun yarn properties. Badbade[12] confirmed that elastane core liveliness affected physical and mechanical properties of elastane-cotton core-spun yarn fabric. On the other hand, some parameters, such as the elastane linear density, the steaming process, the relaxation durations, and the temperature during steaming were investigated to analyze their effects on the mechanical property of elastic denim yarns[13].

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All these studies focused on the elastane filament's effect on the physical and mechanical properties, especially tenacity and elongation. Only, a few authors were interested in the elastic core-spun yarn modeling. They presented various theories concerning the stress-strain behavior of the elastic core-spun yarns[14-17]. However, none of them has already studied the stress relaxation behavior of the elastic core-spun yarns, except for studies done by Chhatpuriya *et al.*[18] and Elrys *et al.*[19] who were interested in the stress relaxation behavior of the dual-core stretchable ring-spun yarn and a new type of elastic core-spun yarn which is called tri-core (elastane/T400/elastane). Yet, in this context, it is important to notice that stress relaxation tests have become, increasingly, useful to determine the yarn's properties. Besides, stress relaxation is considered one of the most important mechanical behaviors of textile materials explaining their responses to stress.

The stress relaxation phenomenon can be described as the gradual viscoelastic stress decay over time until reaching a limiting value. The stress relaxation properties estimation is not simple, as several parameters are considered, such as the textile raw material and the textile structure[20]. When a textile structure is sustained under constant deformation, stresses decay over the time and the stress relaxation process is prominent and advantageous to be understood, particularly for the required properties of a textile structure used for long periods[20-23]. In general, relaxation measurements arealso interesting for engineers and chemists in any applications, where materials are maintained under loads for a long-time lap[24].

The stress relaxation tests were initially used in scientific projects at the universities. However, in recent years, growing use of these tests has been observed; this is, in fact, the consequence of introducing them to product standards[25].

Numerous authors have investigated the rheological approach to model the stress relaxation behavior of spun yarns. Liu *et al.*[26] proposed the generalized Maxwell model to describe the relaxation modulus of a single spun yarn. Also, Ben Amar and Halleb[27] used the L.Vangheluwe model to study the viscoelastic behavior of ring and open-end spun yarns during tensile and relaxation tests. In addition, Feng-jun *et al.*[16] employed the standard linear solid model to describe the stress relaxation properties of blended yarns. Also, Shayan *et al.*[28] evaluated and compared the stress relaxation behavior of selected sewing threads in the straight and loop form varying strain values and extension rates. Also, a two-component Maxwell's model was performed to verify the results of the experimental tests. Rosyidan *et al.*[29] suggested a modified form of the Maxwell model to calculate the stress relaxation and creep behaviors for polyester yarns. Gao *et al.*[30] analyzed the stress-strain behavior of the polypropylene yarn by using the standard linear and nonlinear three-parameter discrete viscoelastic models. Moreover, Zou[31] developed a stress relaxation model to predict the stress relaxation mechanism of vortex spun yarn under different external conditions. To analyze the stress relaxation behavior of polyester/viscose and regenerated bamboo fibre/cotton blended yarns, Shi[32] adopted a standard linear solid model. The theoretical prediction was in good agreement with the experimental results.

All the researchers mentioned above have considered the good adjustment of the experimental and theoretical curves and the high correlation coefficient value R^2 as the best result even if rheological parameter values haven't any physical signification. Indeed, the established results are just an identification of the rheological models existing in the literature. There is no investigation in the development of a specific model for spun yarns depending on these mechanical and physical characteristics. With their approach, the relaxation behavior of the spun yarns can only be described, but it cannot be predicted.

The current study is aimed at developing a rheological model for describing and predicting the stress relaxation behavior of the cotton-covered elastane core-spun yarns based on experimental data of tensile and relaxation tests carried out for various yarn counts, elastane draft values, and imposed deformations levels.

2 Materials and Methods

2.1 Materials

In the present work, Dorlastan® filament was used. It is produced by Bayer Faser GmbH with the polyurethane filament, and it has a very interesting stretch elasticity, reaching 550%. However, a very poor tenacity is noticed[33]. For that, the Dorlastan® filaments are wrapped by cotton fibres (4.1 µg/inch micronaire. 0.9 maturity, 29.7 mm UHML, 29.3cN/tex tenacity and 8.4 % elongation).

In this investigation, elastic core-spun yarns were produced on an industrial scale. They were made using the short-staple ring spinning machine (Fig. 1). In the production of elastic coreyarns, the elastane filament was stretched before being supplied to the spinning process ahead of the front top rollers. The advantage of this feed is that the draw elastane filaments were stable at the center of the spinning triangular space and completely wrapped by staple fibres. The elastane is protected superbly against mechanical stress. A ring frame was set up in the same conventional way one would spin a regular ring yarn from roving. The cotton fibres were stretched in the ring frame drafting system. The elastane filament was covered and twisted with the cotton fibres at the spinning triangular space to produce the elastic core-spun yarns. These yarns are employed as weft yarns in denim fabrics. The Dorlastan® draft is determined using the following equation:

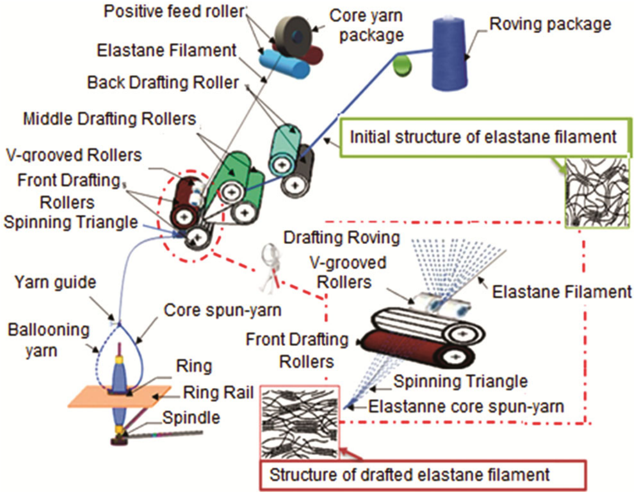

Fig. 1 — Schematic views of core spinning process

$$\text{Dorlastan}^{\circledR}\text{drafts} = \frac{\text{Dorlastan}^{\circledR}\text{ Count}}{\text{Yarn Count}\times\text{Dorlastan}^{\circledR}\text{ratio (\%)}} \quad \dots (1)$$

In this study, core-spun yarns were produced with the same twist factor (equal to 138) and various counts. For each yarn, the elastane counts 156, 78, and 44 dtex respectively for yarn counts 100 tex, 50 tex, 33.33 tex, and 25 texwere used. Yarn codes are defined as 100/156, 50/78, 33.33/78, 33.33/44 and 25/44 yarn count/Dorlastan® count.

Studying the mechanical behavior of yarns requires specific conditions. That's why we have used the results established in an earlier paper[34]. The Dorlastan® draw ratio and pretension values for various yarns are given in Table 1.

2.2 Tensile and Relaxation Tests

Tensile and relaxation tests were performed on a dynamometer managed by Lloyd software (Fig. 2). Specimens were conditioned in a standard atmosphere of 20°C± 2°C and 65%±2% RH according to NF G00 003 French Standard[35]. The testing length was 500 mm for each test. For the tensile test, speed was chosen to have a breaking time equal to 20s ± 3s as defined in the French standard NF G07-003 (AFNOR). The number of specimens used for each tensile test is 50. For the relaxation test, specimens were stretched up to strain levels equal respectively to 10%, 30%, 60% and 90% of breaking elongation at a speed of 500mm/min and held in this position for 900s.

Table 1 — Dorlastan draft, constraint thresholds and pretension values for different yarns

					Yarn 100/156				
Dorlastan®, ratio %	4.00	4.50	5.00	5.50	6.00	6.5	7.00	7.50	8.00
Dorlastan®, drafts	3.90	3.47	3.12	2.84	2.60	2.40	2.23	2.08	1.95
Pretension, cN/tex	0.70	0.65	0.64	0.60	0.54	0.52	0.50	0.48	0.43
Constraint threshold (S), cN/tex	13.13	9.18	11.83	11.96	10.23	12.25	12.59	11.05	10.11
					Yarn 50 /78				
Dorlastan®, ratio %	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
Dorlastan®, drafts	3.90	3.47	3.12	2.84	2.60	2.40	2.23	2.08	1.95
Pretension, cN/tex	1.11	0.86	0.81	0.79	0.70	0.69	0.63	0.62	0.51
Constraint threshold (S), cN/tex	11.34	10.14	8.96	9.92	8.26	8.78	8.04	8.9	9.18
	Yarn 33.33/44				**Yarn 33.33/78**				
Dorlastan®, ratio %	4.00	4.50	5.00	5.50	6.00	6.5	7.00	7.50	8.00
Dorlastan®, drafts	3.30	2.93	2.64	2.40	3.90	3.60	3.34	3.12	2.93
Pretension, cN/tex	1.15	1.09	1.01	0.97	0.92	0.85	0.79	0.71	0.65
Constraint threshold (S), cN/tex	9.57	9.42	8.61	11.61	11.43	9.66	9.03	6.99	7.26
					Yarn 25/44				
Dorlastan®, ratio %	4.00	4.50	5.00	5.50	6.00	6.5	7.00	7.50	8.00
Dorlastan®, drafts	4.40	3.91	3.52	3.20	2.93	2.71	2.51	2.35	2.20
Pretension, cN/tex	1.69	1.39	1.34	1.11	1.01	0.93	0.87	0.76	0.79
Constraint threshold (S), cN/tex	8.40	8.52	6.84	7.88	7.40	6.60	8.20	7.16	8.40

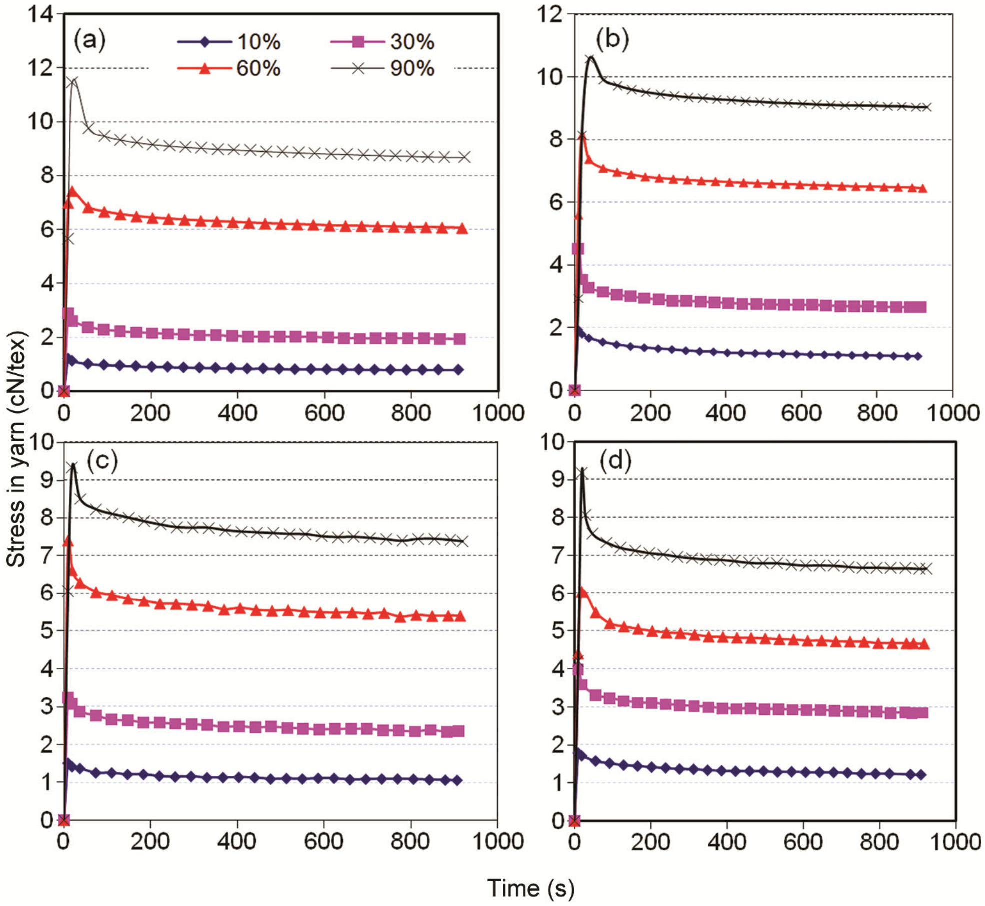

Fig. 2 — Relaxation curves of yarn (a) 100/156, (b) 50/78, (c) 33.33/44 and (d) 25/44 for various extension rates

To find out the different zones of the tensile curves of the elastic core-spun yarn and to determinethe constraint thresholds of different yarns with various Dorlastan®drafts, the cord method[36] was applied. The constraint threshold values for different yarns are given in Table 1.

2.3 Rheological Model

The mechanical behavior of a material can be explained using mechanical models which are composed of rheological elements such as springs and dashpots. The elastic properties of a linear solid material are described by a spring, whereas the dashpot represents the viscous properties of liquids. As a result of different combinations of these basic elements, several models[37] (linear and nonlinear) can be obtained.

A clear classification of the materials can be observed such as rigid, elastic, viscous, plastic, and perfectly plastic. This is the outcome of tensile, relaxation, and cyclic tests. In order to develop a rheological model describing the stress relaxation test, we combined the Kelvin Voight model, a standard non-linear viscoelastic model, and a viscoplastic behavior model altogether.

To fit the relaxation curves model, Gauss-Newton procedure is used employing an iterative search algorithm in order to determine the estimation value minimizing the sum of deviation squares f (a)[38]. This function, as shown by following equation, depends on unidentified coefficients $a_i (i = 1 \; to \; n)$:

$$f(a) = \frac{1}{2}\sum_{j=1}^{n}[y_j^c\,(a,x) - y_j^E\,(X_j)]^2 \qquad \dots (2)$$

where y_j^C and y_j^E are respectively the experimental and calculated values.

3 Results and Discussion

3.1 Relaxation Test

Relaxation curves of the elastic core-spun yarn 100/156, 50/78, 33.33/44, and 25/44 for Dorlastan® draft equal to 3.12, 3.12, 2.64, 3.52, and 3.52

respectively and corresponding to a Dorlastan® ratio of 5%, are shown in Fig. 2. It is observed that the tenacity increases over the time to reach a non-null constant value even for the low deformations. In fact, when the elastic core-spun yarn is maintained with a fixed length, there is an internal tension that decreases gradually with time until a limit value, as compared to the time scale of the test without attaining zero. The tension reduction can be due to a continuous rupture of the inter-fibre links.

In addition, maintaining the yarn at a constant extension may induce a rearrangement in the structure of the Dorlastan®core[17]. Also, it is observed that stress relaxation is strongly dependent on the deformation level. Indeed, Fig. 2 shows clearly that the elastic core-spun yarn stretched at low deformation (10%) presents a constant tension. This is the behavior of an elastic solid. For higher deformations values (60% and 90%), the negative slopes at the origin of relaxation curves lower than that of low deformations determine the elastic core-spun yarn viscosity. Thus, the behavior of the elastic core-spun yarn in the relaxation test is characteristic of a viscoelastic solid.

Figure 3 shows that the standardized tenacity at the relaxation time (t=900s) depends on the imposed deformation level[17]. Thus, the elastic core-spun yarn presents nonlinear viscoelastic behavior[39]. So, the model describing the mechanical behavior of this yarn should involve a nonlinear component.

3.2 Effect of Dorlastan® Drafts

Figure 4 shows the variation of force fall (ΔF_r) according to the Dorlastan® draft for the various imposed deformations for different elastic core-spun yarns. As observed, these figures show an increasing trend of force fall (ΔF_r) according to the Dorlastan® draft increasing. This is remarkable for high deformation levels.

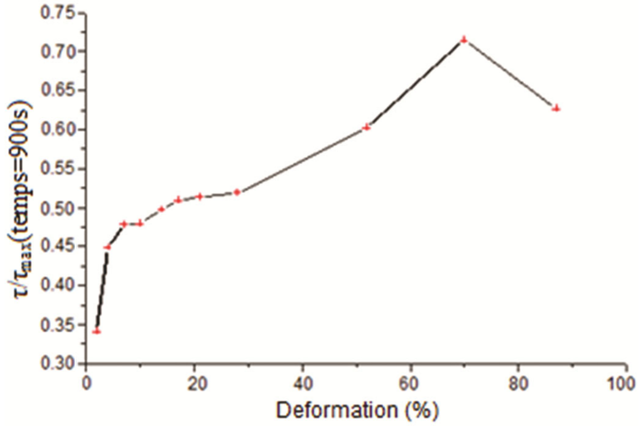

Fig. 3 — Evolution of standardized tenacity *vs* imposed deformation for yarn 100/156

3.3 Rheological Modeling

The rheological model established to describe and predict the stress relaxation behavior of the cotton covered Dorlastan® core-spun yarn is shown in Fig. 5.

For a constant extension $\varepsilon = \varepsilon_0$, the response of Kelvin Voight model [Fig. 5 (a)], standard non-linear viscoelastic model [Fig. 5(b)], and viscoplastic behavior model [Fig. 5 (c)] to the relaxation test are respectively as follows:

$$\sigma(t) = \varepsilon_0 \times E_c \quad \ldots (3)$$

$$\sigma(t) = E_{ve} \times \varepsilon_0 \times \left(\exp\left(-\frac{E_{ve}}{\eta_{ve}} \times t\right)\right) + C \times \varepsilon_0^n \quad \ldots (4)$$

$$\sigma(t) = \left(\frac{E_{vp} \times S}{\eta_{vp}} + E_{vp} \times \varepsilon_0\right) \times \exp\left(-\frac{E_{vp}}{\eta_{vp}} \times t\right) \quad \ldots (5)$$

where σ is the constraint; E_c, the elasticity modulus of the core; E_{ve}, the elasticity modulus of the nonlinear viscoelastic zone; η_{ve}, the viscosity modulus of the nonlinear viscoelastic zone; C, the coefficient of nonlinear spring; E_{vp}, the elasticity modulus of viscoelastoplastic zone; η_{vp}, the viscosity modulus of nonlinear viscoelastoplastic zone; and S, the constraint threshold.

Thus, the response of rheological model proposed to describe the stress relaxation behavior of the Dorlastan® core-spun yarn to the relaxation test is as follows:

$$\sigma(t) = \varepsilon_0 \times E_c + E_{ve} \times \varepsilon_0 \times \left(\exp\left(-\frac{E_{ve}}{\eta_{ve}} \times t\right)\right) + C \times \varepsilon_0^n + \left(\frac{E_{vp} \times S}{\eta_{vp}} + E_{vp} \times \varepsilon_0\right) \times \exp\left(-\frac{E_{vp}}{\eta_{vp}} \times t\right) \quad \ldots (6)$$

To validate the stress relaxation model, the experimental values of the relaxation curves for deformations equal to 10%, 30%, 60%, and 90% of elongation-at-break are simulated.

Figure 6 shows the experimental and theoretical relaxation curves of yarns 100/156 with various Dorlastan® drafts. As observed, the stress relaxation model fits well the experimental data of the relaxation test for the elastic core-spun yarns 100/156 with

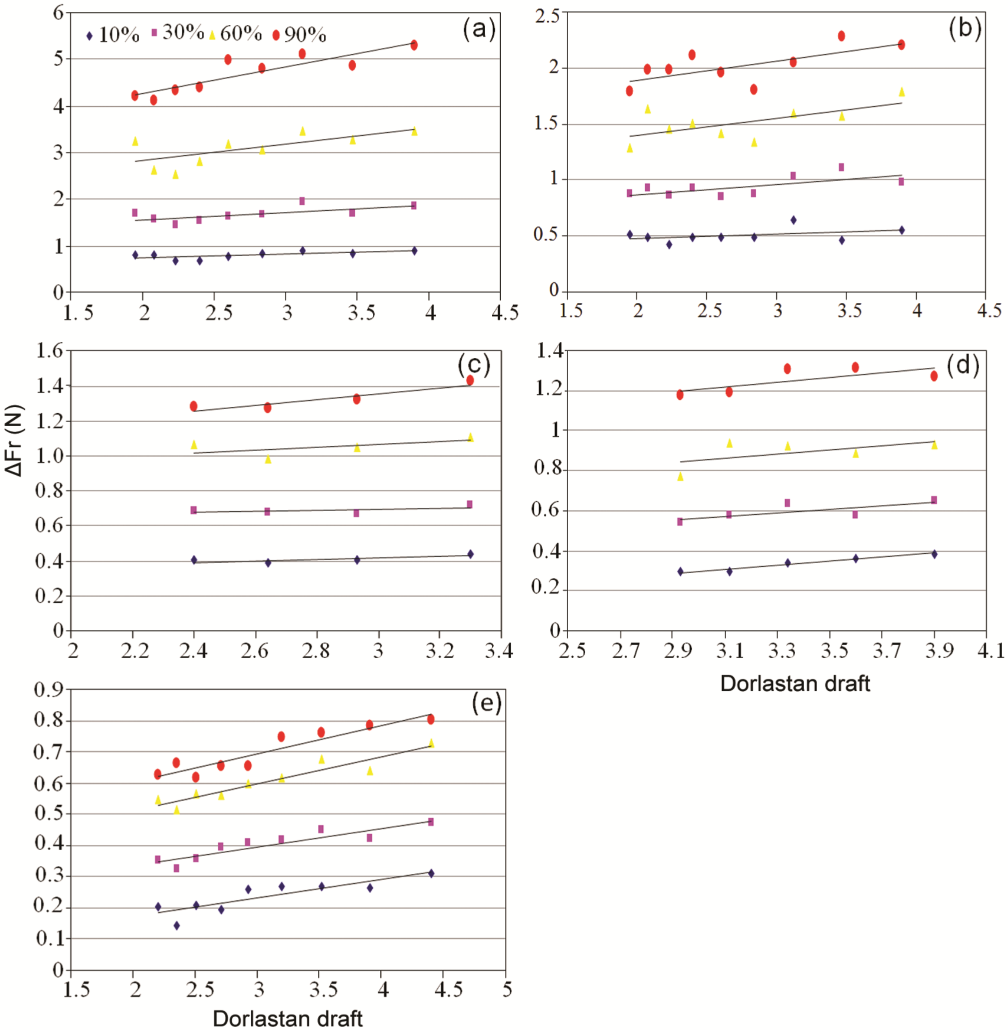

Fig. 4 — Fall of force (ΔF_r) *vs* Dorlastan® draft for yarns; (a) 100/156, (b) 50/78, (c) 33.33/78, (d) 33.33/44 and (e) 25/44

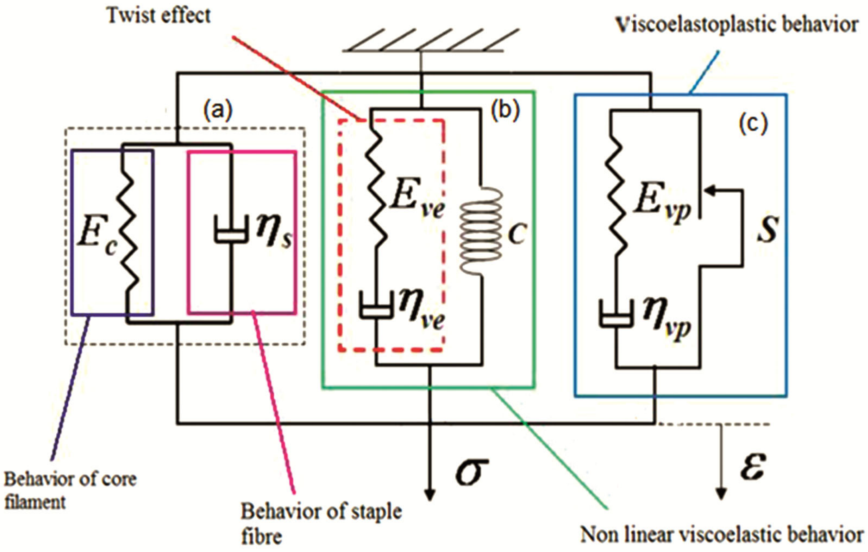

Fig. 5 — Rheological model for predicting stress relaxation behavior of elastic core-spun yarns [(a) Kelvin-Voight model, (b) standard non-linear viscoelastic model and (c) viscoplastic model]

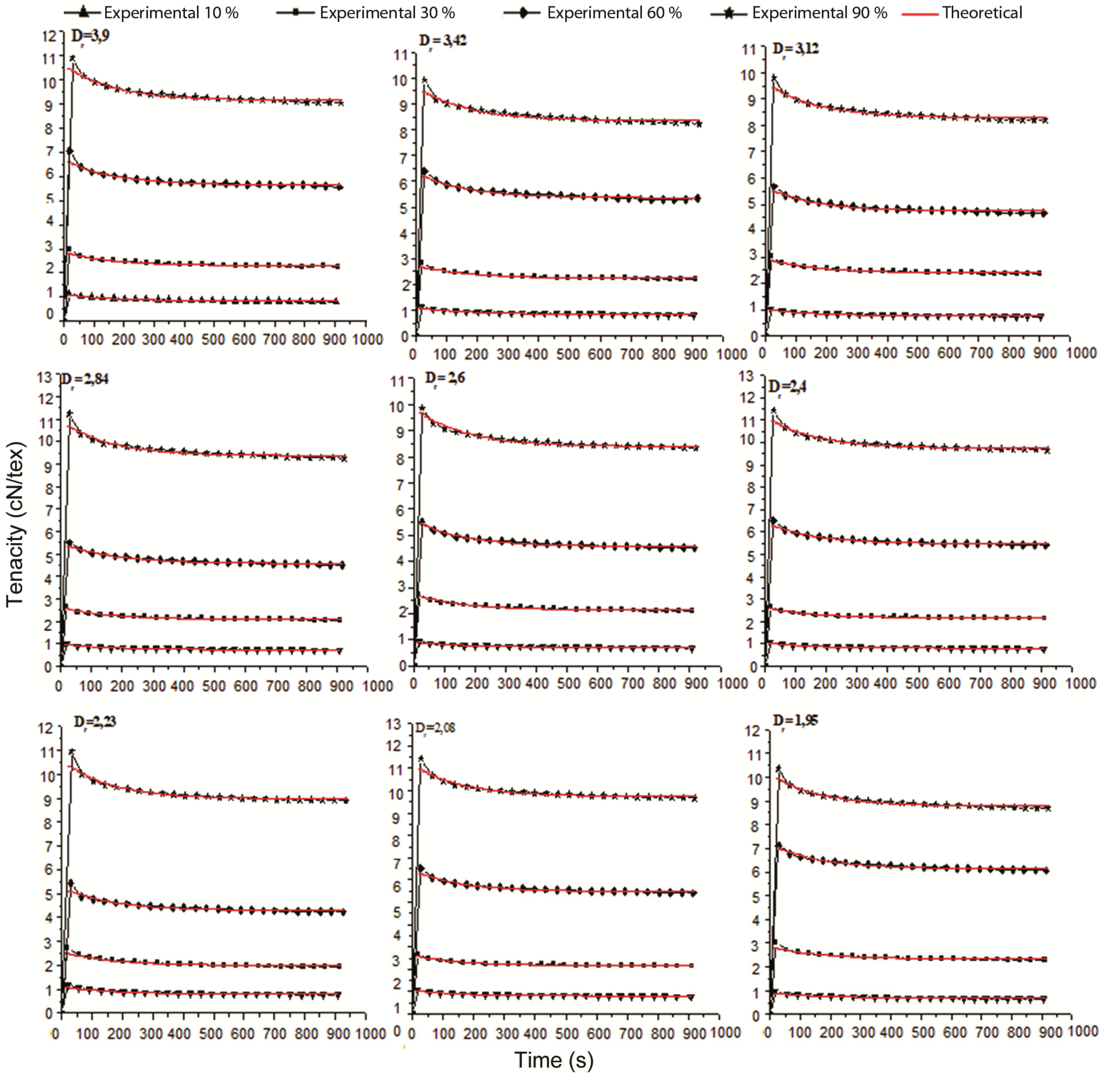

Fig. 6 — Experimental and theoretical curves of relaxation test for yarn 100/156, and for various Dorlastan® drafts

various Dorlastan drafts and for various imposed deformations. In fact, Fig. 6 shows a very good correlation between the fitted and the experimental curves.

The identification of the rheological parameters and the coefficient of determination of the yarns 100/156 for various Dorlastan® drafts and for the imposed deformation equal to 60% are displayed in Table 2. It is observed that most of the model parameters for the yarn 100/156 are almost constant for various Dorlastan® drafts and for the imposed deformations, except for E_C exhibiting a slight variation as a function of Dorlastan® drafts. Similar results are achieved for yarns 50/78, 33.33/44, 33.33/78, and 25/44.

Table 3 is a summary of the identified rheological parameters and the coefficient of determination value for yarns 100/156, 50/78, 33.33/44, and 25/44, for

Table 2 — Rheological parameters and determination coefficient values for relaxation test of the yarns 100/156 for the imposed deformation equal to 60%

Rheological parameters	Draft								
	3.9	3.47	3.12	2.84	2.6	2.4	2.23	2.08	1.95
E_c, cN/tex	0.130	0.140	0.110	0.130	0.140	0.140	0.130	0.130	0.110
η_{ve}, cN.S/tex	6.140	6.140	6.140	6.140	6.140	6.140	6.140	6.140	6.140
E_{ve}, cN/tex	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
C , cN/tex	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
N	1.890	1.890	1.890	1.890	1.890	1.890	1.890	1.890	1.890
η_{vp}, cN.S/tex	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820	0.820
E_{vp}, cN/tex	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
R^2	0.99	0.990	0.990	0.990	0.990	0.990	0.990	0.960	0.990

E_c- The elasticity modulus of core, E_{ve}- elasticity modulus of nonlinear viscoelastic zone, η_{ve}- viscosity modulus of nonlinear viscoelastic zone, C- coefficient of nonlinear spring, E_{vp}- elasticity modulus of viscoelastoplastic zone, η_{vp}- viscosity modulus of nonlinear viscoelastoplastic zone, S –constraint threshold and R^2- coefficient of determination.

Table 3 — Rheological parameters and coefficient of determination values for relaxation test of various Dorlastan core-spun yarns

Yarn	Deformation levels, %	Rheological parameters							
		E_c, cN/tex	η_{ve}, cN.S/tex	E_{ve}, cN/tex	C, cN/tex	N	η_{vp}, cN.S/tex	E_{vp}, cN/tex	R^{2*}
#100/156	10	0.110	6.140	0.020	0.002	1.890	0.820	0.030	0.930
	30	0.110	6.140	0.020	0.002	1.890	0.820	0.030	0.970
	60	0.110	6.140	0.020	0.002	1.890	0.820	0.030	0.980
	90	0.110	6.140	0.020	0.002	1.890	0.820	0.030	0.990
#50/78	10	0.170	6.140	0.020	0.002	1.890	0.820	0.030	0.940
	30	0.170	6.140	0.020	0.002	1.890	0.820	0.030	0.960
	60	0.170	6.140	0.020	0.002	1.890	0.820	0.030	0.970
	90	0.170	6.140	0.020	0.002	1.890	0.820	0.030	0.970
#33.33/44	10	0.170	6.140	0.020	0.020	1.890	0.820	0.030	0.890
	30	0.170	6.140	0.020	0.020	1.890	0.820	0.030	0.970
	60	0.170	6.140	0.020	0.020	1.890	0.820	0.030	0.980
	90	0.170	6.140	0.020	0.020	1.890	0.820	0.030	0.970
#25/44	10	0.190	6.140	0.020	0.002	1.890	0.820	0.030	0.900
	30	0.190	6.140	0.020	0.002	1.890	0.820	0.030	0.900
	60	0.190	6.140	0.020	0.002	1.890	0.820	0.030	0.930
	90	0.190	6.140	0.020	0.002	1.890	0.820	0.030	0.950

*Coefficient of determination.

Dorlastan ratio equal to 5% for each yarn corresponding to Dorlastan draft equal respectively to 3.12, 3.12, and 2.64 and 3.52 and for various imposed deformations. Table 3 reveals that the stress relaxation model parameters remain constant for various relaxation test conditions. Furthermore, the coefficient of determination value R² close to 1 for various imposed deformations confirms that the established model simulates very well the stress relaxation behavior of the elastic core-spun yarns.

3.4 Statistical Analysis

A linear regression analysis has been performed to determine the relationship between the rheological parameter E_c and the experimental parameters such as Dorlastan® draft, yarn count, and Dorlastan® count. Figure 7 shows that all the experimental values fall

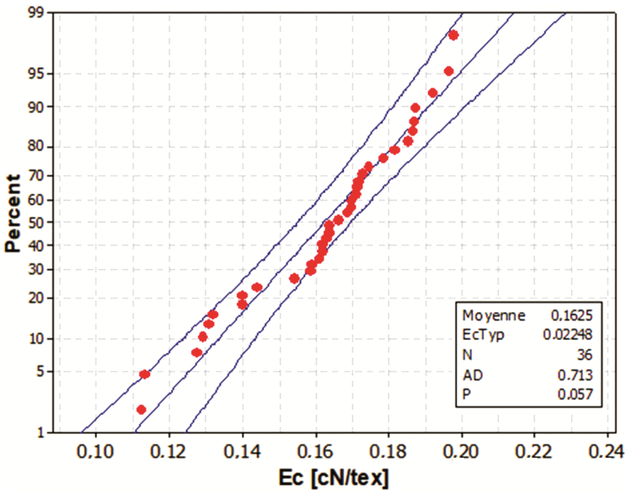

Fig. 7 —Anderson Darling test for E_c parameter for the relaxation test

according to the line layout in the confidence intervals. Also, statistically, for parameter E_C, Anderson Darling's probability value 'P' is equal to 0.057, which is higher than 0.05 (α value), thus the experimental data perfectly fit a normal distribution. The statistical model and analysis of the rheological parameter (E_c) are given below:

Factors: yarn count, tex (X_1); Dorlastan® count, dtex (X_2); and Dorlastan® draft (X_3).

Statistical model (Y) = $0.199 - 0.000090\ X_1 - 0.000396\ X_2 + 0.00067\ X_3$

$R^2 = 80\%$

Fisher coefficient (F)= 42.53

Significance threshold (P)= 0.00

The linear regression model is found significant. To examine the impact of the experimental parameters on the rheological parameter (E_c), statistical analysis is applied. P- values for yarn count, Dorlastan® count and Dorlastan® draft are 0.769, 0.057 and 0.823 respectively. It is observed that the P-value of the experimental parameters is higher than α-value equal to 0.05. Hence, the experimental parameters do not affect the rheological parameter E_c. That's why it is considered almost constant and equal to 0.2. Consequently, the response of the developed model to the relaxation test is as follows:

$$\sigma(t) = 0.2 \times \varepsilon_0 + 0.02 \times \varepsilon_0 \times exp(-0.003 \times t) + 0.002 \times \varepsilon_0^{1.89} + (0.036 \times S + 0.03 \times \varepsilon_0) \times exp(-0.036 \times t) \quad \ldots (7)$$

Hence, considering the established model [Eq.(4)], it is possible to simulate the stress relaxation behavior of the elastic core yarn under different situations and constraints, such as yarn count, Dorlastan® count, Dorlastan® draft variations, and different imposed deformations levels; as a result, several characteristic parameters needed to predict the fabric behavior will be easily identified.

4 Conclusion

The study of the elastane draft effect on the stress relaxation test of the elastic core-spun yarn with different yarn counts shows that when the elastane draft increases, the fall of force during the relaxation test is also increased. Moreover, characteristic tests, such as tensile and relaxation tests, show that the elastic core-spun yarn presents viscoelastoplastic behavior with nonlinear viscoelasticity.

Furthermore, the developed rheological model to describe the mechanical behavior of the elastic spun yarn is fitted at best the stress relaxation behavior of this yarn's type. This model is validated for the whole yarns range subject to study and it adjusted well the experimental curves with a good coefficient of determination R^2 and a high significance level.

Regarding the previous studies related to this topic in the literature, in the present work, we are, particularly, interested in modeling the stress relaxation behavior of the cotton-covered elastane core-spun yarns.

Normally, in the literature, most of the previously existing models aim at identifying the mechanical behavior based on pre-existent models (Maxwell model, Vanghluwe model, etc.) and to adjust well the experimental data of the textile materials, such as yarns, fibres, etc. That's why, in some cases, the obtained results present negative rheological parameter values without any scientific significance.

However, in this study, the approach is totally different, since a rheological model of predicting the mechanical behavior of cotton-covered elastane core-spun yarns has been established based on data collected through the tensile and relaxation tests performed.

Moreover, this model has been developed considering the specific mechanical parameters of the elastic core-spun yarns, such as elasticity modulus, viscosity modulus, constraints, elastic deformation values, viscoelastic deformation values, etc. Hence, this model can be applied to diverse elastic core-spun yarn types and different tested parameters.

In addition, the model has been validated with ANOVA statistical analysis, and it is reliable to describe and predict the stress relaxation behavior of the cotton-wrapped elastane core-spun yarns.

For future research, this work is fruitful, especially for modeling and simulating the mechanical behavior of textile structures containing cotton-covered core-spun yarns (e.g. denim fabrics) from the elastic core-spun yarn models, process parameters and data.

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