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The Behaviour of Fabric with Elastane Yarn During Stretching

Abstract
This paper presents an investigation into the behaviour of fabric with elastane yarn during stretching. The aim of the research was to study the viscoelastic part of the stress-extension curve and behaviour of fabrics with elastane yarn after one hour stretching above the yield point. Research results of the viscoelastic part of the stress-extension curve show low values of stress and extension in the yield point (extension at the yield point is from 0.25% to 0.75%), which means a larger area of the viscoelastic behaviour of the fabrics was analysed. The results of research into the viscoelastic properties of fabrics with elastane yarn also show greater differences in viscoelastic properties on the stress-extension curve above the yield point, which means that the elastane in the yarn had started to affect the viscoelastic properties, with an extension which is higher than the one at the yield point. The results of the research also show that elastic extension after one hour of stretching the fabric to the specified extension of 25% is higher than the extension at the yield point, which moves between 22.2% and 24.1%. This figure is considered to be very high.

Key words: *fabric, elastane yarn, stress-extension curve, viscoelastic properties, elastic extension.*

Introduction

During stretching, stress is applied to a textile material and causes it to stretch (extension). At the beginning of stretching, the relation between stress and extension is proportional. With further stretching, the extension begins to increase more rapidly than the stress. Consequently, the relation between stress and extension is no longer linear, and the first viscoelastic extension starts. The border between the area where the relation between stress and extension is linear (elastic region) and the area where the relation is not linear (viscoelastic region) is called the yield point, which is the limit of elastic extension where all extension is completely recoverable.

Beyond the yield point, a large part of the extension is recoverable in time (viscoelastic region). When the load is high enough, plastic extension is abserved. In practice there is no clear border between the elastic, viscoelastic and plastic behaviour of textile materials. The yield point presents the area where the orientation of the textile material is improved.

Textile materials with increased elasticity, like fabrics with elastane yarn, have a lower breaking force and higher breaking extension than ordinary fabrics, as well as a proportionally lower load and higher extension at the yield point. Fabrics with elastane yarn have a wider region of time-dependent deformations or viscoelastic regions [1].

The aim of the research was to study the stress-extension curve of fabrics with elastane yarn as well as the elastic and viscoelastic deformation after one hour of stretching the fabric to an extension of 25%, which is higher than the extension at the yield point.

The behaviour of textile material during stretching

In textile materials, both viscous and elastic properties coexist. The viscous property behaves in accordance with Newton´s liquids, while the elastic property means that which behaves in accordance with Hooke`s solids. Under lower extension the behaviour of most textile materials is linearly elastic.

When the extension becomes higher than the "limit extension", which is at the yield point, the response of the textile material is no longer elastic and reaches the viscoelastic extension, which is recoverable with a definite time component.

With a higher extension, the relation between the stress σ and viscosity η is no longer linear , which means non-linear viscoelastic behaviour. The basic characteristic of the non-linear viscoelastic part of the stress-extension curve is that the extension grows more rapidly than the input stress [2, 3].

Initially, the elastic modulus E of textile materials increases fast. Increasing the elastic modulus E depends on the force which acts on the material. At the start, the loads cause deformation in the fibres in the sheath of the yarn and position them in the direction of loading. The oriented fibres are in close contact with each other and a greater force is needed. In this case the maximum elastic modulus E (the value E_0) also occurs. The maximum elastic modulus is obtained from the curve of the first derivative of the stress-extension curve at the point where the first derivative of the stress-extension curve is maximal (σ = max) and the second derivative of the stress-extension curve is zero, $\sigma'' = 0$ (see Figure 1, page 64).

After that, the elastic modulus decreases very quickly and causes the first movements in the spun yarn fibres. From this moment on the stress is no longer proportional to the extension or deformation. The stress-extension curve changes its shape. At this point the maximum change in the velocity of the elastic modulus is reached, which means the minimum of the second derivative of the stress-extension curve (σ'' = min), and the third derivative of the stress-extension curve is zero, $\sigma''' = 0$. The point where the minimum of the second derivative of the stress-extension curve and the third derivative is zero is called the yield point σ_y, ε_y . The yield point is the numerical point obtained on the stress-extension curve and presents the limit of the elastic area on the curve. From the moment when the first flowing of fibres span in the yarn appears, the tension force does not change, and results in a decrease in the modulus. This value decreases till value E_1 when the flowing and the deformation of fibres span into yarn is the greatest.

After that, loads cause greater stresses in fibres span into yarn. They are highly stretched and cause transversal pressure in the stretch direction. Because of the transversal forces, which are a result of the radial compression of the fibres, a greater force is needed for stretching. This can be seen in the greater stress and an increase in the elastic modulus until the value E_2 [4]. The modulus E_3 presents the highest velocity of changes in the magnitude of moduli during stretching.

At the moment when fibres span into yarn can no longer resist the stretching, the yarn breaks (see ***Figure 1***).

A typical stress-extension curve for the fabrics with elastane yarn analysed is shown in ***Figure 1***.

Elastic and time-dependent deformations

Textile materials are very complex and anisotropic. At the beginning of drawing a textile material, the deformation is completely recoverable, but this is a very straight region and extends to the yield point. This region consists of elastic deformations, which are completely recoverable after stretching (see ***Figure 1***). Increasing the load beyond the yield point results in the movement of fibres in the core of the yarn, which causes time-dependent deformation. The time-dependent deformation is also recoverable, which recovers with time and depends on the initial load. The area with time-dependent deformation is also called the non-linear viscoelastic field. The relation between the stress and extension is no longer linear; on the contrary, the extension grows more rapidly than the stress, which also causes changes in the the stress extension curve. In fabrics with elastane yarn, the first part of the curve with elastic deformation is very straight – but more interesting is the second part of the curve (above the yield point), the region of time-dependent deformations which extends between the yield point and modulus E_2 ,where the first permanent movements of fibres in the yarn begin [4, 5].

Methods

Based on the given theoretical elements, the investigation into the behaviour of fabrics with elastane yarn during stretching was focused on four two-way stretch and one one-way stretch wool woven fabrics which were intended for making trousers. All fabrics were of twill weave *T 1:2* and had incorporated elastane multifilament in the yarn with a different percentage of elastane content, between 0% and 6.6%.

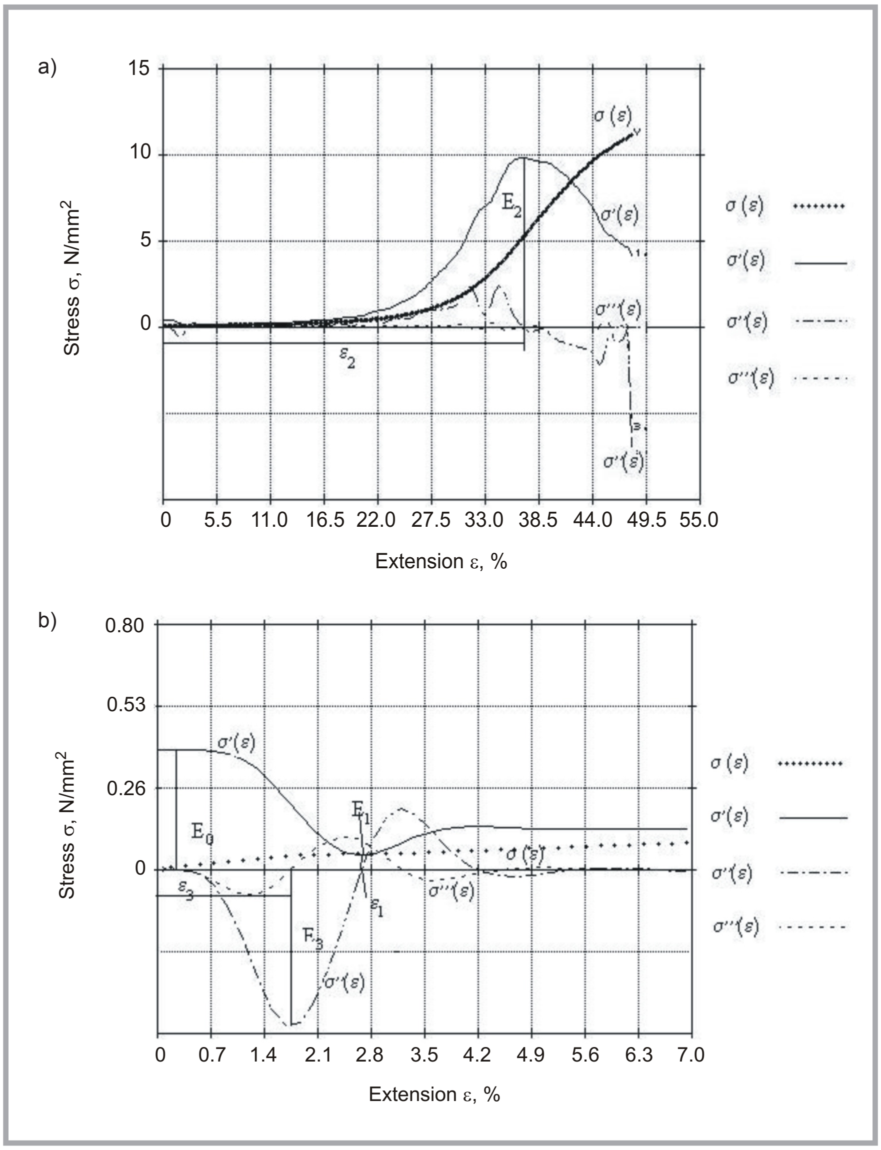

Figure 1. *Average stress-extension curve $\sigma(\varepsilon)$ for the fabrics with elastane yarn analysed; a – stress-extension curve with modulus E_2 and extension ε_2; b – part of the stress-extension curve $\sigma(\varepsilon)$ and derivatives of the curve, with extension till 7 %; $\sigma'(\varepsilon)$ – first derivative of the stress-extension curve, $\sigma''(\varepsilon)$ – second derivative of the stress-extension curve, $\sigma'''(\varepsilon)$ – third derivative of the stress-extension curve, E_0 – elasticity modulus, E_1 – modulus in the second turn of the first derivative curve $\sigma'(\varepsilon)$, E_3 - the highest velocity of change in the magnitude of moduli during stretching, ε_0 – extension with modulus E_0, ε_1 – extension with modulus E_1, ε_3 – extension with modulus E_3.*

The first part of the research focused on the stress-extension curve which was obtained by stretching the specimen, using the standard method, to the extension and force at rupture [6]. From the stress-extension curve, the viscoelastic parameters were calculated with a *DINARA* program [6].

For the investigation into the deformation of textile material during one hour of stretching the fabric to the specified deformation (25%), a method based on Standard DIN 53835 was used [7]. Using the Standard DIN 53835 method, the elastic and viscoelastic extension (time-dependent extension) was measured after one hour of maintaining the specified deformation [7].

General properties of the fabrics used are listed in ***Table 1***.

Correlation and regression analysis

With correlation and regression analysis, the relation between two random variables of the specimen are discussed and their accordance (for example: the relation between the percentage of elastane content in the yarn and the elastic extension of the fabric). The relation between random variables is represented by the correlation coefficient r_{xy}.

Correlation coefficient r_{xy}, also called Pearson's product moment correlation, after Karl Pearson, is calculated by [8]:

$$r_{xy}=\frac{\frac{1}{n}\sum_{i=1}^{N}(x_i-\bar{x})\cdot(y_i-\bar{y})}{\sqrt{\frac{1}{n}\sum_{i=1}^{N}(x_i-\bar{x})^2\cdot\frac{1}{n}\sum_{i=1}^{N}(y_i-\bar{y})^2}}. \quad (1)$$

Where x_i and y_i are two random variables (i = 1, 2, 3 to n), $\bar{x}$ and $\bar{y}$ are the mean values of the two random variables.

The correlation coefficient may take any value between −1.0 and +1.0. The correlation coefficient is 1.0 in the case of an increasing linear relationship, −1.0 in the case of a decreasing linear relationship, and some value in between in all other cases, indicating the degree of linear dependence between the variables. The closer the coefficient is to either −1.0 or 1.0, the stronger the correlation between the variables [8].

The significance of the correlation coefficient is determined by testing the null hypothesis H_0 (r = 0) from the point of view of alternative hypothesis H_1 ($r \neq 0$), using Student`s t-Test with the equation:

$$t=\frac{r_{xy}}{s_r}=\frac{r_{xy}}{\sqrt{1-r_{xy}^2}}\cdot\sqrt{N-2} \quad (2)$$

where s_r is standard error of the correlation coefficient, and N is the number of tests.

$$s_r=\frac{\sqrt{1-r_{xy}^2}}{N-2} \quad (3)$$

If the calculated value of t is smaller than the read value from the table of the t-distribution t_{tab} ($t \leq t_{tab}$) with the statistical confidence S = 95% and degree of freedom $k = N - 2$, then the null hypothesis H_0 (r = 0) is valid. This means that the correlation between variables x and y is random and not significant. Conversely, if the calculated value of it is greater than the read value from the table of the t-distribution t_{tab} ($t \geq t_{tab}$) with the statistical confidence S = 95 % and degree of freedom $k = N - 2$, then the null hypothesis is rejected. This means that value of correlation coefficient r_{xy} is statistical significant.

The correlation coefficient is closely related to the linear regression. The square of R^2 is called the regression coefficient and denotes the portion of total variance explained by the regression model [8].

The regression coefficient also takes any value between –1.0 and +1.0 and is calculated by

$$R^2=\frac{a\sum_{i=1}^{N}y_i+b\sum_{i=1}^{N}x_iy_i-\frac{(\sum_{i=1}^{N}y_i)^2}{N}}{(\sum_{i=1}^{N}y_i)^2-\frac{(\sum_{i=1}^{N}y_i)^2}{N}} \quad (4)$$

__Table 1.__ General properties of the fabrics.

Fabric	Thickness, mm	Mass, $m \cdot gm^{-2}$	Yarn density per 10 mm		Fabric type	Percentage of elastane in the yarn, %	
			Warp	Weft		Warp	Weft
Wo/El – O	0.51	232.6	35	24	One-way stretch	0	5.4
Wo/El – T1	0.44	201.2	28	26	Two-way stretch	4.3	4.6
Wo/El – T2	0.47	229.8	31	29		6.6	6.4
Wo/El – T3	0.44	237.7	39	36		4.9	4.8
Wo/El – T4	0.65	233.0	33	22		3.4	3.3

Results and discussion

The results of the investigation into the behaviour of fabrics with elastane yarn during stretching are represented as:

- Results of the viscoelastic properties of the fabrics with elastane yarn analysed.
- Results of elastic and viscoelastic extension after one hour of maintaining the specified deformation.
- Results of correlation and regression analysis.

Results of the viscoelastic properties of the fabrics with elastane yarn analysed

Results for the viscoelastic properties calculated from the average stress-extension curve are listed in ***Table 2***.

The analysis of viscoelastic parameters shows that fabrics with elastane yarn have a low value of elasticity modulus, and hence low resistance to the acting force during measuring. Table 2 shows interesting results for the stress and extension at the yield point, which was very low for all fabrics (from 0.25% till 0.75%, see ***Table 2***). It also means that a very small area of elastic deformation and a larger area of viscoelastic behaviour in the fabric was analysed. A wider viscoelastic area in used fabrics with elastane in the yarn is the consequence of the way of deformation of the elastane yarn. At the beginning of loading, there is deformation of the fibres in the sheath of the yarn, and the elastane in the core has no effect on the behaviour of the yarn during stretching. From the moment

__Table 2.__ Viscoelastic properties of stretched fabrics.

Viscoelastic parameters	Fabric									
	Wo/El – O		Wo/El – T1		Wo/El – T2		Wo/El – T3		Wo/El – T4	
	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
Breaking stress - σ_{pr}, Nmm^{-2}	13.65	5.64	11.02	9.21	9.31	5.60	11.74	6.22	11.21	6.23
Breaking extension - ε_{pr}, %	34,40	49.25	48.00	56.50	39.50	32.50	46.19	54.94	47.85	37.50
Elasticity modulus - E_0, Nmm^{-2}	0.095	0.051	0.075	0.071	0.079	0.071	0,077	0,073	0,075	0,071
Extension with E_0 - ε_0, %	0.050	0.050	0.075	0.075	0.075	0.075	0,077	0,075	0,077	0,075
Stress in the yield point, - σ_y, Nmm^{-2}	0.048	0.032	0.041	0.043	0.021	0.0312	0.042	0.040	0.035	0.037
Extension at the yield point - ε_y, %	0.75	0.75	0.50	0.75	0.25	0.50	0.25	0.50	0.50	0.75
Modulus - E_1, Nmm^{-2}	0.030	0.002	0.010	0.0010	0.005	0.0007	0.007	0.0005	0.005	0.0005
Extension with E_1 - ε_1, %	1.0	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4
Modulus - E_2, Nmm^{-2}	1.048	0.329	0.66	0.53	0.712	0.534	0.813	0.737	0.623	0.574
Extension with E_2 - ε_2, %	15.00	43.75	39.75	47.25	33.50	29.75	35.87	31.74	27.88	28.35
Modulus - E_3, Nmm^{-2}	-0.051	-0.058	-0.15	-0.083	-0.157	-0.120	-0.145	-0.075	-0.178	-0.067
Extension with E_3 - ε_3, %	0.75	0.75	0.50	0.75	0.25	0.50	0.25	0.50	0.50	0.75

when the increasing load causes transversal pressure in the fibres in the sheath of the yarn on the elastane in the core, the elastane in the core begins to affect the mechanical properties of the yarn. That is the reason for the higher breaking extension of fabrics Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4, which were two-way stretched. Because the elastane in the yarn had started to affect the value of extension of the fabric with the load, which was higher than the load at the yield point, there were only small differences among the values of the stresses and extensions at the yield point and modulus E_0 with extension ε_0 of the fabrics analysed .

Results show that there are higher differences between the fabrics with modulus E_1, whereas among the values of modulus E_0, there were small differences. Modulus E_1 is the point on the stress-extension curve where an increasing load causes transversal pressure in the fibres in the sheath of the yarn on/in the elastane in the core; this is when the elastane in the core begins to affect the value of modulus E_1. Modulus E_1 also represents the lowest modulus of the stress-extension curve and modulus of the viscoelastic region, where the deformation is recoverable with time (see Figure 1). The highest modulus E_1 was calculated for fabric Wo/El – O, which was one-way stretch (with elastane only in the weft direction), whereas for two-way stretch fabrics Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4, the calculated values of modulus E_1 were quite similar.

In short, the values of moduli E_1, E_2 and E_3 were quite similar among the fabrics analysed. The exception was fabric Wo/El – O, where the mentioned moduli were much higher in the warp direction, where elastane was not incorporated in the yarn. Consequently, the lowest value of extensions ε_1, ε_2 and ε_3 were measured with one-way stretch fabric Wo/El – O (see ***Table 2,*** see page 65).

It was found that there are greater differences in extensions ε_1, ε_2 and ε_3 between the one-way (Wo/El – O) and two-way stretch fabrics used (Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4), while the differences between extension ε_0 of corresponding moduli E_0 are hardly noticeable. A lower load (under the yield point) results in an extension of the fibres in the sheath of the yarn, and the elastane in the core of the yarn does not have any influence on the extension of the yarn; however, by increasing the load above the yield point, when the fibres in the sheath are stretched and cause a transversal pressure in the stretch direction, the elastane in the yarn influences the extension value of the fabric.

Results of elastic and viscoelastic extension of fabric after one hour keeping to the specified deformation

Results of the elastic and viscoelastic extension of analysed fabrics after one hour keeping to the specified deformation are listed in ***Table 3***.

The analysis of results of elastic and viscoelastic extension of the fabrics after one hour of keeping to the specified deformation shows differences between one-way stretch and two-way stretch fabrics.

The results show that two-way stretch fabrics with a higher value of elastane incorporated in the yarn also have a higher elastic extension, and consequently higher elastic recovery. The analysis shows that fabric Wo/El – O has the lowest extension, which is one–way stretch with elastane incorporated only in the weft direction, while for the two-way stretch fabrics (Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4), the value of elastic extension is much greater, and higher elastic recovery is also expected (see ***Table 3***). Results of elastic extension show that after one hour of keeping the fabric under the specified deformation of 25%, the elastic extension is still high and amounts for two-way stretch fabrics in the warp direction, from 23.0% to 24.1%, while the total extension for these fabrics amounts to 25.0% (see ***Table 3***). From the results of elastic extension of two-way stretch fabrics Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4, it can be observed that there are small differences in the values of elastic extension of two-way stretch fabrics. Two-way stretch fabrics have an elastane content from 3.3% to 6.6% in the yarn, and it seems that the percentage of elastane content in the yarn does not have a significant influence on the elastic extension of two-way stretch fabrics Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4;however, statistical analysis showed that when comparing one-way stretch fabric Wo/El – O and two-way stretch fabrics, the elastane content in the yarn has a significant influence on the elastic extension.

Fabric Wo/El – O, which is one-way stretch and has an elastic extension of only 22.2% in the warp direction (see ***Table 3***).

These results were to be expected because the elastane in the yarn behaves like a spring, which tends to return to its original length after stretching. As with a spring, the recovery of core-spun elastane yarn is not 100 percent because the fibres in the sheath of the yarn exert transversal pressure on the elastane core and prevent the recovery of the yarn; even the input load was lower than the load at the yield point.

Analysis of the results shows that two-way stretch fabrics Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4 with a higher value of elastane in the yarn also have a higher elastic extension than the one-way stretch fabric Wo/El – O after further subjecting it to the deformation which belongs to the viscoelastic area of the stress-extension curve. It was also found that two-way stretch fabrics have an elastane content of 3.3% to 6.6% in the yarn, and it seems that the percentage of elastane content in the yarn does not have a significant influence on the elastic extension of the two-way stretch fabrics

Table 3. *Elastic and viscoelastic extension of analysed fabrics after one hour keeping with specified deformation.*

Fabric	Direction	Extension after one hour of keeping to the specified deformation (25.0 %)		
		Total extension, %	Elastic extension, %	Viscoelastic extension, %
Wo/El – O	Warp	25.0	22.2	2.8
	Weft	25.0	23.3	1.7
Wo/El – T1	Warp	25.0	23.0	2.0
	Weft	25.0	23.3	1.7
Wo/El – T2	Warp	25.0	23.8	1.2
	Weft	25.0	24.1	0.9
Wo/El – T3	Warp	25.0	23.1	1.9
	Weft	25.0	23.3	1.7
Wo/El – T4	Warp	25.0	22.8	2.2
	Weft	25.0	23.0	2.0

Table 4. *Correlation and regression coefficients, t-Test and significance of the correlation coefficient between the percentage of elastane content in the yarn and modulus E_1.*

Number of tests - N	Percentage of elastane content in the yarn (warp and weft direction) - x_i, %	Modulus E_1, y_i (Nmm^{-2}) (warp and weft direction)	The significance of correlation coefficient, r_{xy}
1	0.0	0.030	Statistical significant ($t \geq t_{tab}$), S = 95 %, k = N – 2, H_0 (r = 0)
2	5.4	0.002	
3	4.3	0.010	
4	4.6	0.0010	
5	6.6	0.005	
6	6.4	0.0007	
7	4.9	0.007	
8	4.8	0.0005	
9	3.4	0.005	
10	3.3	0.0005	
Correlation coefficient, r_{xy} (equation (1))			- 0.862
Regression coefficient, R^2 (equation (4))			0.743
t-Test (t, calculated value) (equation (2))			4.808
t-Test (t_{tab}, S = 95 %, k = 8)			2.310

Table 5. *Correlation and regression coefficients, t-Test and significance of the correlation coefficient between the percentage of elastane content in the yarn and the elastic extension of the fabrics analysed.*

Number of tests - N	Percentage of elastane content in the yarn (warp and weft direction) - x_i, %	Elastic extension $\varepsilon 1$ (warp and weft direction), %	The significance of correlation coefficient, r_{xy}
1	0.0	22.2	Statistical significant ($t \geq t_{tab}$), S = 95 %, k = N – 2, H_0 (r = 0)
2	5.4	23.3	
3	4.3	23.0	
4	4.6	23.3	
5	6.6	23.8	
6	6.4	24.1	
7	4.9	23.1	
8	4.8	23.3	
9	3.4	22.8	
10	3.3	23.0	
Correlation coefficient, r_{xy} (equation (1))			0.920
Regression coefficient, R^2 (equation (4))			0.846
t-Test (t, calculated value) (equation (2))			6.763
t-Test (t_{tab}, S = 95 %, k = 8)			2.310

(Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4) used in the investigation. However, statistical analysis showed that when comparing the one-way stretch fabric Wo/El – O and two-way stretch fabrics, the elastane content in the yarn has a significant influence on the elastic extension.

Results of correlation and regression analysis

The results of correlation between the percentage of elastane content in the yarn of the fabrics analysed, modulus E_1, the percentage of elastane content in the yarn, the elastic extension of the fabrics, and the regression analysis are listed in ***Tables 4*** and ***5***.

The correlation and regression analysis shows that the correlation between variable x (percentage of elastane content in the yarn) and variables y (modulus E_1 and elastic extension, see ***Tables 4*** and ***5***) is very good. The correlation coefficient of the correlation between the percentage of elastane content in the yarn and modulus E_1 is - 0.862 (see ***Table 4***) and the correlation between the percentage of elastane content in the yarn and elastic extension amounts to 0.920 (see ***Table 5***). Analysis of the t-Test shows that the calculated values of t are greater than that from the table of the t-distribution t_{tab} ($t \geq t_{tab}$) with statistical confidence S = 95 % and degree of freedom $k = N - 2$ for both of the regression coefficients mentioned. This means that the null hypothesis is rejected, and the value of correlation coefficient r_{xy} is statistically significant.

The significance of the correlation between the percentage of elastane content in the yarn and modulus E_1 means that with an increasing elastane content in the yarn, modulus E_1 begins to decrease,which means a decreasing linear relationship (r_{xy} = - 0.862). Conversely, the correlation coefficient of the correlation between the elastane content in the yarn and the elastic extension has a positive value (r_{xy} = 0.920), which means that the relation between the variables mentioned is increasing linear.

Statistical analysis included modulus E_1, among others, in the paper as well as viscoelastic parameters, because similar values of correlation and regression coefficient were also expected with other viscoelastic parameters calculated.

Based on statistical analysis, it can be stated that the percentage of elastane content in the yarn of the fabrics analysed has a significant influence on modulus E_1 and the elastic extension after one hour of keeping to the specified deformation, which is above the yield point in the stress-extension curve.

Conclusions

Based on the investigation into the behaviour of fabric with elastane yarn during stretching, we can conclude that the fabrics with elastane yarn analysed have a low value of stress and extension at the yield point; the extension in the yield point moves from 0.25% to 0.75%.

The area of elastic deformation of the stress-extension curve of the fabrics analysed is consequently very small. However, the field of viscoelastic deformation which are recoverable with time is wider. Due to the elastane incorporated in the yarn, lower values of moduli and greater differences between the moduli were expected, because the percentage of elastane content in the yarn of the fabrics analysed was moved between 0% and 6.6%. However, the elastane in the yarn of the fabrics analysed had started to influence the viscoelastic properties with extension, which was higher than the extension at the yield point. Therefore, the first of the greater changes amongst the viscoelastic parameters were calculated with the point of modulus E_1 and corresponding extension ε_1, as well as further viscoelastic parameters on the stress-extension curve.

Even after one hour of keeping the fabric under the specified deformation of 25%, the elastic extension was still high (from 23.0% to 24.1%) for fabrics Wo/El – T1, Wo/El – T2, Wo/El – T3, Wo/El – T4, which is much higher than the elastic extension of fabric Wo/El – O, which is one-way stretch. Higher elastic extension also means higher elastic recovery.

Comparing the fabrics analysed, it can be concluded that they have a wider field of viscoelastic deformation. The percentage of elastane content in the yarn starts to influence the viscoelastic properties of the fabrics above the yield point. Elastic extension after one hour of keeping the fabric to the specified extension, which is higher than the yield point, is from 22.2% to 24.1 %.

The percentage of elastane content in the yarn has a significant influence on the elastic extension after one hour of stretching above the yield point, as well as on the viscoelastic properties of the fabrics analysed.

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