The Effect of Spandex Yarn on Structural Parameters and Elasticity of Polyamide-Spandex Knitted Fabric

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Abstract

This study used three types of knitted fabric, which have similar knitted structure and differ in use of yarns. Each fabric used two types of yarn, the first one being the same for three fabrics, the second one is different. The first yarn was wound yarn, it was composed of one PA texture multi-filament yarn and one covered yarn (the core component is spandex monofilament; the covered component is composed of PA texture multi-filament yarn). The second yarn is spandex mono-filament yarn, it was different for three fabrics. This research was studied the effect of spandex content of fabric, fineness and structure of spandex yarn on the structural parameters and elasticity of fabrics. The tests to determine the structural parameters and elasticity of fabrics were carried out according to the Vietnamese or international standard methods. The results of the study showed that the fineness of spandex yarn (second yarn) is the important factor that could effect on the elasticity of fabric.

Keywords: knitted fabric, elasticity of fabric, fineness of yarn, structure of yarn, spandex.

1. Introduction

In recent years, there has been increasing interest in the use of compression garments in many areas such as medical textile, sportive clothing and body-shaping clothing etc [1, 4, 6]. All these garments use the similar principle to create pressure on the surface of the body, they are usually made of high elastic fabric. When compression garments are wearing, fabric is always extended, but, due to its elasticity, it is always tended to shrink back to its original length (un-stretched state), thank to that, the pressure is created on the curvature surface of the body. The produced pressure is proportional to the stretching force on the curvature of the body [7]. Therefore, fabric of compression garments is usually made in knitted structure of high elastic yarns including spandex yarn. Depending on the required pressure, the spandex content of fabric could be varied from 2 to 30%. In this type of fabric, spandex component may be pure spandex filament yarn or composite yarn with the core spandex [2, 5, 8]. All spandex-related factors have a close relationship to the structural parameters of fabric and further, thus changes its mechanical properties and ability to create pressure on the body surface. This is the reason, in this paper, the effect of spandex yarn on the structural parameters and elasticity of polyamide-spandex knitted fabric was studied.

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2. Experimental

2.1 Material

In this study, three types of knitted fabric were used they are coded as follows: F1, F2, F3. These three fabrics have similar knitted structure and differ in use of yarns. Each fabric uses two types of yarns, the first one is the same for three fabrics, the second one is different.

The used yarns

Y1: wound yarn, it was composed of one PA texture multi-filament yarn (DTA 78 dtex f48 Z) and one covered yarn (core component is spandex mono-filament yarn; the covered component is composed of 35 PA texture filaments).

Y2: 100% spandex mono-filament yarn but Y2 are different for each fabric.

Y21: Spandex mono-filament yarn: 210 dtex

Y22: Spandex wound yarn composed of two Spandex mono-filament yarn: 140dtex + 210dtex

Y23: Spandex wound yarn composed of two Spandex mono-filament yarn: 140 dtex x 2

Knitting pattern

Knitting pattern of these three fabrics is simillar, its schema of worked needles is shown in Fig 1.

Figure 1 shows that knitting pattern of these three types of fabric includes 4 courses and 4 wales, in the courses 1,2, 3 all the loops were knitted by first yarn (Y1), the fourth course used second yarn (Y2), but in this course, there are every one knitted loop followed three miss loops.

8	X				X				Y2
7	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Y1
6	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Y1
5	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Y1
4	X				X				Y2
3	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Y1
2	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Y1
1	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	Y1
	1	2	3	4	5	6	7	8	

Fig 1. Schema of worked needles of fabrics

During knitting, loop length was similarly designed for these three fabrics. The dyeing and finishing process were also similar for them. Knitting process was carried out at Phu Vinh Hung Company on the Cixing circular knitted machine, dyeing and finishing process were carried out at X 20 company.

2.2 Methods

2.2.1. Determination of structural parameters of fabrics

The knitted structure of fabrics was determined according to the standard method ISO 7211 -1 – 84

The course and wale densities of fabric were determined according to the standard method TCVN 5794 – 1994.

The weight of fabrics was determined according to the standard method TCVN 4897-89.

The thickness of fabrics was determined according to the standard method ISO 5084 using Mitutoyo ABSOLUTE equipment.

The fiber content of fabrics was determined according to the standard method ISO 1833 – 2006.

2.2.2. Determination of the elasticity of fabrics in course and wale directions under different elongations of fabrics

Elasticity of knitted fabrics in the wales and course directions was determined at the fabric extension of 20, 40, 60, 80, 100 and 120% according to the standard method NF G07-196.

The samples were prepared as follows:

Dimensions of the samples (LxB) were 100mm x 50mm respectively. There were five samples for each type, direction and elongation of fabric.

Each sample was stretched to the designed elongation on the Testometric M350-5kN, then the sample was kept at this stretched state for the period of 30 minutes (5 samples for each elongation). After that, the sample was removed from the machine and it was relaxed for 30 minutes.

The elasticity of the sample was calculated by the following formulas.

$$E = \frac{A_0 - A_1}{A_0} 100 \ (1)$$

$$A_0 = \frac{L_0}{L} 100 \ (2)$$

$$A_1 = \frac{L_1}{L} 100 \ (3)$$

E (%) – Elasticity of fabric;

A_0 (%) – Imposed extension of sample (they were 20, 40, 60, 80, 100 and 120%);

A_1 (%) – Residual (un-recovered) extension of sample after 30 minutes of relaxation;

L_0 (mm) – Imposed elongation of sample; Corresponding to the earlier designed extension, they were 20, 40, 60, 80, 100, 120 mm respectively;

L_1 (mm) – Residual (un-recovered) elongation of samples after 30 minutes of relaxation; (L_1 is average value of five samples);

L (mm) – Initial length of samples, (L =100 mm).

All these experiments were carried out at the Testing Center of Textile Research Sub-Institute.

3. Results and disscution

3.1. Effect of the spandex component on the structural parameters of fabrics

The determined structural parameters of 3 types of fabric are presented in the table 1.

Table 1 shows that there were the clear difference in the spandex content of three fabrics, this value of sample F1 is the highest and that of sample F3 is lowest. This phenomenon is contrary with the ealier expectation (the higher fineness of the spandex yarn, the greater spandex content of fabric). However, it may be explained by yarn structure. F2, F3 used wound filament yarns including 2 components, so their tension on the knitted machine may be needed higher than those of the mono-filament yarn (for F1) to be knitted. It may be that the high tension of yarn on the knitted machine make the spandex content of F2 and F3 lower than that of F1. If the comparison is limited for the wound yarns (F2 and F3), it could say that the higher fineness of the spandex yarn, the greater spandex content of fabric. About other structural parameters such as weight, thickness or density of fabrics, there were not clear difference between these three fabrics.

Table 1. Structural parameters of fabric

Structural parameters			Knitted fabrics		
Parameters		Used standards	F1 Y21 (210 Denier)	F 2 Y22 (210D +140D)	F 3 Y23 (140 Dx2)
Weight of fabric (g/m^2)		TCVN 4897-89	306.52	277.72	305.12
Thickness of fabric (mm)		ISO 5084	1.069	0.853	1.068
Fiber content of fabric (%)		ISO 1833 - 2006	79.5% Polyamide; 20.5% Spandex	84.2% Polyamide; 15.8% Spandex	88.8% Polyamide; 11.2% Spandex
Line density of fabric	Number of wales / 100mm	TCVN 5794 – 1994	230	230	280
	Number of courses /100mm		320	320	296
Surface density of fabric	Number of loops/100 cm^2	Number of wales / 10cm X Number of courses /10cm	73.600	73.600	82.880

Table 1 shows that there were the clear difference in the spandex content of three fabrics, this value of sample F1 is the highest and that of sample F3 is lowest. This phenomenon is contrary with the ealier expectation (the higher fineness of the spandex yarn, the greater spandex content of fabric). However, it may be explained by yarn structure. F2, F3 used wound filament yarns including 2 components, so their tension on the knitted machine may be needed higher than those of the mono-filament yarn (for F1) to be knitted. It may be that the high tension of yarn on the knitted machine make the spandex content of F2 and F3 lower than that of F1. If the comparison is limited for the wound yarns (F2 and F3), it could say that the higher fineness of the spandex yarn, the greater spandex content of fabric. About other structural parameters such as weight, thickness or density of fabrics, there were not clear difference between these three fabrics.

3.2. The elasticity of fabrics under different elongations

3.2.1. The elasticity of fabrics in the course direction

Following the method presented in 2.2.2. subsection, there were five samples of each fabric at each extension. The average value of length after relaxation ($L+L_1$) of 5 samples and their coefficient of variation were presented in the table 2.

Table 2 shows that the values of coefficient of variation are very small in all case, that means the measured results of one case study were quite stable, so these average values are sufficiently reliable for the further calculations.

From the average values (AV) of table 2, the values A_0, A_1 and E were calculated according to the formulas (2), (3) and (1) respectively. The calculated values of elasticity of fabrics in course direction under specified elongations are presented in the table 3

Table 2. The average values (AV) and coefficient of variation (CV) of length of 5 samples after relaxation ($L+L_1$) for three fabrics

Extension of samples (%)	Length of the samples after relaxation ($L+L_1$) for fabric					
	F1		F2		F3	
	AV (mm)	CV (%)	AV (mm)	CV (%)	AV (mm)	CV (%)
20	101	0.83	101	0.54	101	0.70
40	103	0.53	102	0.87	103	0.53
60	104	0.68	104	0.96	103	0.69
80	105	0.52	105	0.80	105	0.52
100	106	0.79	107	1.07	105	0.67
120	108	0.51	108	0.77	107	0.66

Table 3. Elasticity of fabrics in course direction at different extensions

Extension of samples A_0 (%)	Elasticity of fabrics in course direction E (%) for fabric		
	F1	F2	F3
20	95.00	95.00	95.00
40	92.50	95.00	92.50
60	93.33	93.33	95.00
80	93.75	93.75	93.75
100	94.00	93.00	95.00
120	93.33	93.33	94.16

The results from table 3 show that the elasticity of all fabrics at extension from 20% to 120% are quite good, the highest value of elasticity is 95%, the lowest value is 92.5%. For all these three fabric, elasticity showed tendency to decrease in increasing of extention of the samples. However, this reduction is quite small, the elasticity of these fabrics decreased only about 2% when the extension were increased from 20 to 120%. It could say that these three fabrics have a good elasticity in course direction, even at the extension of 120% the elasticity of fabrics are still very good with the values of 93.33; 93.33; 94.16 correspondingly to F1, F2, F3 respectively.

Besides, it was hard to find the effect of spandex content, fineness of spandex yarns or structure of spandex yarns on elasticity of fabic. Three variables may be too much to indicate a clear relationship between elasticity of fabric and these factors.

3.2.2. The elasticity of fabrics in the wale direction

The elasticity of fabric in wale direction was also determined by the method presented in the 2.2.2 subsection. The average values (AV) of length after relaxation ($L+L_1$) of five samples for each extension and their coefficients of variation (CV) were presented in the table 4.

Table 4. The AV of length of five samples after relaxation ($L+L_1$) and their coefficient of variation (CV) of three fabrics at different extensions

Extension of samples (%)	Length of the samples after relaxation ($L+L_1$) of fabric					
	F1		F2		F3	
	AV (mm)	CV (%)	AV (mm)	CV (%)	AV (mm)	CV (%)
20	101	0.44	101	0.54	101	0.54
40	102	0.44	102	0.53	102	0.54
60	103	0.44	103	0.43	103	0.53
80	106	0.79	104	0.80	104	0.52
100	107	0.78	105	0.52	105	0.80
120	108	0.41	107	0.51	107	1.07

Similarly to the results of table 2, the values of coefficient of variation in the table 4 are quite small, so the average values in the table 4 could be used to calculate the elasticity of fabrics in wale direction. From the average values of ($L+L_1$), the values of A_0, A_1 were calculated following the formulas 2 and 3. Then the values of E for each extension of three fabrics were calculated following the formula 1, and the calculated values of elasticity in wale direction of all fabrics at different extensions are presented in table 5

Table 5: Elasticity of fabrics in wale direction at different extensions

Extension of samples A_0 (%)	Elasticity in wale direction E (%) of fabric		
	F1	F2	F3
20	95.00	95.00	95.00
40	95.00	95.00	95.00
60	95.00	95.00	95.00
80	92.50	95.00	95.00
100	93.00	95.00	95.00
120	93.33	94.16	94.16

The values of the table 5 show that the values of elasticity of three fabrics were similar and constant when the extension was varied from 20 to 60%. For fabric F1, its elasticity has started to decrease from the extension of 80%. While, the elasticity of F2 and F3 decreased only when the extention reached 120%. Therefore, it is similar to the elasticity in course, the elasticity of fabrics in wale direction vary according the extension of the fabric. The higher extension of sample, the lower elasticity of fabric. However, in course direction, this reduction started earlier from extension of 40% for all three fabric. Moreover, the effect of fineness of the spandex yarn on the elasticity of fabric in wale direction seems to be clearer than that in course direction, from the extension of 80%, the elasticity of fabric 2 and fabric 3 was always higher than that of fabric 1, this difference may be due to the difference in the fineness of spandex yarns of these three fabrics, it was only 210 dtex for F1, while it was 350 dtex and 280 dtex for F2 and F3 respectively. So, it could be concluded that the fineness of spandex yarn is important factor for elasticity of fabric. The coarser of spandex yarn, the higher elasticity of fabric.

4. Conclusion

From the above results, the following conclusions can be drawn

- When it was used the spandex yarn to knit fabric, it is hard to control the structural parameters of knitted fabric, control of tension of spandex yarn on knitted machine may be quite hard but it should be needed to control the structural parameters of fabric.

- The use of pure spandex yarn is effective factor to improve the elasticity of knitted fabric. The elasticity of fabric is very good (more than 90%) even at extension of 120%.

- When pure spandex yarn was used in knitted fabric, the fineness of spandex yarn could be important factor to improve the elasticity of fabric. It seems be that the coarser of spandex yarn, the higher elasticity of fabric.

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