ISSN 1392–1320 MATERIALS SCIENCE (MEDŽIAGOTYRA). Vol. 10, No. 1. 2004

The Dimensional Change of Used Pure and Compound Cotton Knitwear

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Received 30 September 2003; accepted 26 October 2003

The dimensional change of used pure and compound cotton knitwear has been investigated in this work. Knitwear change of the size according to the body movements has been analyzed. At that certain time they undergo either reiterated single or double directional stretching. The value of the deformation in different parts of knitwear can obtain 10 ÷ 20 %. The samples of knitted fabric were reiterated deformed in a transversal and in a longitudinal direction. One part of the samples were laundered and dried at once after deformation and the other part of samples – after 24 h relaxation. It was defined the influence of deformation value and relaxation process after deformation on value of cotton knitwear shrinkage after laundering and drying. The experimental samples were knitted from cotton yarn and their combination with PES yarns. The dependence of dimensional stability upon the fibre composition has been investigated in this work also. The power of recovery in stretched cotton knitted fabrics is generally inadequate and therefore synthetic thread is increasingly used to impart a more dimensional recovery than can be achieved with pure cotton.
Keywords: shrinkage, knitwear, dimensional stability, laundering and drying, longitudinal and lateral strain.

INTRODUCTION

The non-balanced condition of cotton knitwear is quite easy changing when the knitwear is laundered and dried. Therefore the geometrical dimensions of knitwear are changing. Being used knitwear undergoes an influence of deformations of different size. When the knitwear is made from unbalanced fabric the dimensions of knitwear after first wear can change so much, that the knitwear will be unfit for use [1].

The structure of knitted fabric is a system of yarn, bent out into stitches. Integrity and a friction of a yarn stretching stitch by stitch determine the form of a knitted fabric stitch. The friction appears as a result of stitches interdependent relations. The ties of the second type are flexible and allowing changes of a stitch form and width-height dimensions.

The yarn bent out into a stitch is in a strained state. The resiliency forces straightening the yarn in a stitch decrease in a time. The form of stitch becomes as a natural state of a yarn. Anyway the relaxing resiliency forces do not reach zero level and all the parts of a stitch retain a certain amount of the resiliency forces by the static condition in the sample. On the other hand it is known, the value of resiliency forces of a stitched yarn depends on the several factors: the fibre raw material, the yarn structure, the yarn twist, the stitch length, the yarn linear density and an external conditions [2].

Being used knitwear change their dimensions according to the body movements. At that certain time they undergo either reiterated single or a double directional stretching. The value of the deformation in different parts of knitwear can reach 10 ÷ 20 % [3 – 5]. If a deformation is large enough a stitch form and a yarn orientation change and contact points between the stitches move.

In a time the relaxation process in knitwear slows down, the internal tensions decreases and wear gradually moves into a state balancing certain conditions. Two main forces affect the knitwear change from no balanced to balanced condition. The first one, it is the resiliency force of a stitched yarn that try to straighten a yarn, to change its configuration and to switch knitwear into a balanced state. The second one, it is the yarn friction force impending the yarn movement in a stitch and fixing the non-balanced state [1, 6, 7].

Longitudinal and lateral deformation, caused by mechanical forces, results in tension in yarn bending and at the binding points which can by reduced again to a minimum by appropriate relaxation. The stitch has assumed in its lowest flexing energy state when the internal forces of the yarn bent into stitches cause no further change in the stitch shape [8 – 10].

The forces occurring when the yarn is bent into stitch loops and the frictional forces at the binding points are brought to a minimum and are in equilibrium [11].

One reason (the raw material, the linear density of yarns, the type of fabric pattern, the tightness factor the finishing processes and others) or their complex can have a principal value to cotton knitted fabric shrinkage index [6]. The shrinkage value of ready to use knitted fabric must not exceed 3 % [11]. Knitted fabric residual shrinkage values are directly connected with the dimensional stability. A conditional balanced state of cotton knitwear that was stretched by producing or using is relatively easily changeable by laundering. That results in the dimension changes of knitwear. From unbalanced fabric made knitwear their dimensions after first wear and washing can change so much, that the knitwear will be unfit for use [3, 5].

An investigation of the longitudinal and lateral strain influence upon the dimensional change enables to foresee knitwear dimensional changes by wearing.

The goals of this work were:

- to determine the dimensional change of washed and dried knitwear after the reiterated deformation (the size of deformation in one case was 10 % and in the other case was 20 %);

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- to determine the influence of a yarn structure, yarns combination in knitwear and relaxation process upon to the dimensional stability of knitwear.

EXPERIMENTAL

For the experimental testing 6 types of samples were knitted on a circular knitting machine. First part of the samples was knitted from 11.8 tex × 2 linear density cotton yarns and their combination (two variants of percentage composition) with PES yarn. The second part of samples was knitted from 29 tex linear density cotton yarns and their combination with PES yarn (also two variant of percentage composition). Thus influence of fiber composition (PES yarns percentage quantity in the fabric) upon dimensional stability has been established. The influence of cotton yarn structure upon dimensional stability of knitted fabric has been investigated also.

The characteristics of used knitted fabrics are presented in Table 1.

The shrinkage value was defined by equation (ISO 26330:1993 [12]):

$$\lambda = \frac{L - L_0}{L_0}\ 100\ \%; \qquad (1)$$

where L_0 is the dimension of the sample before laundering and drying; L is the dimension of the sample after laundering and drying.

All investigated samples in longitudinal and transverse direction have been deformed (the size of deformation: $\varepsilon = 10\ \%$ and $\varepsilon = 20\ \%$). The duration of reiterated stretching deformation was 20 minutes. One part of the samples was laundered and dried right away after deformation. The second part of samples was laundered and dried after 24 hours of relaxation. Samples were laundered in a fully automatic washing machine 45 minutes at 60 °C.

RESULTS AND ANALYSIS

Being used knitwear change their size according to the body movements. The value of the longitudinal and lateral strain in different parts of a product is different and can reach 10 – 20 %.

The dependencies of investigated samples (six variants: A, B, C, D, E, F) shrinkage in longitudinal and transverse directions upon quantity of lateral strain and fibre composition are presented in Fig. 1 and 2.

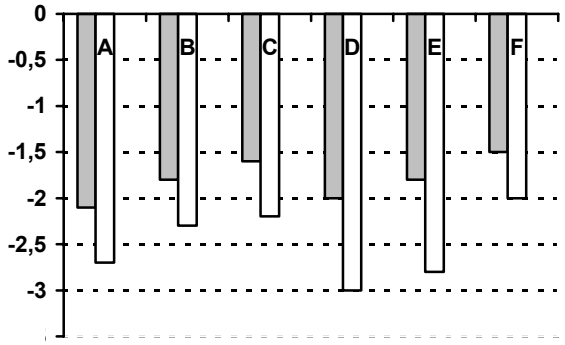

Fig. 1. The dependence of shrinkage in longitudinal direction λ upon the reiterated lateral strain ε:
■ $-\varepsilon = 10\ \%$, □ $-\varepsilon = 20\ \%$

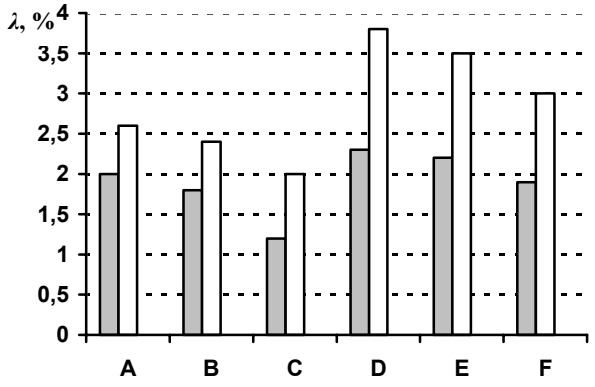

Fig. 2. The dependence of shrinkage in transverse direction λ upon the reiterated lateral strain ε (marked as in Fig. 1)

From cotton yarns, and samples, knitted form untwisted cotton yarns, is different also. The samples A, B, C, knitted from twisted cotton yarns and their combination with PES yarn, are more stable (especial in transverse

Table 1. Characteristics of used knitted fabrics

Fabris article	Pattern	Yarns (cotton C and PES)		Density, cm^{-1}		Fabric density, g/m^2
		Linear density	Percentage composition, %	P_h	P_v	
A	Interlock	C 11.8 tex × 2	100	12	12	255
B	Interlock	C 11.8 tex × 2 PES 10 tex x 2	65 35	11	12.5	243
C	Interlock	C 11.8 tex × 2 PES 10 tex × 2	50 50	11	13	250
D	Interlock	C 29 tex	100	11	12	275
E	Interlock	C 29 tex PES 10 tex × 2	65 35	11.5	13	280
F	Interlock	C 29 tex PES 10 tex × 2	50 50	11.5	12.5	277

rection). Their shrinkage value in longitudinal and transverse direction is about 1 % smaller as samples D, E, F, knitted from non-twisted cotton yarns and their combination with PES yarn.

The dependencies of investigated samples shrinkage in longitudinal and transverse direction upon quantity of lateral strain and fibre composition after 24 hours are presented in Fig. 3 and 4.

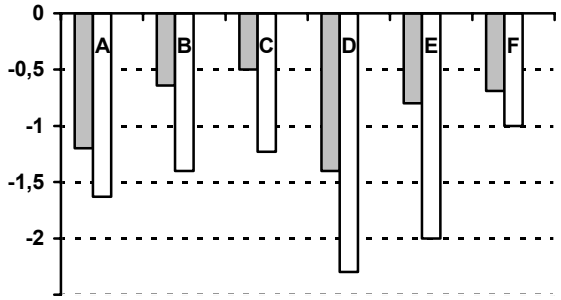

Fig. 3. The dependence of shrinkage in longitudinal direction λ upon the reiterated lateral strain ε after 24 h relaxation (marked as in Fig. 1)

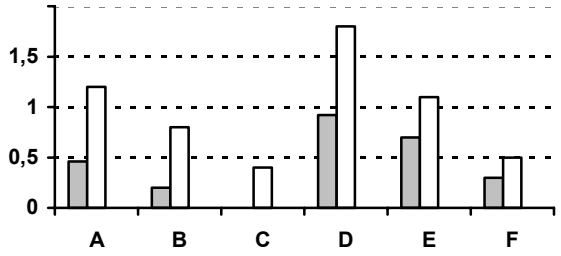

Fig. 4. The dependence of shrinkage in transverse direction λ upon the reiterated lateral strain ε after 24 h relaxation (marked as in Fig. 1)

After 24 h of relaxation the shrinkage value in longitudinal direction decreased approximately 1 % and the shrinkage value in transverse direction decreased approximately 2 % in comparison with samples, which were laundered and dried right away after reiterated lateral strain. The influence of relaxation after reiterated longitudinal strain on shrinkage value after laundering and drying is larger again (Fig. 7 and Fig. 8).

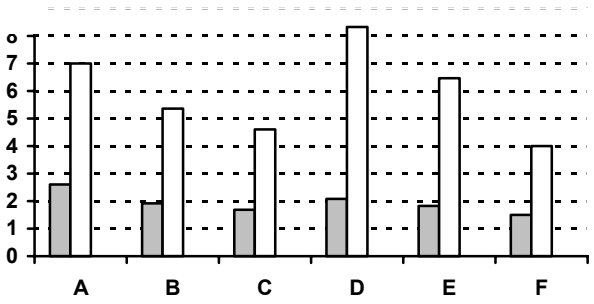

Fig. 5. The dependence of shrinkage in longitudinal direction λ upon the reiterated longitudinal strain ε (marked as in Fig. 1)

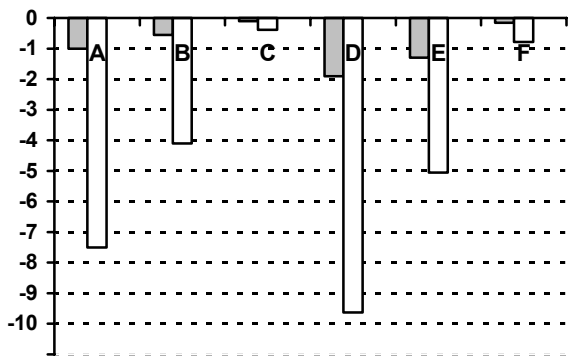

Fig. 6. The dependence of shrinkage in transverse direction λ upon the reiterated longitudinal strain ε (marked as in Fig. 1)

The dependencies of investigated samples shrinkage in longitudinal and transverse direction upon quantity of longitudinal strain and fibre composition are presented in Fig. 5 and 6.

From the results presented in Fig. 5 and Fig. 6 it is possible to notice that the longitudinal and transverse shrinkage value is largest for samples, knitted from 100 % cotton yarns. The dimensional stability increases when percentage quantity of PES yarn in fabric composition increases. The power of recovery in cotton knitted fabrics that have been stretched is generally inadequate and therefore PES yarn is increasingly used to impart a more dimensional recovery than can be achieved with pure cotton.

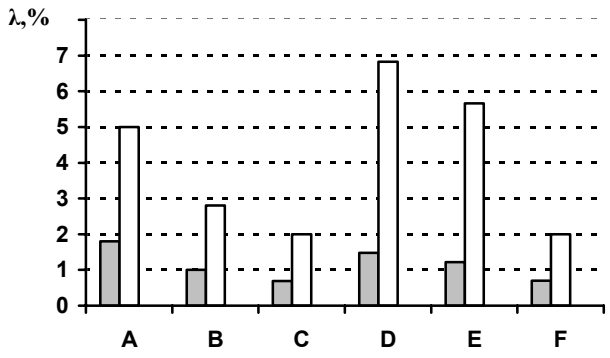

Fig. 7. The dependence of shrinkage in longitudinal direction λ upon the reiterated longitudinal strain ε after 24 h relaxation (marked as in Fig. 1)

The small quantity of PES yarns gives to compound cotton knitwear more dimensional stability and does not change its hygienically and mechanical characteristics [5].

The dependencies of investigated samples shrinkage in longitudinal and transverse direction upon quantity of longitudinal strain and fibre composition after 24 hours are presented in Fig. 7 and Fig. 8. After 24 h relaxation the shrinkage value in longitudinal direction decreased approximately $1.5 \div 4$ % and the shrinkage value in transverse direction decreased approximately $1.5 \div 2.5$ % in comparison with the samples, which were laundered and dried right away after reiterated longitudinal strain.

The value of relative error in all cases was up to 4.5 %.

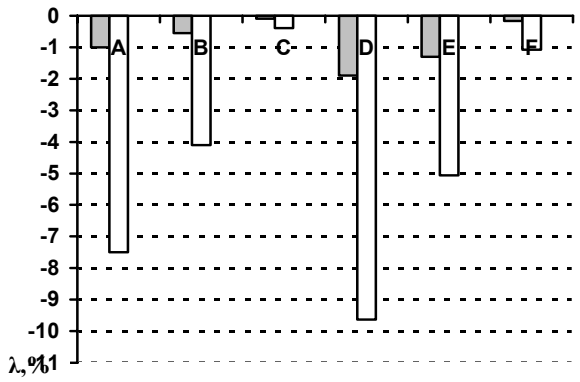

Fig. 8. The dependence of shrinkage in transverse direction λ upon the reiterated lateral strain ε after 24 h relaxation (marked as in Fig. 1)

CONCLUSIONS

The size and direction of reiterated deformation, the fibre composition and structure have influence on the magnitude of knitwear dimensional change.

The presented results show:

- The influence of reiterated longitudinal strain on change of knitwear dimensions is three – four times larger as the influence of reiterated lateral strain. The geometry of loop determines this difference.
- The larger reiterated strain causes the larger residual dimensional change of knitwear.
- The decreasing of elastic deformation part and the increasing of residual deformation part after laundering and drying cycle when the knitwear is 24 h relaxed after reiterated deformation $\varepsilon = 20\ \%$ is larger (especially after longitudinal strain) than after reiterated deformation $\varepsilon = 10\ \%$. The part of elastic deformation is the largest part of all deformation of knitwear. The beginning and the disappearing of elastic deformation are related to active inner forces of knitwear.

From the results of experiment it's possible to notice that the dimensional stability of knitwear basically depends on the raw material, i.e. on the structure of cotton yarns and on the percentage quantity of PES yarns in knitwear:

- The fabric is more stable when is knitted from twisted $11.8\ \text{tex} \times 2$ cotton yarns in comparison with fabric knitted from non-twisted 29 tex cotton yarns, though the linear density at the first case (fabrics A, B, C) is smaller as at the second case (fabrics D, E, F).
- Knitted fabric made from cotton / PES yarns is more dimensional stable in comparison with pure cotton knitted fabric.
- The dimensional stability increase when increase percentage quantity of PES yarns in fabric composition.

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