ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 8, August 2023

On the Dimensional Stability of Textile Materials and Products Made from Them

G.Kh. Gulyaeva

PhD, docent, Tashkent Institute of Textile and Light Industry, Tashkent, Uzbekistan

ABSTRACT: The article presents the results of a study of the mechanism for changing the shape of knitwear caused by tensile, bending, compression deformations, as well as friction when clothing parts come into contact with other surfaces. In this case, the process is considered as a complex deformed state, i.e. simultaneous action of several types of deformations. It was established that in order to more deeply study and substantiate an objective assessment of the shape stability of knitted fabrics and products made from them, it is necessary to introduce a knitwear parameter into the calculation model for assessing shape stability, which will allow a comparative analysis of the shape stability of various knitted fabrics and, on its basis, to predict this most important performance property of products.

KEYWORDS: knitting, fabric, loop, structure, compression deformations, deformation characteristics, elasticity, stiffness, shrinkage, coefficient of elastic-elastic properties.

I. INTRODUCTION

The most important requirement for textile materials used for the manufacture of a wide range of clothing is to ensure dimensional stability during operation, since it is through this quality indicator that the consumer value, reliability and visual appeal of clothing are realized.

Shape stability should be understood as the ability of a textile fabric or product to maintain its original state, the constancy of its volumetric shape when exposed to mechanical and physicochemical factors without the accumulation of plastic or residual deformations. The absence of plastic deformation is possible in the case of ideal elasticity of textile materials, when their original state is completely restored after the disappearance of various types of disturbances.

In the manufacture of clothing, the flat shape of individual parts, cut from various textile materials, is transformed into a three-dimensional one, which is fixed with the help of adhesive materials and wet-heat treatment. The operation of garments, which occurs under the influence of mechanical loads, moisture and heat, leads to a violation of the original shape and wear of the product. These phenomena are caused by tensile, bending, compression deformations, as well as friction when clothing parts come into contact with other surfaces. In this case, a complex deformed state is almost always observed; simultaneous action of several types of deformations. Thus, the loss of dimensional stability and the deterioration of the appearance of products are of a combined nature, which lead to a violation of the given proportion of the product, its anthropometric conformity to the figure of the consumer.

II. LITERATURE REVIEW

Currently, there is no single generally accepted definition and method for assessing dimensional stability, which is caused by the lack of Standards. Therefore, each researcher interprets this indicator in his own way and develops methods depending on the tasks facing him and the objects being studied [1-4]. The problem is aggravated, in our opinion, by the fact that it is necessary to have a differentiated approach to determining the criterion assessment of the dimensional stability of textile materials and separately products made from them.

There are two main approaches to methods for determining the dimensional stability of materials from flat samples and volumetric packages:

1) direct method, when the actual dimensional stability of materials is assessed using special measuring instruments;

2) an indirect method in which dimensional stability is evaluated using the considered indicators of physical and mechanical properties (deformation characteristics, elasticity, stiffness, shrinkage, etc.)

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 8, August 2023

III. METHOD USED

Direct methods for determining dimensional stability are based on the implementation of a single principle - assessing the stability of flat and volumetric samples after any disturbing external influence. In this case, the volumetric shape of the sample has the advantage that it imitates the real shape of the parts of the garment [5, 6]. These methods are characterized by the consumption of materials and time spent on preparing samples for testing, as well as low information content about the dimensional stability of the material, since they do not take into account the totality of all changes that occur with the material during its operation. Most of the direct methods for assessing the dimensional stability of textile fabrics cannot be applied to the entire range of textile fabrics and products made from them, but only to molded and duplicated garments.

Direct methods for assessing the shape stability of garments also include organoleptic and laboratory (theodolite surveying, stereophotogrammetry) methods that often require complex and expensive experimental setups, duration and laboriousness of experiments, which is not possible under production conditions [7].

To study the dimensional stability, operational tests or experimental socks are also carried out. Taking into account the actual operating conditions, expert assessment at the same time allows you to conduct a qualitative analysis of the dimensional stability and the state of the external product, identify problem areas and the main factors affecting dimensional stability. It is also possible to quantitatively assess the stability of the product during experimental wear, if we take the stability of the linear dimensions of the product as a criterion, the measurement of which for fabrics is carried out, as a rule, in the directions of the warp and weft threads, and for knitwear in the direction of the buttonhole and column. However, according to experts, the distortion of the shape occurs due to a change in the linear dimensions (due to the accumulation of plastic deformations) of the product both along the threads and at angles to them, as well as due to the formation of folds during longitudinal bending, violation of the smoothness of the surface of the product etc.

Test socks undoubtedly remain to this day the most objective and reliable way to assess the dimensional stability of clothing under operating conditions. But the duration of the process, laboriousness, high cost, lack of reliable criteria for quantifying the loss of shape are limiting factors for using experimental wear data to predict the properties of clothing details at the design stage - an urgent problem in the design and production of modern clothing.

Indirect methods for assessing dimensional stability involve the study of a complex of physical, mechanical and geometric properties of textile materials that determine their behavior during processing and, thus, affect the stability of the technological process. When using indirect methods for assessing dimensional stability, it is important to study the relationship of individual properties of materials and highlight the dominant property, taking into account the purpose and requirements for the designed clothing.

Based on the above, we can conclude that the assessment of the shape stability of products made from textile materials, for example, clothing, should be carried out separately for the material according to some criterion and only then assess the shape stability of the finished product.

Let us analyze the limited information on assessing the dimensional stability of textile fabrics. A.N. Soloviev [8] proposed the number x_m of series (cycles) of tissuedeformation as a positive characteristic of shape stability, in which the magnitude of the residual deformation f_c reaches a certain constant value, noticeably disturbing the shape of the product (Fig. 1).

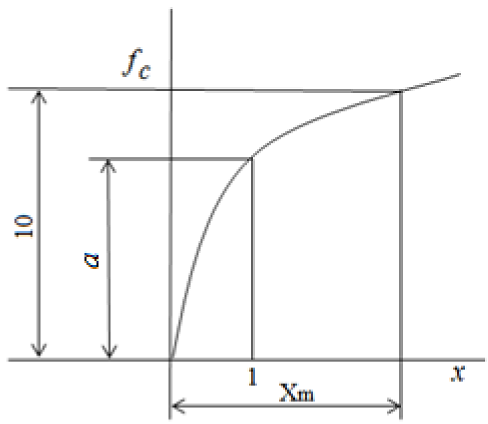

Figure 1. The dependence of the change in residual deformation f_c on the number of series (cycles) of deformation during experimental wear

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 8, August 2023

The dimensional stability of various fabrics (wool , wool-nitron, linen-lavsan, cotton, viscose) was compared during experimental wearing of arm ruffles. They were worn daily for 7 hours, then they were left to rest for 17 hours, and after 5 days they were washed. All this constituted one series of experimental wear. The assessment of residual deformation was given after 6 series using the formula:

$$x_m = \left(\frac{10}{a}\right)^{1/b}, \qquad (1)$$

which is obtained from the dependence of the change in residual deformation on the number of series (cycles) of deformation during experimental, express wear and on devices, which is quite accurately described by the equation:

$$f_c = ax^b, \qquad (2)$$

wherex is the number of deformation cycles in each series;
a ,*b* are constant coefficients that depend on the composition and structure of the canvas and characterize the instability of the form;
f_c – residual deformation (negative characteristic of the dimensional stability of fabrics);
x_m – the number of cycles of fabric deformation at which the value f_c reaches a certain constant value, noticeably disturbing the shape of the product;
10 – average value of residual deformation in mm , at which sleeves made of various fabrics lose their shape in the elbow area.

Thus, the positive indicator x_m makes it possible to determine the service life of products based on dimensional stability and serves as a criterion for assessing the reliability of fabrics.

IV.RESULT AND DISCUSSION

An analysis of expert assessments of the significance of the dimensional stability indicators of suit and dress fabrics [9] showed that wrinkle resistance and shrinkage are predominant (0.27 and 0.25, respectively), and residual (plastic) cyclic deformation is the third most important (Table 1).

It is known to estimate the dimensional stability of clothing packages (half-woolen fabric + cushioning fabric with a dot adhesive coating) by changing the network angle φ between the warp and weft threads of the main fabric [10].

In samples subjected to 100% moisture, the greatest change in the angle is observed in samples duplicated at an angle ψ equal to 0 and 90°. Samples with an angle ψ equal to 30 and 45° have the greatest stability, since they have no deformation of the angle φ.

Table 1
Dimensional stability indicators and corresponding weight coefficients

No. n / n	Dimensional stability index	Indicator weight coefficient
1	Crinkle resistance	0.27
2	Shrinkage	0.25
3	Residual cyclic deformation during repeated stretching: spatial flat	 0.18 0.17
4	Flexural rigidity	0.07
5	Components of strain during a single stretch and rest	0.06

According to the author [1], the category "plasticity" has great potential in assessing the shape stability of garments, which makes it possible to associate express diagnostics of the processes of creating, maintaining and destroying shape during product use.

The search for expert methods for assessing the dimensional stability of fabrics is of particular relevance due to the fact that they are an alternative to well-known methods that are complex, laborious and require the use of unique experimental facilities in production conditions, which is not possible. One of such works is the study of the dimensional stability of a fabric in a package according to conditional layouts made in the form of a spherical segment [5]. The spherical surface of the latter, as well as the surface of the costume products on the support areas, is non-developable and the radius of curvature (R = 90mm) of the layout corresponds to the radius of curvature of the pillow SPB-1 of the press for forming jacket shelves. The experiments were carried out for 28 articles of pure wool and wool blend costume worsted fabrics of various fiber composition.

ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 10, Issue 8, August 2023

The given shape of the samples was fixed by wet-heat treatment (temperature 165 °C , moisture content 30%, pressure 0.15 kg/cm ^{2}, holding time 40 s.) on the experimental setup. The samples were evaluated by their ability to keep their shape for 24 and 48 hours under conditions of free storage and varying humidity (φ=55-85%). The criterion for the stability of the shape of spatial samples is the ratio of the fixed height of the sample to its initial height (Fig. 2), measured using a profilometer:

$$К_ф = \frac{100l}{l_0}, \% \quad (3)$$

where$l$ and l_0 are the length of the sample, respectively, after free storage at varying humidity and immediately after wet-heat treatment.

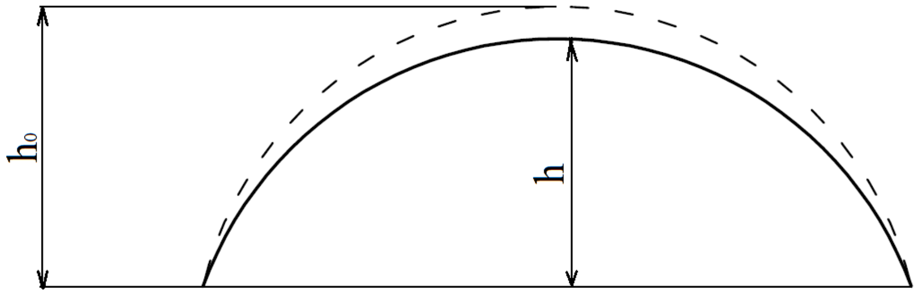

Figure 2. Evaluation of shape retention of tissue samples in a package according to conditional layouts in the form of a spherical segment

In the developed method for assessing the dimensional stability of fabrics for samples of a spatial shape, the dependences of dimensional stability on the elastic fraction of tensile strain, which affects the ability of fabrics to maintain the skew obtained during molding, are obtained. The possibility of estimating the dimensional stability of fabrics and clothing packages through the elastic fraction of tensile strain, determined by the generally accepted method on standard instruments, has been proved.

It is also noted in [2] that in relation to the assessment of shape stability for textile fabrics, clothing parts and garments, the most acceptable and objective criterion for assessing shape stability is elasticity - the ability to restore shape after unloading. The concept of elasticity is inextricably linked with the ability of a fabric or a package of materials of a product to resist bending deformation (change in shape under the action of external forces) - rigidity. The authors proposed standard and new indicators as criteria for assessing dimensional stability:
1) conditional bending rigidity, cN;
2) elasticity of volumetric spherical samples after a single bend, %
3) change in stiffness and elasticity of spherical samples after multi-cycle bending, %.
4) smoothness of the sample surface.

New indicators (No. 3) reflect the kinetics of shape change during the operation of garments, characterized by a multi-cycle loading. Smoothness is determined visually by the absence or presence of creases, wrinkles, folds on the surface of a spherical sample after repeated bending and after testing (changes in stiffness and elasticity) for multi-cycle bending, which makes it possible to predict the shape stability of products during operation. It is important to note that the standard technique [4] of experimental study of the rigidity and elasticity of materials and clothing packages in some cases does not allow an objective assessment of the ability to restore the volumetric shape after the application of a load, since high rigidity does not always provide high elasticity.

Taking into account only elastic deformation when assessing dimensional stability seems to be insufficient, because the deformation of textile materials is characterized by three components:

$$\varepsilon_p = \varepsilon_y + \varepsilon_e + \varepsilon_{pl}, \quad (4)$$

where ε_p is the total relative deformation;
ε_y – elastic deformation;
ε_e – elastic deformation;
ε_{pl}- plastic deformation.

Thus, a more objective assessment of the dimensional stability of materials and products made from them should also take into account the share of elastic deformations, which is commensurate with the share of elastic deformations, slightly inferior to them (data by A.I. Koblyakov when stretching knitwear).

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 8, August 2023

It is quite obvious that using the sum of relative elastic and elastic deformation, one can obtain a positive indicator of dimensional stability. If we express the plastic deformation ε_{pl} from expression (4) and take the inverse of it, we also obtain a positive indicator of dimensional stability

$$К_{ф} = \frac{1}{\varepsilon_{п}(1-К_{у.э})} \quad (5)$$

where$К_{у.э} = \frac{(\varepsilon_{у}+\varepsilon_{э})}{\varepsilon_{п}}$is the coefficient of elastic-elastic properties.

The dimensional stability coefficient for knitted fabrics [11] provides for the determination of the maximum deflection f_0 of a rectangular plate of unit width, length l and thickness $h = 1$ *mm*, loaded with a uniformly distributed load q = 0.074 ... 0.153 H / mm^{2}when bent along a cylindrical surface with a radius *R*. Since deflection f_0*is* a negative indicator, it is advisable to present the dimensional stability coefficient in the form:

$$К_{ф} = \frac{1}{f_0}, \quad (6)$$

where $f_0 = \frac{5}{384} \cdot \frac{ql}{D}$, mm;

$D = \frac{Eh^3}{(12(1-\mu^2))}$- cylindrical rigidity of the knitted fabric plate, N mm ^{2};

μ is Poisson's ratio;

E is the modulus of longitudinal elasticity, MPa.

Evaluation of dimensional stability by formula (5) involves an experimental study of single-cycle characteristics [12] using a standard method. The strain components are determined on the basis of long-term stretching of the sample under a load of a constant value, followed by unloading and recording changes in the magnitude of the sample deformation during the experiment.

Calculations according to dependence (6) are possible if the parameters of the physical and mechanical properties of textile materials are known: the elastic modulus E and Poisson's ratio μ. For textile materials there are specifics to the use of these parameters. So, most often, the modulus is used for the initial stage of stretching (elongation of the order of 1-2%), when the overwhelming proportion of elongation is conventionally considered as elastic. Some conventionality also applies to Poisson's ratio, since the deformations of textile fibers of threads consist of three components, and in accordance with the provisions of the theory of elasticity, Poisson's ratios are determined for bodies with elastic tension and shear deformations.

Assessing dimensional stability using formulas (5) and (6) leaves out of sight the parameters of the loop structure of knitwear (loop length, thread thickness), which differs in comparison with fabric by increased mobility and deformability. Therefore, in order to more deeply study and substantiate an objective assessment of the shape stability of knitted fabrics and products made from them, it is necessary to introduce a knitwear parameter into the calculation model for assessing shape stability, which will allow a comparative analysis of the shape stability of various knitted fabrics and, on its basis, to predict this most important performance property of products.

REFERENCES

1. Titov V.A. Problems of characteristics of shape stability and competitiveness of garments. // Innovations. -2006, No. 2 (89). -p.120-121.
2. Chagina L.L., Smirnova N.A., Lapshin V.V. A method for assessing the dimensional stability of materials and clothing packages. // News of universities. Textile industry technology. -2008. No. 4C (310). –S.10-12.
3. Girfanova L.R. Improving the dimensional stability of clothing using cushioning materials. // News of universities. Textile industry technology. -2013. No. 4(346). –S.106-109.
4. Shin E., Kasimova A., Nigmatova F. Evaluation of dimensional stability by deformation properties of cotton -nitron knitted fabric in the design of sports products. // Problems of textiles. -2017, No. 3. -p.100-110.
5. Surovtseva N.A. Assessment of the dimensional stability of suit fabrics. // News of universities. Textile industry technology. -1977, No. 2. –S.22-25.
6. Kirillova L.I. Investigation of the elastic properties of clothing package materials. // Collection. Scientific works. -M :Legprombytizdat . 1989. 30 p.
7. Mostovaya L.A. Investigation of a complex of properties that ensure the dimensional stability of textile products. Abstract dis ....cand.tech.n.auk . _ _ – L.: LITLP, 1980. -26s.
8. Soloviev A.N., Bostanjyan A.G. A positive indicator of the dimensional stability of fabrics. // News of universities. Light industry technology. -1983. No. 1. –P.16-17.
9. Soloviev A.N., Bostanjyan A.G. Modeling and accelerating the assessment of the crease resistance of fabrics in a sock. // News of universities. Light industry technology. -1981. No. 5. –P.23-27.
10. Kleptsov A.D., Melikov E.K. Development of a method for increasing the shape stability of clothing parts . // Clothing industry. – 1980. No. 2, -S. 35-36.
11. Nabidzhanova N.N., Alimova H.A., Shin I.G. Analysis of the stress-strain state of a knitted fabric in the process of biaxial stretching in bending along a cylindrical surface. // Economy and society. -2020, No. 11(78). –P.972-984.
12. Kukin G.N., Soloviev A.N., Koblyakov A.I. Textile materials science (fibers and threads). -M .: Legprombytizdat . 1989.-352p.