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INFLUENCE OF DEFORMATION PROPERTIES OF YARN ON THE QUALITY OF KNITTED FABRIC

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Abstract:

For the study, samples of simple and compact melange yarn No. 30 were selected. The optical device was used to determine the deformation states of the obtained yarn samples. The results of the samples were analysed in practice and theoretically. Single-cycle deformation state of the thread is analyzed. Influence of deformation properties of simple and dense threads of different structure on the quality of knitted webs is investigated and analyzed. As a result, the knitted fabric of compact melange yarn is 14% thicker than the knitted fabric of conventional melange yarn; a fabric of compact melange yarn 13% longer in elongation at break; fabric length is less than 15%, and fabric width from compact melange yarn is less than 40%. Experiments have shown that a knitted fabric of compact melange yarn with high deformation properties is higher and more competitive in all parameters than traditional yarn.

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I. INTRODUCTION

Competitive products are important for increasing the position of enterprises in the world market. Although the product model is beautiful, if it does not maintain the good quality during operation, the demand for it will inevitably decrease. To avoid this, it is necessary to improve the quality and competitiveness of finished products. The physical and mechanical properties of the materials used to improve the quality of the product must comply with regulatory requirements. For quality preparation of materials, it is important that the yarn used first meets the regulatory requirements for raw materials. In the production of high-quality yarn, the quality of the fibre and the right choice of

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the process for the production of yarn is of great importance. Based on this, it can be said that high-quality yarn improves the quality of the finished product.

One method of determining the quality of yarn knitted articles is the method of operation. During operation, the fabric is twisted, rubbed, washed and stretched again and again. The high-quality fabrics that have passed these steps retain shape well. The deformation properties of the fabric play a very important role in maintaining its shape. Yarn from knitted articles also plays an important role in the good deformation properties of knitted articles. It was therefore considered appropriate to study the deformation of yarn and knitwear therefrom.

Numerous studies to improve the quality of yarn were carried out by researchers Gafurov, J. K. [2-9], Mardonov, B. M.[2, 4, 7], Dushamov, O. S.[4, 7], Ergashev, O. O.[4], Bobajonov, H. T.[5], Yuldashev, J. K.[5], Tashpulatov, D. S.[6], Murodov, A. J.[6], Akhmetkhanov, R. S.[9].

Scientific sources provide information on the study of the mechanical properties of yarn, taking into account its structural structure. In his study, J.W.S.Hearle [1] studied cord yarns consisting of thread-like continuous fibres or individual yarns, as well as fibre of (final) length. His research did not take into account the displacement of fibres relative to each other or the slipping of the end of the fibre from the bundle, as well as related events. The distribution of the transverse and longitudinal threads necessary to evaluate the mechanical properties of the product has not been studied. Therefore, it was necessary to study the events occurring in yarn under different conditions, taking into account time.

II. MATERIALS AND METHODS

A standard method was used to test the experimental results. This method includes individual or group marking of materials, raw materials, products, machines and devices, applicable rules of tests, standards, requirements, various designs, standard checklists, etc. test methods which meet rules and standards, are legalized.

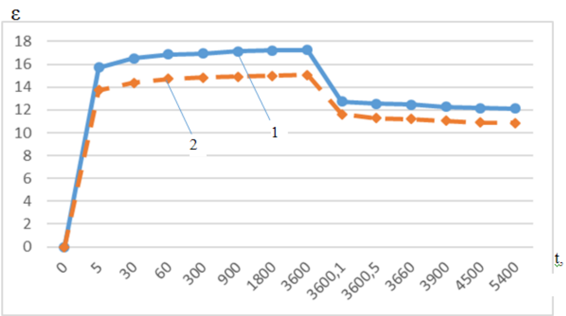
OSBORN Textile, located in the Bustanlyk district of the Tashkent region, at a specialized enterprise for the manufacture of melange yarn using the German ring spinning machine "Zincer-350" and the compact device "RoCoS" of the company "Rotorcraft," received yarn samples with texture t = 20 (Ne = 30) with a rotation speed of 15000 min^{-1}. In the production of test tubes, fibres of the 1st grade of cotton selection IV of the type "Bukhara-102" and "Mehnat" were used.

The quality indicators of the obtained samples were determined in modern instruments (USTER TESTER4, Zweigle D 314), and the results are summarized in Table 1.

Table 1. Linear density T = 20 (No. 30) physical and mechanical indices of textile threads.

№	threads (No.)	Spinning method	Frequency of rotations x10^3, min^{-1}	Practical durability, K_a, b/m	Relative tensile strength, (Rkm)	Elongation at break, ε, (%)	woolliness, H, (%)	Unevenness, CV, (%)
1	30	Simple melange yarn	15000	800	14,28	4,12	6,05	16,66
2		Compact (RoCos) melange yarn	15000	800	17,84	4,22	4,7	15,99

A new optical instrument proposed by the researchers [10] was used in determining the deformation fractions of the samples. In the experiment, it was found that the deformation index of the obtained strands is different. When the samples are not loaded, they deform differently, over time the difference between them increases (Fig. 1). The first example-conventional yarn may extend for a relatively short time. Deformation of compact thread at initial moments of load occurs slower than conventional thread. This condition is, of course, due to the structure and condition of the fibres in the yarn, as well as their arrangement. A similar situation occurs when the yarn is encumbered. The conventional thread is slower, and the compact thread is quickly compressed. It can be seen from the graph that the residual deformation of the strands is different. It turned out that the residual deformation in the compact thread is relatively less. Changing the strain of the yarn per unit time is the law of rheology, for the first time with the help of an optical device the presence of this phenomenon was established.



1-simple melange yarn, 2-compact melange yarn, *t*-seconds.

Figure 1. Diagram of yarn sample deformation in one cycle.

The study showed that compact yarn (Figure 1, 2) had less deformation than conventional yarn (Figure 1, 1). This is due to the structural nature of the yarn. This difference in the yarn also affects the properties of the fabric from which it is made and leads to differences in tissue quality [11]. Experiments were conducted to more fully study changes in simple and compact samples of melange yarn taken in two or more seconds [3]. For the experiment, the previously tested yarn was fixed between the upper and lower clamps of the bench, and the distance between the clamps was indicated as "50 cm".

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Table 2. Deformation of conventional melange yarn and compact yarn “RoSoS”.

№	4 seconds			3 seconds			2 seconds		
	Simple yarn	Compact yarn	X	Simple yarn	Compact yarn	X	Simple yarn	Compact yarn	x
0	0	0	0	0	0	0	0	0	0
1	0,067	0,067	0,05	0,067	0,067	0,05	0,067	0,067	0,05
2	12,451	6,651	0,1	12,441	6,672	0,1	12,365	6,599	0,1
3	13,415	7,902	0,15	13,422	8,145	0,15	13,442	8,368	0,15
4	14,136	9,208	0,2	14,157	9,325	0,2	14,181	9,546	0,2
5	14,836	10,207	0,25	14,828	10,222	0,25	14,818	10,294	0,25
6	15,236	10,858	0,3	15,375	10,907	0,3	15,361	11,057	0,3
7	15,751	11,376	0,35	15,747	11,545	0,35	15,753	11,671	0,35
8	16,141	11,902	0,4	16,112	12,058	0,4	16,019	12,235	0,4
9	16,203	12,276	0,45	16,208	12,445	0,45	16,191	12,665	0,45
10	16,302	12,759	0,5	16,299	12,854	0,5	16,294	12,996	0,5
11	16,425	13,098	0,55	16,407	13,182	0,55	16,363	13,367	0,55
12	16,439	13,364	0,6	16,424	13,471	0,6	16,401	13,588	0,6
13	16,455	13,631	0,65	16,451	13,786	0,65	16,446	13,837	0,65
14	16,461	13,919	0,7	16,458	14,025	0,7	16,452	14,011	0,7
15	16,467	14,053	0,75	16,453	14,125	0,75	16,447	14,198	0,75
16	16,471	14,156	0,8	16,469	14,298	0,8	16,468	14,204	0,8
17	16,475	14,284	0,85	16,471	14,383	0,85	11,854	10,603	0,85
18	16,48	14,371	0,9	16,479	14,402	0,9	11,458	9,508	0,9
19	16,487	14,405	0,95	16,482	14,445	0,95	11,068	9,084	0,95
20	16,493	14,483	1	16,488	14,501	1	10,817	8,803	1
21	16,502	14,524	1,05	12,524	11,378	1,05	10,548	8,586	1,05
22	16,511	14,537	1,1	12,161	10,552	1,1	10,398	8,357	1,1
23	16,521	14,548	1,15	11,824	10,032	1,15	10,234	8,125	1,15
24	16,531	14,569	1,2	11,525	9,567	1,2	10,137	8,017	1,2
25	12,815	11,65	1,25	11,321	9,325	1,25	10,002	7,903	1,25
26	12,615	10,899	1,3	11,254	9,225	1,3	9,882	7,812	1,3
27	12,531	10,643	1,35	11,112	9,118	1,35	9,754	7,704	1,35
28	12,468	10,474	1,4	11,058	9,014	1,4	9,635	7,625	1,4
29	12,452	10,321	1,45	10,971	8,934	1,45	9,553	7,562	1,45
30	12,439	10,295	1,5	10,836	8,865	1,5	9,474	7,501	1,5
31	12,427	10,254	1,55	10,785	8,812	1,55	9,412	7,458	1,55
32	12,415	10,237	1,6	10,683	8,785	1,6	9,386	7,416	1,6
33	12,391	10,211	1,65	10,603	8,705	1,65			
34	12,378	10,204	1,7	10,584	8,694	1,7			
35	12,367	10,186	1,75	10,571	8,688	1,75			

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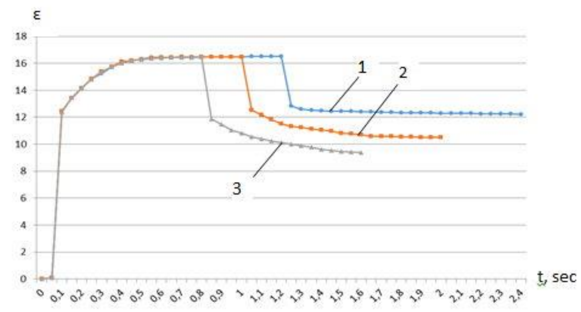
36	12,346	10,162	1,8	10,558	8,655	1,8			
37	12,334	10,148	1,85	10,536	8,631	1,85			
38	12,323	10,115	1,9	10,524	8,628	1,9			
39	12,315	10,082	1,95	10,511	8,609	1,95			
40	12,304	10,044	2	10,497	8,587	2			
41	12,295	10	2,05						
42	12,284	9,996	2,1						
43	12,271	9,987	2,15						
44	12,265	9,961	2,2						
45	12,256	9,934	2,25						
46	12,248	9,913	2,3						
47	12,236	9,894	2,35						
48	12,225	9,886	2,4						

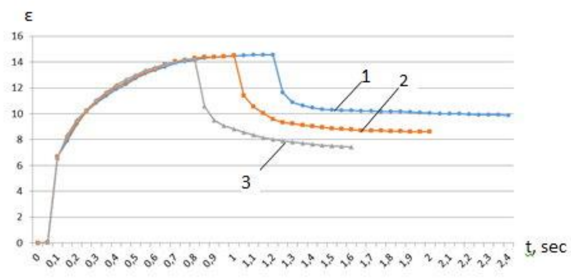
This table 2 shows the results obtained during 4, 3, and 2 seconds when deforming compact and simple yarns at the initial moments of loading and unloading the yarn. Based on the results obtained, graphs were prepared.



1). 4 seconds, 2). 3 seconds, 3). 2 seconds.
Figure 2. Loading and unloading deformation of conventional melange threads.

Based on the values obtained in the experiment, general graphs of compact and simple melange threads were constructed and analyzed (Figures 2-3). If we generalize the single-cycle deformation of

the normal yarn between 4, 3 and 2 seconds (Fig. 2), the resistance of the yarn to load decreases over time. The reason why the resistance of the rope to the load on the one-time interval (Fig. 2, 3) is higher than the resistance of the rope on two (Fig. 2, 2) and three (Fig. 2, 3) seconds, the yarn is unloaded in a short period without meeting the impedance. Therefore, the yarn with a short time interval is less elongated than the yarn with a relatively large time load.



1). 4 seconds, 2). 3 seconds, 3). 2 seconds.
Figure 3. Deformation of loading and unloading of compact melange threads.

In generalizing single-cycle strains of compact melange yarns (Fig.3), as for conventional yarns, the resistance of the yarn to load is relatively high for a short period (Fig. 3, 3).

Over time, two (Fig. 3, 2) and three (Fig. 3, 1) seconds showed a decrease in yarn resistance to load.

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III. RESULTS AND DISCUSSION

The patterns of time change during loading and unloading of yarn deformation are experimentally and theoretically determined. Suppose that the time strain change graphs for rope loading and unloading are shown experimentally (Fig. 4).

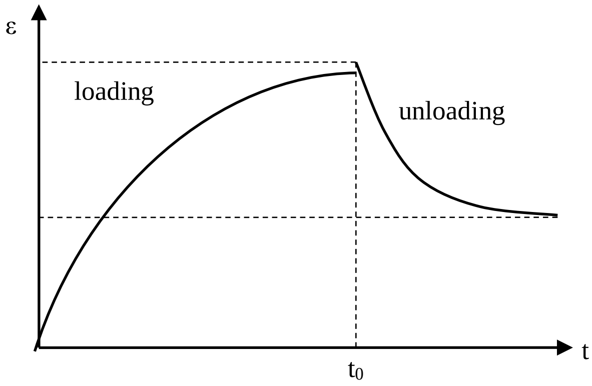

Figure 4. Scheme of loading and unloading yarn over time.

We define the following relationship between deformation ε and strain σ during rope loading and unloading based on the Kelvin – Foygt model. This model adopts laws between deformation and strain during loading and unloading, as well as various lines during loading and unloading.

$$\sigma = E_0\varepsilon \qquad \text{if } \dot{\varepsilon} > 0$$

$$\sigma = E_0\varepsilon_0 + E_1(\varepsilon - \varepsilon_0) \text{ if } \dot{\varepsilon} < 0 ,$$

According to Kelvin's model, we write the following references for each period.

$E_0\varepsilon + \eta\dot{\varepsilon} = \sigma_0$; - during loading $\dot{\varepsilon} < 0$ (1)

$E_0\varepsilon_0 + E_1(\varepsilon - \varepsilon_0) + \eta\dot{\varepsilon} = 0$; during the unloading period (2)

$E_0,\ \eta,\ E_1$,– rheological and mechanical parameters of yarn ($E_1>E_0$). when $\varepsilon = \varepsilon_1(t)$ $0 < t < t_0$ and $\varepsilon = \varepsilon_2(t)$ $t > t_0$ accepting appointments, we integrate equations (1) and (2) and under the conditions $\varepsilon_1(0) = 0$, $\varepsilon_2(t_0) = \varepsilon_0$.

$$\varepsilon = \overline{\sigma}_0(1 - e^{-\frac{E_0}{\eta}t}) \qquad 0 < t < t_0$$

$$(\overline{\sigma}_0 = \frac{\sigma_0}{E_0}) \qquad (3)$$

$$\varepsilon = \varepsilon_0[(1 - \frac{E_1 - E_0}{E_1})e^{-\frac{E_1}{\eta}(t - t_0)} + \frac{E_1 - E_0}{E_1}] \qquad t > t_0 \qquad (4)$$

The continuous strain condition at $t = t_0$ using $\varepsilon_1(t_0) = \varepsilon_0$ gives the relationship between t_0 and ε_0. The formulae, (3) and (4) are bonds defining the rheological properties of the filament in which the parameters are present.

The formulae $\varepsilon_0 = \overline{\sigma}_0(1 - e^{-\frac{E_0}{\eta}t_0})$, (3) and (4) are bonds defining the rheological properties of the filament in which the $E_0,\ \eta,\ E_1$, – parameters are present.

Also, the stress and discharge time parameters t_0, which determine the deformation processes, should be given in the experiment. at $t \to \infty$ (4) $\varepsilon_\kappa = \varepsilon \to \ \varepsilon_0\frac{E_1 - E_0}{E_1}$ emerges from Formula. $\varepsilon_\kappa = \varepsilon_0\frac{E_1 - E_0}{E_1}$ defines residual deformation.

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E_0, η, E_1 – - define parameters. Suppose that the strain values $\varepsilon = \varepsilon_\text{i}$ at a time $\text{t} = \text{t}_\text{i}$ in the range $0 < \text{t} < \text{t}_0$ are known experimentally. In this case, we use the method of minimizing the quadratic constraint to determine E_0 and η in the bundle during loading (3).

$$S_1 = \sum[\varepsilon_i - \overline{\sigma_0}(1 - e^{-\bar{\eta} t_i})]^2$$

here $\overline{\sigma_0} = \dfrac{\sigma_0}{E_0}$, $\bar{\eta} = \dfrac{E_0}{\eta}$

For $S_1 = S_{1\min}$ the condition $\dfrac{\delta S_1}{\delta \overline{\sigma_0}} = 0$ $\dfrac{\delta S_1}{\delta \overline{\eta}} = 0$ must be satisfied. From these conditions, we derive the following equations

$$\overline{\sigma}_0 \sum_{i=1}^{n} (1 - e^{-\bar{\eta} t_i})^2 = \sum_{i=1}^{n} \varepsilon_i (1 - e^{-\bar{\eta} t_i})$$

(5)

$$\overline{\sigma}_0 \sum_{i=1}^{n} (1 - e^{-\bar{\eta}\, t_i}) t_i e^{-\bar{\eta} t_i} = \sum_{i=1}^{n} \varepsilon_i t_i e^{-\bar{\eta} t_i})$$

(6)

If we define from the first equation and put it in the second equation, we get a transcendent equation with respect to.

$$\overline{\sigma}_0 = \frac{\sum\limits_{i=1}^{n} \varepsilon_i (1 - e^{-\bar{\eta} t_i})}{\sum\limits_{i=1}^{n} \ (1 - e^{-\bar{\eta} t_i})^2} \qquad (7)$$

$$\sum_{i=1}^{n} (1 - e^{-\bar{\eta} t_i}) t_i e^{-\bar{\eta} t_i} \sum_{i=1}^{n} \varepsilon_i (1 - e^{-\bar{\eta}\, t_i}) - \sum_{i=1}^{n} (1 - e^{-\bar{\eta} t_i})^2 \sum_{i=1}^{n} \varepsilon_i t_i e^{-\bar{\eta} t_i}) \qquad (8)$$

When solving the equation, based on the experience, we use the values of Ti and E1 given in Table 3. Define $\overline{\eta}$ from equation (8).

Table 3. Experimental load deformation of compact melange yarn in 4 seconds.

t_i	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.5	0.55	0.60
ε_i	0.067	6.651	7.902	9.208	10.207	10.858	11.376	11.902	12.276	12.759	13.098	13.364
t_i	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.0	1.05	1.10	1.15	1.20
ε_i	13.631	13.919	14.053	14.156	14.284	14.371	14.405	14.483	14.524	14.537	14.548	14.569

The values of $\overline{\eta} = 5.02$, $\overline{\sigma}_0 = 14.25$ are obtained from the calculation results.

Thus, it follows from the above notations that $E_0 = 14.25\sigma_0$, $\eta = 2.84\sigma_0$ sec.

Consider the change in thread strain during the time load period. (4) the formula we will build with this functionality.

$$S_2 = \sum_{i=n}^{N} \{\varepsilon_0[\sigma_1 e^{\overline{\eta}(t_i - t_0/\sigma} + 1 - \sigma_1] - \varepsilon]^2\}$$

(9)

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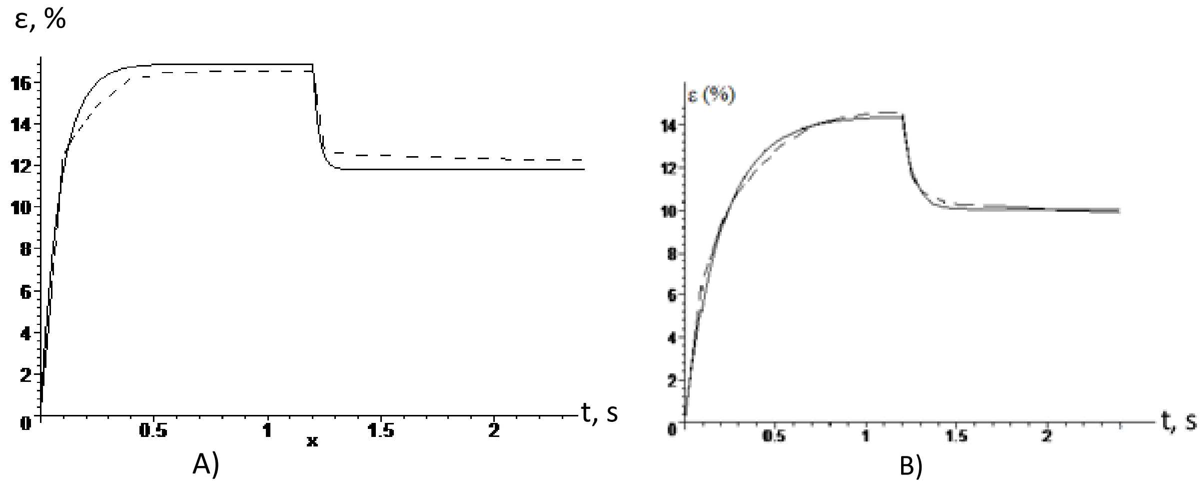
Here $\sigma_1 = E_0 / E_1$, $\frac{\delta S_2}{\delta \sigma_1} = 0$, we obtain this equation to determine σ_1 from the conditions.

$$\sum_{i=m}^{n}\{\varepsilon_0[1+\bar{\eta}(t_o-t_0)/\sigma_1]e^{-\bar{\eta}(t_i-t_0)/\sigma_1}-\varepsilon_i)=0 \quad (10)$$

The change in strain time during unloading is given below (Table 4).

Table 4. Experimental deformation of compact melange yarn in 4 seconds.

t_i	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80
ε_i	11.65	10.899	10.643	10.474	10.321	10.295	10.254	10.237	10.211	10.204	10.186	10.162
t_i	1.85	1.90	1.95	2.0	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40
ε_i	10.148	10.115	10.082	10.044	10	9.996	9.987	9.961	9.934	9.913	9.894	9.886



A) – Simple yarn, B) – Compact yarn

Figure 5. Time change graphs of yarn deformation based on experimental (dotted line) and rheological model (solid line) in loading and unloading state for 4 seconds.

Considering the values of t_i and ε_i in Table 4, as well as the value of $\bar{\eta}$, the solution of equation (10) will be $\sigma_1 = 0.303$. Thus, using the designation D1, it can be determined that the wool yarn module $E_1 = E_0 / 0.303 = 3.3E_0 = 47.03\sigma_0$ during the unloading period.

Analysis of the presented graphs (Figure 5) shows that in the experimental determination of the parameters of the selected rheological model, the processes of yarn deformation during loading and unloading can be sufficiently studied based on classical rheological models.

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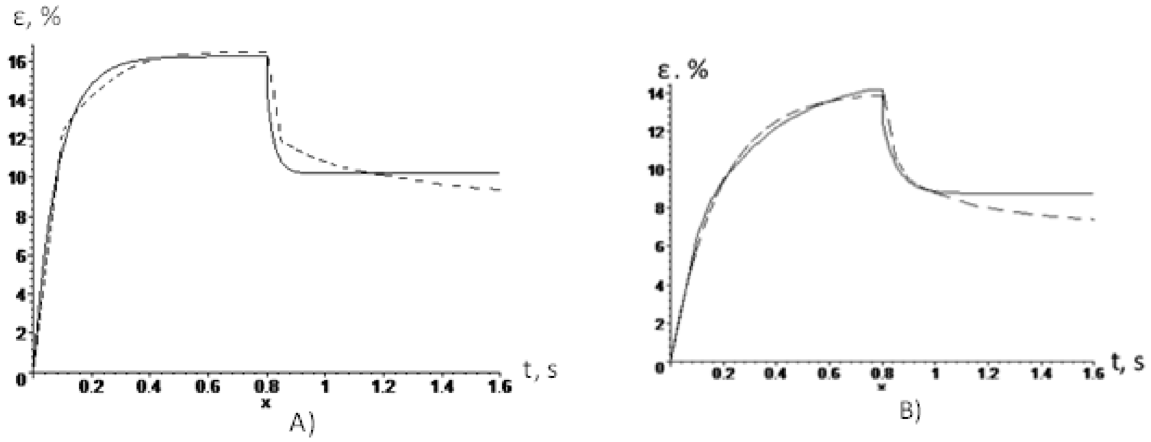

A) – Simple yarn, B) – Compact yarn
Figure 6. Time change graphs of yarn strain derived from the experimental (dashed line) and rheological model (dashed line) in the loading and unloading state for 2 seconds.

In the above graphs, the optical webcam revealed periodic deformations of compact melange threads and simple melange threads, as well as their theoretical lines. (Figure 6) Once again, it became known that compact threads have greater resistance to load, and when cleared, their competitiveness with residual deformation is small. It was proved that a correctly selected definition of strand deformation at the beginning of the time of day based on the Kelvin-Foigt model. Considering that the deformation states of these yarns in the next step can also affect the properties of the fabric, in order to study the properties of the knitted fabric, experiments were carried out on a flat needle knitting machine of the brand "LXC260" made of compact and simple melange yarns. On this machine, texture samples from 20x4 tex compact and simple melange threads were obtained. Texture indices of the obtained samples were analyzed (Table 5).

Table 5. Physical and mechanical characteristics of the texture lastic, made of simple and compact (20x4) melange threads.

№	Name	Fabric thickness, T, mm	Friction strength, friction quantity, thousand	Tensile strength, H		Elongation at break,%		Fabric shrinkage , U, %		Air permeability, $Sm^3/(sm^2*s)$	Surface density, M, gr/m^2
				By length	By Width	By length	By Width	By length	By Width		
1.	Plain melange yarn fabric	1,2	28,800	816,0	331,9	66,7	231	10	-5	106,7	474,1

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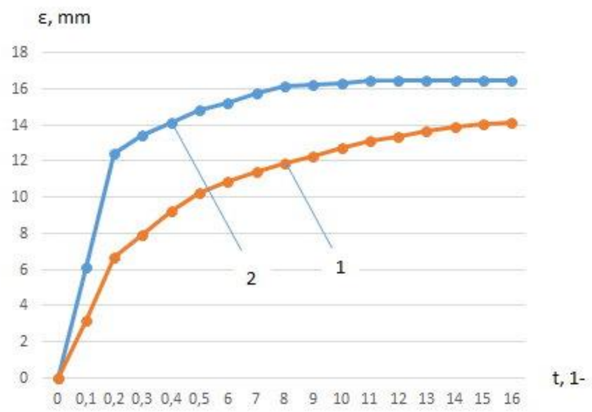
2.	Compact (RoCos) melange yarn fabric	1,4	32,000	835, 2	348, 5	67,0 5	263, 7	8,5	-3	108,5	505, 9

Using instruments installed in the laboratory, physical and mechanical texture indices were determined (Table 5). The data presented in this table were analyzed by comparison. Based on this analysis, it can be said that the difference in the thickness of the knitted fabric obtained from two identical number threads was manifested. It turned out that a knitted fabric using a compact melange yarn is 14% thicker than a knitted fabric made from a conventional melange yarn. It has been found that a knitted fabric produced using a compact melange yarn is durable compared to a fabric made of 10% conventional friction-resistant melange yarn. Even when analyzing the strength of the neck breaks and the width of the samples taken in the experiment, it became known that the knitted fabric of compact melange yarn has a high breaking strength. It turned out that knitted patterns obtained using compact and simple melange yarn are 13% longer than a fabric made of compact melange yarn, even in terms of elongation at break in width. When analyzing the input parameters of the samples, it turned out that access to 15% in the length of a fabric made of compact melange yarn would be insufficient. Concerning the penetration width of the samples, it has been found that the fabric of conventional melange yarn has a 40% higher penetration than a fabric of compact melange yarn. Studies have shown that knitted fabrics made of compact melange yarn have a higher surface density. For all properties, the knitted fabric of compact melange yarn obtained in the experiment turned out to be higher in quality than the fabric obtained from conventional melange yarn. The main reason for such changes in the above-knitted fabric is that the initial deformation state of the yarn changes. The compact yarn has a higher load resistance than conventional yarn. This condition was determined experimentally.



1 - Compact (RoCos) melange yarn, 2 - Simple melange yarn

Figure 7. Sample extension graph at intervals of 1 second.

During the experiment, plots of tensile strength and elongation of yarn samples were determined at intervals of 1 second (Figure 7). During knitting, the yarn is slightly stretched. Thus, resistance to yarn elongation during elongation to 2% of yarn samples was studied. It has been found that compact melange yarn has

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resistance 13% higher than conventional melange yarn. Despite the same amount and steepness, the study showed that the difference in the properties of the fabric obtained from the obtained yarn is mainly due to the deformation properties of the yarn. It is also desirable to take into account the deformation properties of the yarn when making fabrics.

IV. CONCLUSION

1. It has been found that a knitted fabric made of a simple and compact melange yarn with the same line density is different in thickness. It turned out that a knitted fabric using a compact melange yarn is 14% thicker than a knitted fabric made from a conventional melange yarn.
2. It also became known that the knitted fabric of compact and simple melange yarn is 13% more than that of compact melange yarn, even in terms of elongation at rupture in width.
3. Analysis of the input values of the samples showed that the length of the compact melange yarn fabric was less than 15%, while the width of the compact melange yarn fabric was less than 40%.
4. It has been found that in order for the density of a moth obtained from compact and simple yarns of the same linear density to be the same, it is necessary to increase the tension of the compact melange yarn.
5. It turned out that the density of the knitted fabric obtained by increasing the stress of the compact melange yarn by 10 sN with the density of the fabric obtained from the conventional yarn.
6. From the experiments, it became known that the knitted fabric in the lastic weaving from compact melange yarn is high and competitive in all texture indicators.

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