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ANALYSIS OF TECHNOLOGICAL PARAMETERS AND PHYSIC-MECHANICAL PROPERTIES OF INTERLOCK KNITTED FABRIC KNITTED FROM COTTON-NITRON YARN

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Abstract:

Objective. For the purpose of effective use of local raw materials in the scientific work was carried out on the technological indicators and physical-mechanical properties of interlock fabric from cotton-nitron yarn. The purpose of research is develop and recommend the new technology of production of interlock knitted fabric with high heat and shape retention properties by using mixed yarn from nitron and cotton.

Method. Theoretical analysis and synthesis methods, the research of the knitting process was used, and experimental researches in the production conditions by Hanma (China) circular knitting machine were carried.

Results. A positive result of the properties of the fabric was achieved by the creation of the technology of knitting interlock fabric using cotton-nitron yarn.

Conclusion. Experimental samples of interlock knitted fabrics obtained from spun cotton and cotton-nitron yarns were taken and their technological indicators and physical-mechanical properties were analyzed.

Keywords: knitting, cotton-nitron, interlock, air permeability, abrasion, rupture, deformation.

Introduction. Double knitted interlock fabric is a derivative of rib stitch. The “Interlock” word is an English word that means "to cross in the form of a cross" and it consists of two rib stitch rows, the protuberances of which cross each other in the form of a cross (Figure 1).

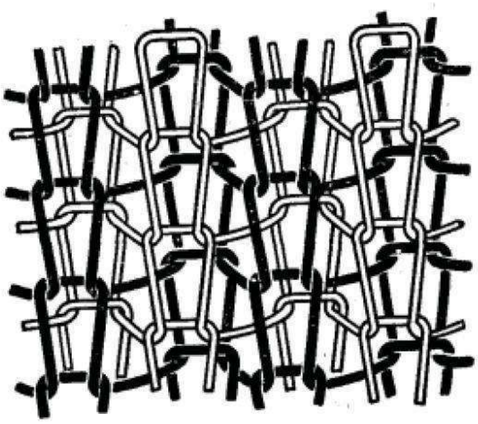

Figure 1. The structure of interlock stitch

As practice shows, interlock stitch is widespread in the manufacture of knitwear, as it has the most stable structure. A number of studies by foreign scientists are devoted to the study of the parameters and properties of interlock.

The aim of this study was to investigate the effect of knitting parameters on the moisture management and air permeability of the interlock fabrics. Samples were produced at two different knitting gauges, each with three different stitch lengths. It was found that the fabric mass per square metre increases by increasing machine gauge and decreasing the stitch length, whereas the fabric thickness and porosity increase at these settings. It was further concluded that the loosely knitted fabric samples with higher amount of entrapped air exhibit good air permeability but poor moisture management properties [1].

The knitting parameters and the type of structure not only affect the comfort but also the performance properties of the knitted fabrics [2]. Knitting machine gauge and the knitting stitch length are the two fundamental knitting parameters that directly affect all structure related properties of the knitted fabric [3-4]. Singh et al. [5] studied the effect of stitch length of jersey fabric and reported that stitch length affects its shrinkage in a direct manner. Available literature does not reveal the effect of knitting stitch length and machine gauge on the 3D moisture management and air permeability of the interlock knitted fabrics. The aim of this work is to fill this gap by investigating these key thermo-physiological comfort properties of the interlock fabrics.

There are cotton, nitron, and also mixed cotton-nitron yarn are made in Uzbekistan. This types of yarn have good consumer properties. So it is actual to investigate knitting ways from these types yarn and analysis of technological parameters and physic-mechanical properties of interlock knitted fabric knitted from cotton-nitron yarn.

Methods. Unraveling of the knitted fabric. Interlock is unravel in the opposite direction to the knitting direction, like a rib stitch. The elasticity of the interlock is slightly less than the elasticity of the rib, which can be explained by the uniqueness of the structure of the interlock fabric.

Thickness. The thickness of the interlock is equal to the thickness of the compound and is directly proportional to the linear density of the yarns. For example, the thickness of the interlock from cotton yarn (coefficient of expansion α= 90÷112) is equal to:

$$M = \frac{7,2 * T}{1000}, \qquad α=\frac{K\sqrt{T}}{31,6}$$

where, T is the linear density of the thread (yarn), tex;

K is the number of occurrences.

The thickness of the interlock stitch from artificial yarns is equal to that of the thread when the coefficient of friction is a=16÷20:

$$M = \frac{4,3 * T}{1000}$$

Surface density. Interlock surface density is determined by the rib surface density formula:

$$m = \frac{0,8 * P_Г * P_B}{\frac{1000}{T}} = \frac{0,8 * P_Г * P_B * T}{1000}$$

Loop thread length. The length of the loop thread of the interlock fabric is formed by the sum of the lengths of the sections. Interlock loop thread length is slightly different than glad and rubber loop thread length, because the length of the interlock loop spacer is slightly different than the length of the rubber and glad loop spacers. Based on this, the loop thread length of the interlock fabric can be calculated using the following formulas. Loop thread length for interlock stitch from cotton thread:

$$L = \frac{90}{P_Г} + \frac{100}{P_B} + 3,6\,F \qquad \text{Or} \qquad L = \frac{110}{P_Г} + \frac{140}{P_B} - 2,2\,F$$

For an interlock stitch from artificial yarns:

$$L = \frac{90}{P_Г} + \frac{100}{P_B} + 1,5\,F$$

In addition, the length of the loop thread can also be determined by the filling factor:

L = *б*f*

b - is the filling factor.

f - is the minimum thickness for cotton thread determined by the formula:

$$f = \frac{0.92}{\sqrt{\frac{1000}{T}}}$$

The filling factor is taken depending on the types of products. It is taken between 29÷31 for the range of inner and sports products, and between 27÷28 for outerwear.

Horizontal density. The horizontal density of the interlock fabric depends on the length of the loop thread.

The thicker the thread and the longer the length of the loop thread, the lower the knitting density and the larger the amount of loop pitch A. The horizontal density of the interlock fabric is higher than that of the tire, because the adjacent loops the interlock fabric are shifted vertically by half a loop relative to each other. The loop pitch of the interlock fabric at the normal length of the loop thread can be determined from the following formula:

$$A=3,3F+0,15$$

The next formula for the pitch of the loop gives its amount, taking into account the length of the loop thread:

$$A = 2,7F + 0,05L + 0,08$$

Horizontal density

$$P_\Gamma = \frac{50}{A}$$

Vertical density. The vertical density depends on the length of the loop thread and the thickness of the thread. The greater the length of the ring thread and the greater the thickness of the thread, the lower the vertical density. The height of the loop row can be determined by the following formula:

$$B=0,3L-2,5F+0,17$$

or B can be determined from the density ratio coefficient:

$$C = \frac{B}{A}$$

$$B = AC$$

It is recommended to take the density ratio coefficient for underwear products in the amount of 1.15÷1.20, and for outerwear in the amount of 1.05÷1.10. Coefficient S can be increased to 1.3 to obtain knitted fabrics with low surface density. [6-8]

Stretchability. High elasticity of Interlok fabric is one of its characteristic features and properties. Taking into account the high elasticity of the interlock, it is used in the manufacture of inner, upper and glove products. [9-14].

Results. Samples were taken from Z spun cotton and cotton-nitron interlock knitted fabrics. Samples differ from each other by the type of used raw materials. As raw materials, spun cotton yarn with a linear density of 20 tex, spun cotton-nitron yarn with a linear density of 20 tex (85/15) and spun cotton-nitron yarn with a linear density of 20 tex (90/10) were used.

In obtaining the I-variant of Interlock fabric, spun cotton yarn with a linear density of 20 tex per 30 systems, spun cotton-nitron (85/15) yarn with a linear density of 20 tex per 30 systems was used.

In the production of the II variant, 1 system of spun cotton yarn with a linear density of 20 tex, 1 system of 20 tex of spun cotton-nitron (85/15) yarn was used.

Next, variant III was used to obtain a knit fabric with a spun cotton-nitron (90/10) yarn with a linear density of 20 tex. The technological parameters and physical-mechanical properties of the obtained samples were determined and presented in Table 1.

Table 1

Technological parameters and physic-mechanical properties of interlock knitted fabric knitted from spun cotton-nitron yarn

Indicators		Variants 1	2	3
Types of threads, linear density		30 sys. cotton thread 30 sys.c/n thread (85/15)	1 sys. cotton thread 1 sys. c/n (85/15)	c/n thread (90/10) 20tex
Surface Density (gr/m^2)		185.4	1197.4	190.7
Fabric thickness (mm)		0.7	0.75	0.8
Bulk density (mg/sm^2)		264.8	260.9	238.4
Air permeability (sm^3/sm^2·sec)		174.5	139.9	155.2
Abrasion resistance, thousand/rotation		10.0	11.0	6.3
Tensile strength, N	height	340.8	326.4	315.7
	width	199.9	95.5	154.8
Stretching to break (%)	height	13.9	13.5	15.5
	width	47.9	48.0	55.0
Irreversible deformation (%)	height	30.0	25.0	36.0
	width	26.7	22.7	24.0
	height	70.0	75.0	64.0

Reverse deformation,(%)	width	73.3	77.3	76.0
Shrinkage , (%)	height	15.0	12.5	9.0
	width	4.5	7.5	5.0

Using the results in the table, the change of the raw material of the samples and the change of the technological parameters and physic-mechanical properties of the tissue in relation to the ratio, the analysis was made by comparing the samples. From the changes in the surface density of interlock fabrics, it was found that the type of raw material used in the production of knitwear affects the ratio of knitwear stitch from the same raw material. I-variant stitch with the addition of cotton yarn spun in 30 systems and cotton-nitron yarn spun in the next 30 systems had the lowest surface density, its surface density is 185.4 g/m^2.

Discussions. Using the same raw material, the surface density of variant II obtained using only 1 system spun cotton-nitron and spun cotton threads is the highest and is 197.4 g/m2. The reason for this is that the rapport of this variant has increased the density of the knitting and the surface density is higher. It was found that the surface density of variant III, stitch from spun cotton-nitron (90/10) yarn, is 2.8% higher than that of variant I, and 3.5% less than that of variant II (Fig. 2).

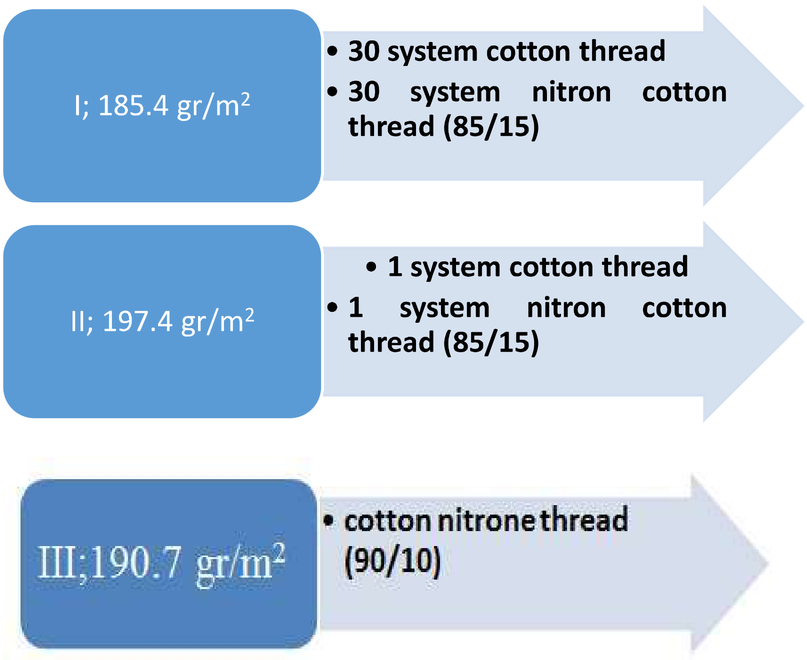

Figure 2. Interlock surface density

The thickness of interlock knitting is higher in III-variant with a higher amount of spun cotton thread than other variants, it is 12.5% higher than I-variant and 6.25% higher than II-variant.

The indicator that provides information on the consumption of raw materials in the production of knitted fabrics is the knitted bulk density. It was found that the volume density of the III -variant of the interlock knitwear obtained from the spun cotton-nitron thread is lower than the other variants, it is 11.1% lower than the I-variant, and 9.4% lower than the II-variant. So, it was determined that the production technology of the III-variant of the interlock fabric, obtained from the spun cotton-nitron thread, is the most resource-efficient (Fig. 3).

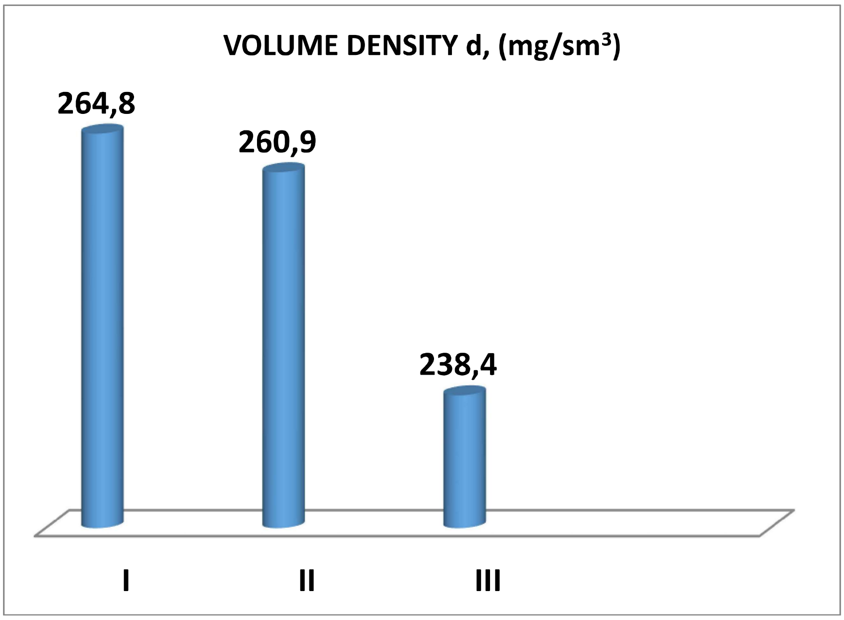

Figure 3. Change in volume density of interlock knitted fabrics

The analysis of the air permeability of the studied knitted samples showed that the knitted fabric made of Rapporti 1 system interstitch cotton yarn and spun cotton-nitron yarn (variant II) has the lowest air permeability, which means that it has the highest heat retention properties. It was found that the air permeability of this variant is 24.7% lower than that of variant I, and 10.9% less than that of variant III (Fig. 4).

The analysis of the change of the friction resistance of the studied interlock knitted samples shows that the friction resistance of the III variant obtained from spun cotton-nitron (90/10) yarn is lower compared to other variants, while in rapporti it is obtained from cotton and cotton-nitron yarns spun with 1 system interlacing and 30 systems interlacing. The abrasion resistance of variants I and II was higher (Fig. 5).

Figure 4. Abrasion resistance of interlock knitwear

The tensile strength of the interlock knitted fabric was determined to be less than the length and width. Variant I is the variant with the highest stiffness in terms of length and width of the knitted fabric.

It was found that the tensile strength of knitted samples containing spun cotton yarn and spun cotton-nitron yarn was higher than that of samples obtained only from cotton-nitron yarn (Fig. 6).

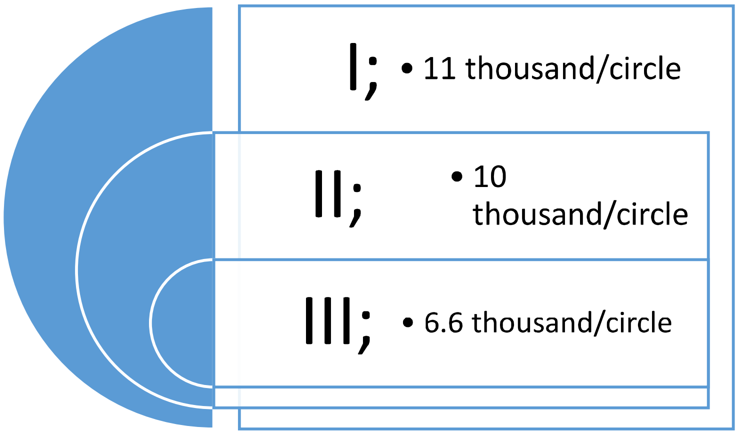

Figure 5. Abrasion resistance of interlock knitwear

Reversible and irreversible deformation changes of experimental interlock knitted samples depend on the composition and ratio of the knitted fabric. The elastic deformation of the samples obtained from the spun cotton-nitron yarn was analyzed.

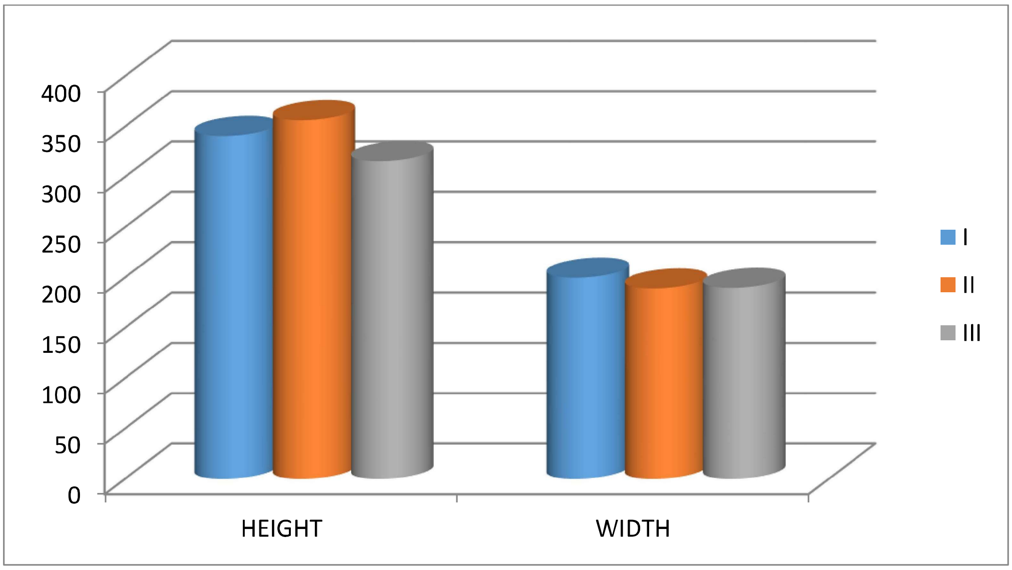

Figure 6. Histogram of change in tensile strength of interlock knitted fabric

1 row of knitted cotton yarn spun from 1 row of spun cotton-nitron (85/15) yarn. Return deformation of variant II. Cotton yarn spun in 30 system, stitch from cotton-nitron (85/15) yarn spun in 30 system. 7%, 5.2% in width, 14.7% in length, 1.68% in width compared to the III-variant stitch from spun cotton-nitron (90/10) yarn (Fig. 7).

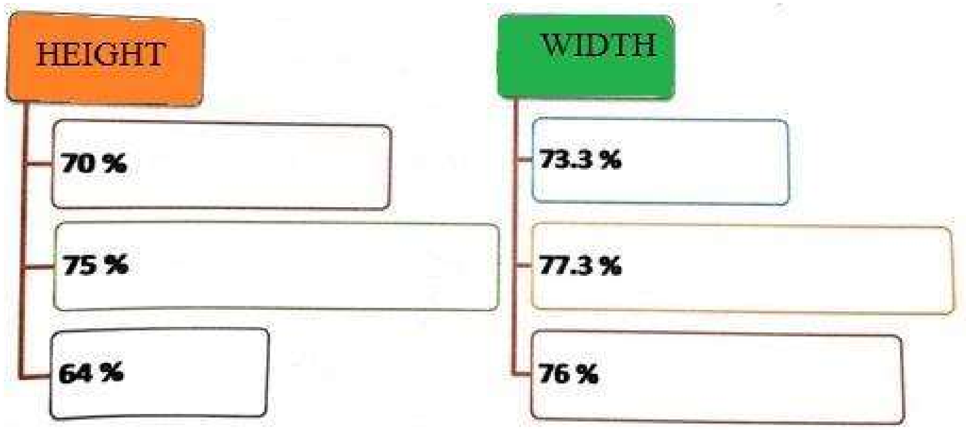

Figure 7. Reverse deformation change of interlock knitted fabric

Conclusion. The analysis of the penetration properties of knitwear revealed that the penetration of knitted samples obtained from spun cotton-nitron yarn is less than the penetration of knitted samples obtained from spun cotton yarn. [15-20].

The permeability of interlock knitting samples is the least in variant III, which is stitch from spun cotton-nitron yarn (90/10), its permeability is 66.6% less in length compared to variant I, 38.9% less in comparison to variant II, and in width I-10% more compared to variant II, 50% less compared to variant II.

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