УДК 677.025
DOI 10.47367/0021-3497_2025_4_148

ANALYSIS OF DIMENSIONAL PARAMETERS OF DOUBLE-LAYER KNITTED FABRIC

АНАЛИЗ РАЗМЕРНЫХ ПАРАМЕТРОВ ТРИКОТАЖА ДВУХСЛОЙНОГО ПЕРЕПЛЕТЕНИЯ

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In order to expand the range of knitwear and efficiently utilize local raw materials, a technology for producing double-layer knitwear from polyacrylonitrile and cotton yarn was developed. A Long Xing 252 SC flat knitting machine equipped with one knitting system that forms loops on the front and back needle beds was used to obtain double-layer knitwear samples Various double-layer weave variations were developed to study the influence of the weave structure on the knitwear process parameters. Cotton yarn with a linear density of 20 tex x 4 and polyacrylonitrile yarn with a linear density of 31 tex x 2 were used in the samples. All variations were obtained with identical yarn tension, knitting depth, and fabric drawdown force. Process parameters such as surface density, loop length and bulk density were measured and analyzed. The results showed that changes in the structure of double-layer knitwear can lead to a decrease in material consumption while maintaining high performance characteristics. The proposed fabric types can meet various requirements in the production of apparel and technical products, and also have potential for use in outerwear and children's clothing. The study demonstrated that the developed double-layer knit weaves demonstrate improvements in both material consumption and structural properties compared to the basic weaves.

Для расширения ассортимента трикотажа и эффективного использования местных сырьевых ресурсов разработана технология выработки двухслойного трикотажа из полиакрилонитрильной и хлопчатобумажной пряжи. Для получения образцов двухслойного трикотажа использовалась плосковязальная машина Long Xing 252 SC, оснащенная одной вязальной системой, которая

формирует петли на передней и задней игольницах. Разработаны различные варианты двухслойных переплетений для изучения влияния структуры переплетений на технологические параметры трикотажа. В образцах использовались хлопчатобумажная пряжа линейной плотностью 20 текс х 4 и полиакрилонитрильная пряжа линейной плотностью 31 текс х 2. Все варианты получены при одинаковых величинах натяжения нити, глубины кулирования и усилия оттяжки полотна. Измерены и проанализированы технологические параметры трикотажа, такие как поверхностная плотность, длина нити в петле и объемная плотность. Результаты показали, что изменения в структуре двухслойного трикотажа могут привести к снижению расхода материала при сохранении высоких эксплуатационных характеристик. Предлагаемые виды полотен могут удовлетворить различные требования при производстве одежды и технических изделий, а также имеют потенциал применения для верхней одежды и детского ассортимента. Исследование показало, что разработанные двухслойные трикотажные переплетения демонстрируют улучшения как по материалоемкости, так и по структурным характеристикам по сравнению с базовыми переплетениями.

Ключевые слова: двухслойные трикотажные переплетения, полиакрилонитрильная пряжа, хлопчатобумажная пряжа, плосковязальная машина, структура, технологические параметры, плотность, длина нити в петле, объемная плотность, ресурсосбережение.

Keywords: double-layer knitwear, polyacrylonitrile yarn, cotton yarn, flat knitting machine, structure, dimensional parameters, density, loop length, bulk density, material consumption, material saving.

In order to expand the range of knitted fabrics and effectively use local raw materials, a technology has been developed for producing of double-layer knitting fabric from polyacrylonitrile and cotton yarn. To obtain samples of double-layer knitting fabric, a double-bed knitting machine from Long Xing, type 252 SC (China), designed for the production of outwear knitted products, was used.

The machine is equipped with single knitting system (the needle carriage has a thread guide and needle locks installed on it), the function of which is to form loop rows on the front and back needle beds in accordance with the fabric repeat when moving from left to right and back from right to left.

It should also be noted that on both of these needle beds, even or odd needles can alternately work, which makes it possible to obtain smooth single, double and patterned knitted fabrics.

In order to study the influence of the structure of knitting fabric on the dimensional parameters of double-layer knitting fabric, 5 variants of double-layer knitting fabric were developed on a flat knitting machine, where polyacrylonitrile and cotton yarn were used as raw materials.

When developing new structures of double-layer knitting fabric, cotton yarn with a linear density of 20 tex x 4 was used as a raw material for one layer and for the other layer, and also polyacrylonitrile yarn with a linear density of 31 tex x 2 was used for the connecting thread in the form of a tuck stitch.

All versions of double-layer knitting fabric were produced under the same conditions, i.e. the tension, depth (value) of sinking and yarn input take-down tension were the same.

Double-layer knitting fabric of ribs and warp fabrics, varied in structure, can satisfy a variety of requirements in terms of parameters and property indicators that are presented in the practice of producing clothing and technical products.

The parameters of any knitted fabric are influenced by the properties of the raw mate-rial, the type of fabric and the finishing method.

In Fig. 1. A graphic record of the production of double-layer knitting fabric is presented.

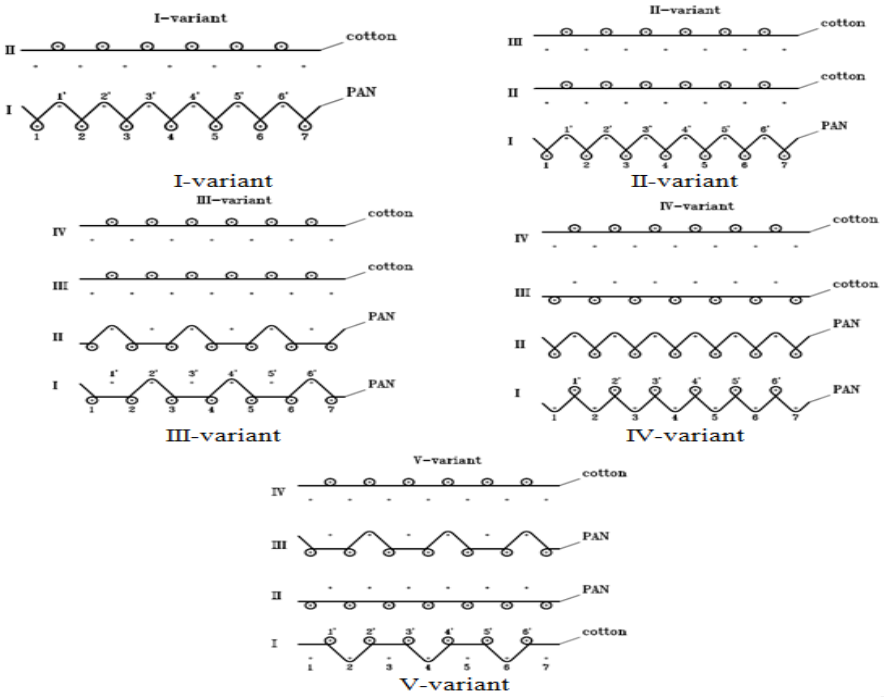

Fig. 1

Double-layer knitting fabric consists of two identical or two different single fabrics; one fabric may differ from the other in the structure of the fabric and the type of raw material. This circumstance determines the interaction of layers. One layer, when connected to another, can change its initial parameters, and the other, in turn, can change the parameters of the first.

Therefore, the density and length of threads in the loops of layers of
double-layer knitting fabric cannot be determined using the corresponding formulas for single fabrics. In addition, these parameters depend on the type and method of connection [1…3].

Dimensional parameters of knitting fabric can be determined in three ways:

1. According to standards (GOST, OST, and technical specifications TU). This method can be used when it is not necessary to determine the parameters of knitting fabric by calculation (for example, when calculating the mass of finishing parts, trims, ribs, etc.) or when the dimensional parameters of knitting fabric, established using existing calculation formulas, have significant deviations from actual indicators (for example, when determining the parameters of knitting fabric with new fabrics or made from new types of raw materials).

2. Experimentally by refueling. This method is most often used in research work related to the development of new fabric knitting fabric. This method requires the necessary equipment, raw materials, etc.

3. Calculation method. This method can be applied in all design cases. The sequence of calculation of dimensional parameters depends on the method adopted for calculating the loop length l [4-7].

Indicators characterizing the structure of knitted fabrics are: surface and volumetric density, density (number of loops per unit length) in the wales and course direction, loop length, skew angle of loop rows and loop columns, thickness of knitting fabric. dimensional parameters of double-layer knitting fabric were determined according to standard methods [8-10] in the “CentexUz” laboratory at TITLI, the results obtained are shown in table 1.

Table 1

Parametrs		Variants				
		I	II	III	IV	V
Type and quantity of yarn (thread) in sample back layer, cotton front layer, PAN	Back layer	47	48	52	47	47
	Front layer	53	52	48	53	53
Wale-spacing A, mm	Back layer	1,7	1,4	1,7	1,5	1,5
	Front layer	1,6	1,4	1,7	1,6	1,5
course-spacing B, mm	Back layer	1,1	0,8	1,2	0,8	1
	Front layer	1	0,8	1,2	0,8	0,9
The horizontal density of the R_G, loops / 100 mm	Back layer	30	35	30	34	33
	Front layer	31	35	30	32	33
The vertical density of the R_v, loops/ 100 mm	Back layer	45	60	40	60	50
	Front layer	50	60	40	60	55
Loop length *l* mm	Back layer	6,3	6,3	9,3	5,7	6
	Front layer	9,0	6,6	10	8,2	10,1
Surface density ρ_s , gr/m^2		558	695	563	585	542
Fabric thickness M, mm		1,92	2,8	2,4	1,9	1,8
Volume density δ, mg/sm^3		290	243	235	295	290
Absolute volume density lightness Δδ, mg/sm^3		-	47,6	55,1	-4,9	0,6
Related volume density lightness θ,%		-	16,4	19	-1,7	0,2

The loop structure of a knitted fabric is characterized by the fact that the filling of a unit of its area with threads, compared to fabrics, is less. As a consequence of this, knitted material has a higher volume (knitted fabric density 0.2-0.3 g/cm^3, fabric density 1.1-1.3 g/cm^3) [11].

At the same time, the consumption of threads when producing a unit area of yarn using the knitting method is small than using the weaving method. The latter is one of the defining criteria for the economic advantages of the knitted production method.

The criterion for material consumption is traditionally considered to be the surface density of the fabric. As is known, a decrease in the surface density of knitting fabric entails a change in operational and hygienic characteristics.

Therefore, an indicator is introduced that simultaneously characterizes both the material consumption of the fabric and the quality indicator. This indicator is an indicator of the lightness of the knitting fabric structure, in which, along with the surface density, its thickness is also taken into account [12].

Volume density can be used as an indicator of the lightness of the knitting yarn structure:

$$\delta = \frac{p_s}{M}; \text{mg/sm}^3, \qquad (1)$$

where δ – volumetric density of knitting fabric, mg/cm^3; ρ_s – surface density of knitting fabric, gr/m^2; M – knitting fabric thickness, mm.

The results of the study showed that the volume density of the recommended samples of double-layer knitted fabrics is significantly less compared to the basic fabric (option I) (Table 1, Fig. 2).

If the surface density of the base fabric is ρ_s=558 gr/m^2 and the thickness is M=1,9 mm, its volume density is δ=290 mg/cm^3.

In this case, the indicators of absolute volumetric lightening of the fabrics compared to the basic fabric will be as follows:

$$\Delta\delta_{II} = \delta_б - \delta = 290 - 243 = 47 мг/см^3, \quad (2)$$

$$\Delta\delta_{III} = \delta_б - \delta = 290 - 235 = 55 мг/см^3, \quad (3)$$

$$\Delta\delta_{IV} = \delta_б - \delta = 290 - 295 = -5 мг/см^3, \quad (4)$$

$$\Delta\delta_{V} = \delta_б - \delta = 290{,}8 - 290{,}2 = 0{,}6 мг/см^3. \quad (5)$$

Here Δδ – absolute volumetric relief, mg/cm^3; δb – volume density of the base fabric, mg/cm^3; δ – volumetric density of the fabric under study mg/cm^3.

The relative lightness of the produced samples of double-layer knitting fabric is:

$$\theta_{II} = (1 - \frac{\delta}{\delta_б}) \cdot 100\% = (1 - \frac{243}{290}) \cdot 100\% = 16\%, \quad (6)$$

$$\theta_{III} = (1 - \frac{\delta}{\delta_б}) \cdot 100\% = (1 - \frac{235}{290}) \cdot 100\% = 19\%, \quad (7)$$

$$\theta_{IV} = (1 - \frac{\delta}{\delta_б}) \cdot 100\% = (1 - \frac{295}{290}) \cdot 100\% = -1{,}7\%, \quad (8)$$

$$\theta_{V} = (1 - \frac{\delta}{\delta_б}) \cdot 100\% = (1 - \frac{290{,}2}{290{,}8}) \cdot 100\% = 0{,}2\%. \quad (9)$$

Based on the results of the study of the dimensional parameters presented in table 1, it can be noted that a comparison of samples of double-layer knitting fabric with each other in terms of surface and volume density showed that option V has the lowest surface density and its numerical value is 542 gr/m^2, in terms of volume density the lowest indicator for the III variants of double-layer knitting fabric, its numerical value is 235 mg/cm^3.

The volume density of double-layer knitted fabrics varies from 235 to 295 mg/cm^3 (table 1, fig. 2). The increase in volume density is due to the fact that the loop rows on the front layer of double-layer knitting fabric are made from polyacrylonitrile yarn with a linear density of 31tex x 2 (fig. 2).

The lowest volumetric density is for the III variant of double-layer knitting fabric, and is 235 mg/cm^3. This can be explained by changes in the structure of knitting fabric and the type of raw material. For example, in option III, the first and second rows are made from polyacrylonitrile yarn with a linear density of 31tex x 2.

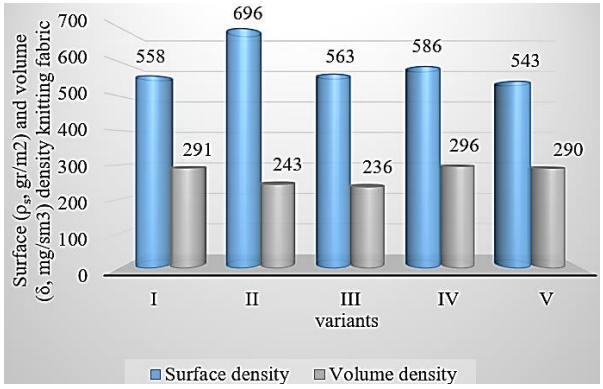

Fig. 2

Knitted fabric option III repeat unit consists two tuck courses and two courses of plain stitch. The loops of the third and fourth row are made of cotton yarn with a linear density of 20 tex x 4.

If we compare the options for double-layer knitting fabric with each other in terms of surface density, we can conclude that the surface density of the II option is the highest and is 695 g/m^2, the lowest surface density is for the V option, which is 542 g/m^2, the basic version has a surface density of 558 g/m^2. The thickness of the base version is 1.92 mm, the V version is 1.87 mm, and the thickness of the IV version is 1.98 mm (Fig. 3.).

Taking into account thickness and surface density, these options can be compared by volumetric density, that is, by a three-dimensional indicator. The volume density of the base option is 290 mg/cm^3, for the V option it is 290 mg/cm^3, for the IV option it is 295 mg/cm^3.

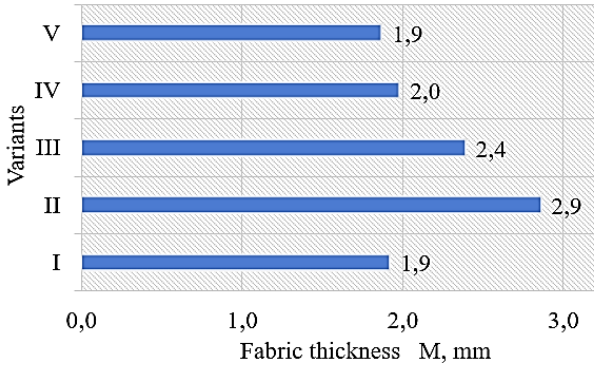

Fig.3

Based on the results of the study of the dimensional parameters of double-layer knitting fabric, presented in the table, it can be noted that a comparison of knitting fabric samples with each other in terms of surface and volume density (Fig. 2.) showed that the III version of double-layer knitting fabric has the lowest volume density.

CONCLUSION

In conclusion, it can be noted that by changing the structure of the layers of double-

layer knitting fabric, it is possible to obtain knitting fabric with specified properties and reduced material consumption. The developed double-layer knitted fabrics can be successfully used for the manufacture of outwear and children's assortment.

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Рекомендована кафедрой технологии промышленности Каракалпакского государственного университета им. Бердаха. Поступила 25.12.24.