**Impact of Thread Density on Quality of Double-Layer Knitted Fabrics**

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**Abstract.** This study investigates how the linear density of polyester threads connecting the layers of double-layer knitted fabrics affects their quality indicators. Two-layer knitted fabrics were produced using round needle knitting machines with varying linear dencities of connecting threads. The research aims to optimize the quality of these fabrics by examining indicators such as breathability, stiffness, extensibility, and abrasion resistance. The findings indicate that using a polyester thread with a linear dencity of 7,7 tex results in improved quality characteristics compared to using a 11,1 tex thread. This study provides insight into enhancing the performance of double-layer knitted fabrics by adjusting the linear dencity of connecting threads.

**INTRODUCTION**

Analysis of the quality indicators of knitted fabrics allows not only to study the types of fabrics obtained, but also to create various knitted fabrics with a new structure and expand the range of knitted fabrics and products [1].

In order to reduce the consumption of raw materials per unit of production, improve the quality indicators of knitted fabric and expand the range of knitted fabrics, three variants of the structure of a two-layer knitted fabric and the method of its production were developed [2].

[3] the work has developed a method for producing a two-layer knitted fabric, consisting of a rainbow element of fabric, the layers of which are fastened with lycra thread, on a circular knitting two-needle rotary machine of class 10.

A method for producing a two-layer knitted fabric for fire-resistant natural children's clothing is presented in [4]. Bamboo and modacrylic threads were used to connect the layers. According to experimental analysis, the percentage of modacrylic yarn in knitted fabric is 40-60%, which increases its fire resistance.

In order to improve the heat-retaining properties of a two-layer knitted fabric, [5] created a method for producing a two-layer fleece knitted fabric with a new structure, in which each independent layer of a two-layer knitted fabric is formed into fleece fabric and the layers are connected using an additional connecting thread.

In order to expand the range of knitted products, a method for producing lining knitted fabric based on a two-layer fabric is presented in [6]. The front and back layers of the jersey are woven from the rainbow element of the fabric. Highly elastic lycra with a linear density of 7.7 tex was used as a connecting thread to join the layers.

Aegean University scientists N. Oglakcioglu, A. Chai and B. Sarilar studied the moisture management and drying properties of two-layer knitted fabric [7]. The research work examined the influence of different types of yarn on the moisture permeability and drying parameters of two-layer knitted fabrics.

In [8] the structure and methods of manufacturing a two-layer knitted fabric with longitudinal weaving are presented. The canvas with a new structure can be used for medicine, everyday life and technical purposes. Two-layer knitwear consists of an outer and an inner layer connected by an elastic thread.

The results of the influence of yarn type on moisture permeability for a number of two-layer knitted fabrics made of cotton, polyester, acrylic, polypropylene, nylon threads used in the production of sportswear are highlighted in [9].

**EXPERIMENTAL RESEARCH**

To create a new knitted fabric, a round needle knitting machine was used and a project for a new knitted fabric was developed [10]. As a result of the analysis of the scientific work carried out, it became known that the influence of the linear density of the connecting thread on the quality indicators of two-layer knitted fabrics has not been studied.

In order to improve the quality of knitting, the technological capabilities of binding and knitting machines with circular needles were used [11], two-layer knitted fabrics with different linear densities of the connecting thread belong to the same class 22 with high performance characteristics. The fabric was woven on a knitting machine and quality indicators were analyzed (Fig 1).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | |  |  | | --- | --- | | Place of production | Korea | | Model name, SD-R2/SD-I4 | SD-I4 | | Inch, 30~36 dyum | 36 | | Gauge, 18~42 | 22 | | Feeder, 96~108 dona | 96 | | interlock/rib | Interlok | | Number of needles | 2 | | Voltage frequency, V | 380 V/50~60 Hz | |
|  |

1. b)

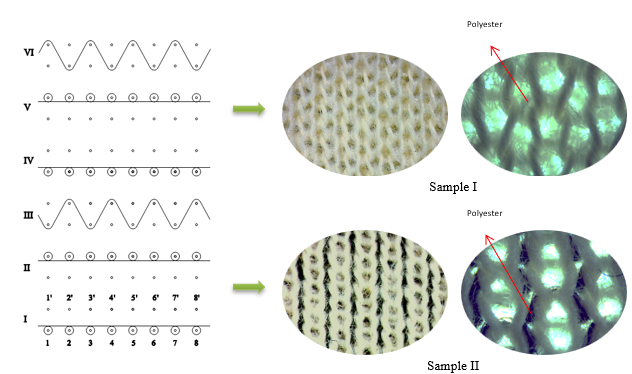
**FIGURE 1**. a) Interlock knitting machine. b) technical classification of the vehicle

The technology of knitting samples on a circular two-needle interlock machine is presented (Fig 2.).

In system I, IV, the satin fabric element is knitted on knitting needles 1, 2, 3, 4, 5, 6, 7, 8 of a cylindrical needle and forms the front loops of the knitted fabric. In the II, V-system, on knitting needles 1', 2', 3', 4', 5', 6', 7', 8', an element of the satin fabric is knitted and the purl loops of the knitted fabric are knitted. In system III, the connecting thread forms half-loops on knitting needles 1,3,5,7 of a cylindrical needle and on knitting needles 2',4',6',8' of a disk needle. In the VI-system, the connecting thread, in contrast to the III-system, forms half-loops in knitting needles 2,4,6,8 of a cylindrical needle and in knitting needles 1',3',5',7' of a disk needle (Fig 2a).

Samples I and II differ from each other in the linear density of the connecting thread used to connect the layers (system III, VI) (fig. 2b). As a connecting thread for sample I, a polyester thread with a density of 11.1 tex (white) and 7.7 tex (black) was used, and for sample II 7.7 tex (black).

In the analyzed samples, it is important to determine the influence of the linear density of the connecting thread on the quality indicators of two-layer knitwear. Indicators such as breathability, stiffness, extensibility, penetration and abrasion resistance can provide information about the quality of knitwear and its functional use [12].



|  |  |  |
| --- | --- | --- |
| a) |  | b) |

**FIGURE 2.** a) graphic symbol for knitting b) double layer knitted fabric.

**RESEARCH RESULTS**

It is especially important to compare the quality indicators of knitted products obtained by changing the linear density [13] of the binding thread. The quality indicators of knitted samples were determined and the results are summarized in Table 1. [14]

**TABLE 1.** The quality indicators of knitted samples were determined and the results

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| № | Raw materials  type, linear  density | | Surface density, МS, g/m2 | Thickness, T | Tensile strength,  Р, N | | Irreversible deformation, εн, % | | Tissue entry U, % | | Abrasion resistance,  a thousand rounds |
| high | width | high | width | high | width |  |
| I | Cotton  18 tex | Polyester 11,1 tex | 203,4 | 0,75 | 312,3 | 256 | 22 | 27 | 7 | 7 | 18,5 |
| II | Cotton  18 tex | Polyester 7,7 tex | 221,2 | 0,75 | 330,8 | 292,5 | 21,1 | 18,6 | 1,5 | 2 | 25 |

The linear density of the threads connecting a two-layer knitted fabric causes a change in its quality indicators, that is, the surface density of the knitted fabric [15] in sample I was 203.4 g/m2, and in sample II - 221.2 g/m2. At the same time, the volumetric density of knitting also increases, the reason for this is that the linear density of the connecting thread in sample [16] II is 7.7 tex. Since in the process of joining the layers, ring spacers bend 7.7 tex yarn more than 11.1 tex polyester yarn, which increases the surface and volumetric density of the knitted fabric, reduces air permeability, which improves heat-retaining properties [17].

The strength of a two-layer knitted fabric varies from 312.3 N to 330.8 N along the length and from 256 N to 292.5 N across the width in samples I and II. At the same time, the indicator of irreversible deformation of the knitted fabric, fabric impregnation and resistance to friction are significantly improved in sample II compared to sample I [18]

According to the results of the analytical comparison, it is advisable to use 7.7 tex polyester thread for knitting this two-layer knitted fabric [19].

**CONCLUSIONS**

It has been established that it is possible to change and improve the quality characteristics of a two-layer knitted fabric by changing the linear density of the connecting thread.

In the production of two-layer knitted fabric obtained on the basis of Glad, due to changes in the linear density of the connecting thread, an expansion of the range of fabric types for lightweight outer knitted products with improved quality indicators was achieved.

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