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TECHNOLOGICAL CAPABILITIES OF KNITTING MACHINES AND COMPRESSION HOSIERY

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INTRODUCTION

The Global Textile market size is estimated at USD 748 billion in 2024, and it expected to reach USD 889,24 billion by 2029 and taking one of the leading positions. According to the analysis of Mordor Intelligence™ Industry Reports on textile market, despite the COVID-19 pandemic has challenged the textile industry drastically in 2020, the textile industry has been constant-growing up economic market with key competitors, such as China, the European Union, the United States, and India. The average yearly growth of textile market expected at a CAGR of 3,52 % during forecast period (2024-2029) [1,2].

In recent years, comprehensive measures have been implemented in our country to develop the textile and sewing-knitting industry, to support the investment and export activities of enterprises in the sector, and certain results have been achieved. 45% of cotton fiber and yarn produced in the republic is being processed, and the annual export potential of the industry has exceeded 3.2 billion dollars. At the same time, the increase of competition in the world markets, the reduction of costs due to the production of mixed types of products by foreign manufacturers require taking additional measures for the development of this sector.

MATERIAL AND METHODS

Much obliged to the achievements of the textile and light industry compression garments, are becoming more widespread on the market. Compression products are demanded within the fields of medicine and sports as well as corrective underwear is in special demand among consumers.

The development and research of knitted products with functional properties, in particular, compression knitted products, is one of the current areas in knitwear technology. Compression products are of great importance not only in modern society. Their use, although in a more primitive form, began in ancient times. Since then, to this day, the issues of expanding the range and improving the quality of knitwear, creating new structures and developing effective methods for obtaining compression products have been addressed by many researchers both in our country and abroad. The history of the development of compression products can be divided into two main periods based on the results of literary analysis [3]: non-elastic materials were used in the first period, while materials containing polyurethane fibers were used in the second.

The market for compression goods is always growing, which drives up the development of new materials, designs, and production techniques.

The scope of application of compression products is expanding with the increase in consumer demand for products.

Modern compression garments divide into three main group.

1. Compression shapewear garments
2. Compression sportwear
3. Compression garments for medical use

The extensibility and bursting strength of knitted compression stockings are examined in study [4] through an experimental effort that attempts to determine the impacts of body and inlay yarn counts as well as inlay yarn amount. Calf high compression stockings were made for this purpose, and their extensibility and bursting strength were subsequently tested. The findings show that there is a significant decrease in the course way extensibility values of compression stockings when the course number of inlay yarns at knit structure increases. Comparing compression stockings knitted with fine body and/or inlay yarn to those knitted with coarse body and/or inlay yarn, the bursting strength values of the previous group were higher. The greatest values of course way extensibility is found in compression stockings with coarse inlay yarns. The correlation study revealed a high relationship between the strain measured by the bursting strength test and the "fabric way strain" determined by the extensibility test. As a raw material the following yarns are used (Table 1)

Table 1.

The properties of body and inlay yarns

Body Yarn Structure (Textured)	**Yarn Count-Fibre Type**	Inlay Yarn Structure (Double Covered)	**Yarn Count-Fibre Type**
	70 Den 68 Filament Nylon		169 Den (Core:70-Elastane+Cover:40 Nylon)
	40 Den 13 Filament Nylon		253 Den (Core:90-Elastane+Cover:70 Nylon)

Hosiery machines are a circular knitting machine that knits sequentially sections of a hosiery and is equipped with the necessary executive devices for switching cams, yarn guides, needle selection mechanisms according to the pattern, trimming and holding the ends of turned off yarns, etc. Switching mechanisms is carried out by the control unit.

According to the assortment, circular knitting hosiery machines are divided into three main groups: for delicate women's stockings and tights; socks and golfs; children's and adult tights made of high linear density yarn. By design, the machines are divided into two groups: single and double cylinder.

Hosiery machine type TTAα 600RT (China) belong to the single-cylinder group of a hosiery machine. Hosiery machine type TTAα 600RT is destined for the production of men's, women's, children's, classic or plush products (socks, knee socks, stockings, long stockings, children's tights) using various weaves and patterns, with different heel designs.

Technical characteristics of hosiery machine type
TTAα 600RT

Manufacturer country	China
Cylinder diameter	3 ¾ inch
Needle count	168
Machine gauge	14.2
RPM	250-300
Drive motor	1 kW
Voltage/Hz	380 V / 50 Hz
Proper conditions	
Voltage fluctuation	7% of rated voltage
Temperature	10 ° C - 30 ° C, 50 ° F-86 ° F
Humidity	75% max
Pure compressed air	6-6.5 kg/sm^3 × 70 L/min

RESULTS

A single fleecy fabric curls up from the edges as a basic knitting structure, but its degree of curling is less in those directions, in courses or wales where the fleecy yarn is laid. Knitted fabrics (knitwear) with the fleecy yarn oriented in the direction of tension, like an inlaid knitting structure, is not very tensile. The degree of elongation of the fleecy fabrics (knitwear) is greater than the inlaid fabrics (knitwear); tucks and floats of its fleecy yarn, for example, laid along the course, are more curved than inlaid knitting fabrics.

Fleecy knitting structures is made up from at least two systems of yarns on weft and warp knitting machines.

Two methods for producing fleecy fabrics are used: one and many cyclic (two and three cyclic methods are known).

In one cyclic method of laying base (main) and fleecy yarns on the needle is performed simultaneously in one loop formation cycle (in one loop-forming system).

In double cyclic method of laying base (main) and fleecy yarns on the needle performed separately in various looping cycles (in various looping systems).

In the three cyclic methods, in separate looping cycle, the fleecy, base and plating yarns are laid in the different cycles of interlooping.

In this research firstly, the following variations of fleecy knitting structures and notations are developed and designated as: 1/1, c = 0; 2/1, c = 0; 3/1, c = 0; 1/1, c = 1; 2/1, c = 1; 3/1, c = 1; 3/2, c = 1 (number of wales in the fleecy yarn float/ number of wales in which fleecy yarn tuck tucks with ground (base) loop; s = number of shifting steps) [5].

Then 14 different variants of compression socks were produced. The structure of the fleecy knitted fabric differs from each other in the rapport, the number of ground loops, the number of shifting steps of the fleecy yarn tucks, and the linear density of the used yarns. All variants of fleece fabric knitted on the basis of plain knit structure, and consists of ground yarn and fleecy yarn. The ground yarn is only visible at the technical face side, and the fleecy yarn is visible at the technical backside. Cotton and spandex yarns are used as a ground yarn of the fleece knit structure, and latex thread is used as fleecy yarn. Cotton yarns were used to ensure air permeability, and spandex and latex threads were used to achieve the compression level [6].

The rapport of fleece knit structure for producing the 1st and 8th variant of compression socks is equal to 1/1, c=0, and consists of one course Rh=1 and two wales Rb=2. There is not shifting steps of fleecy yarn tuck in the knit rapport. The fleece knit structure is produced by tucking in the fleecy yarn tuck onto the ground yarn at same wales position, that is, in each course of knit structure after the fleecy yarn is tucked on the one ground loop, the next fleecy yarn will tuck on ground loop by passing through with regular interval one wales of ground loops. The float of fleecy yarn is equal to the width of one ground loop. The shifting steps of fleecy yarn tuck from the next courses is equal to zero. The effect of rib knitting structure as a strip is obtained. Cotton and spandex yarns are used as a ground yarn of the fleece knit structure, and latex thread is used as fleecy yarn. Variants 1 and 8 differ from each other in the linear density of the cotton yarn. In the production 1st variant of compression sock, cotton yarn with 30 tex linear density were used, and for 8th variant used cotton yarn with linear density 18 tex. All samples had the same linear densities of spandex and latex yarns, with spandex 8.33 tex 40 filament (75d 40 F) and latex 98 tex (Ne 6).

The rapport of fleece knit structure for producing the 2nd and 9th variant of compression socks is equal to 2/1, c=0 (Figure 2.5 - b), and consists of one course Rh=1 and three wales Rb=3.

There is not shifting steps of fleecy yarn tuck in the knit rapport. The fleece knit structure is produced by tucking in the fleecy yarn tuck onto the ground yarn at same wales position, that is, in each course of knit structure after the fleecy yarn is tucked on the one ground loop, the next fleecy yarn will tuck on ground loop by passing through with regular interval two wales of ground loops. The float of fleecy yarn is equal to the width of two ground loop. The shifting steps of fleecy yarn tuck from the next courses is equal to zero. The effect of rib knitting structure as a strip is obtained. The composition of raw materials will be the same as in variants 1 and 8, respectively.

DISCUSSION

The investigated samples of fleecy knitwear are intended for the manufacture of a compression hosiery destined for the treatment and prevention of varicose veins of the lower extremities. Therefore, the most important are properties such as breathability; tensile strength; elongation, working elongation, reversible deformation, which are the main parameters affecting the compression properties of knitwear, as well as shrinkage.

The physical mechanical properties of the studied compression hosiery samples were tested according to the standard method [7-9].

Physico-mechanical properties of fleece knit fabrics created for compression hosiery products were analyzed experimentally using modern devices installed in the "CENTEXUZ" certification laboratory at TITLI.

By mechanical properties of materials is meant those that determine their relation to the action of various kinds of forces applied to them, under the influence of which they deform. One of the main mechanical properties of knitwear, including compression hosiery, regulated by quality standards is tensile strength and breaking elongation.

The results of the analysis show that the elongation at break varies from 140% to 175% in length and from 270% to 357% in width. The elasticity of the compression fleece knitted fabric varies in the range of 87-114% in length, in the range of 180-230% in width

Deformation change in knitted fabric depends on the type of raw material as well as its structure. The lengthwise and widthwise deformation characteristics of the knitted fabric become more varied, when the more additional elements (tucks, floats, elongated floats, transfered loops) are added to the composition of the knitting structure.

CONCLUSION

The analysis of the current state of knitwear production shows that the development of a method of obtaining compression knitwear products using local raw materials is one of the pressing problems of the textile industry.

The types and production methods of compression knit products were studied, the construction and production method of compression socks were developed, 7 different rapports versions of compression fleece knitted fabric were created, and 14 different fabric samples were produced. In order to improve the hygienic properties, cotton yarn was used, and to achieve the compression level, spandex and latex threads were used.

From the analysis of technological indicators, it was found that the surface density changed from 329,9 g/m^2 to 470,5 gr/m^2, and the change in the linear density of cotton yarn in the knitted fabric with the same rapport, surface density decreased by 8-24%, by increasing the number of ground loops corresponding to the fleece yarn float in the knit structure increased the surface density by 6%, and the use of shifting steps caused a decrease in the surface density by 7%. The volume density is reduced by 34% compared to the base fabric, and the lowest value among the samples was observed in variant 14, which indicates that the consumption of raw materials in production is the least.

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