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THE INFLUENCE OF WEFT FILLING YARN ON THE PROPERTIES OF WARP KNITTED FABRIC

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Abstract

An important issue for people today is to extend the solutions to health problems, including treatment and prevention of spine diseases. This increases the need for support and fixing of different spine parts, that promotes the demand growth of the binders and braces. Such special goods prevent the emergence and stop the disease development, improves the well-being condition and normal function of the body, the ability to maintain performance and activity. Despite the huge number of existing structures of therapeutic and prophylactic products, the elastic fabrics of different width are the basic materials for their manufacture. Therefore, the main attention is directed to the formation and investigation of the knitted elastic fabric for special purposes, especially for preventive goods

The knitted fabrics with weft - inserted yarn that produced on crochet knitting machine is the subject of this research. The chain is the basic interlooping of all variants. An elastomeric thread is introduced into the structure as longwise inlaying yarn with preliminary elongation to ensure the necessary extensibility of knitted structure. The weft filling yarn is laid on both sides of the elastomeric threads to prevent its contact with the body and to ensure the hygienic properties of medical goods. The few variants of weft yarn filling have been used: at the whole width of fabric that create a smooth surface and according to the repeats as well. The studies of fabrics properties were carried out at this research. The influence of inlaying variants of weft yarn on structure parameters and mechanical properties was found.

Keywords: warp knitted fabric, filling interlooping, in-laying yarn, chain, elastomeric yarn, structure parameters, stretch characteristics.

INTRODUCTION

The competitiveness of knitted fabric is increasing every year due to the variety of advanced row materials and the formation of new knitted structures. There are a wide technological possibilities of modern knitting equipment for creating the different surface and the original textures of knitted fabric which astonishingly varied. As a result, people have got the new high performance functional and comfortable materials with the necessary properties.

The production of knits for medical purposes is expedient and commonly used. In the dynamic life rhythm of today's world there are a variety of diseases. The use of health care textile products is one of the means of prevention and treatment of them. The celerity of such products development is impressive. The preventive product allows you to normalize the body functioning and to ensure the patient's normal state of health, to preserve health and to prevent the development of diseases in the future as well as to contribute the expanding of an activity and an efficiency. The medical preventive product helps to reduce and to eliminate swelling, relieves pain and other symptoms. Such perspective attracts people generally, and therefore has a great demand [1].

The medical elastic textiles are used for the prevention and the treatment of varicose veins; for fixing of support - motor system; for the bandage manufacturing; for the accelerate of post-surgery tissue regeneration etc. Medical binders are the indispensable goods for the prevention of weakened muscle tone as well as for violated human body frame. They are widely used among different people groups. Therefore, the creation and the investigation of elastic knitted material for the medical binder manufacture are the key issues.

Medical devices are essential for safe and effective prevention, diagnosis, treatment and rehabilitation of illness and disease. The medical-prevention devices are supporting the normal functioning of human body. [**Error! Reference source not found.**]. An abdominal binder serves many important functions, especially in the early postoperative stages of an abdominal surgical procedure. An abdominal binder provides compression and support to both the upper and lower abdomen. It helps to improve blood circulation and oxygen levels at the operative site, increases healing and reduces swelling. With all these improvements, the patient is able to get out of bed sooner and walk around more easily. This further improves breathing and promotes the healing process and a speedy recovery. An abdominal binder is like an elastic belt that you fasten around your stomach, and it provides support for your abdominal muscles while also helping to keep stitches or bandages in place and promoting healing at the incision site.

Functionality of medical binder ensured compliance of the body shape on which it is worn. The shape and size of the human body are determined by the skeleton, the muscles and the fat degree. Medical binder is used externally to compensate lost functions due to changes in the spine and muscles, and to correct them and to fix the desired position. The medical effects of such medical device is indirect by a deformation of the skin and the muscles with the biggest change in the abdominal and thigh. It deforms muscle tissue and partially shift them to the top of the gluteal folds. The body's part with the greatest surface curvature has got the biggest deformation because such area has the highest pressure level. Existing forces should be precisely metered to avoid even minor damages of the skin, blood vessels and peripheral nerve fibers [**Error! Reference source not found.**,**Error! Reference source not found.**].

The needs in compression products continuously increase, so a creating new items and an improving existing methods of production are always very important. Today there are a large number and variety of medical binders depending on their design and end-using. The topical issues of the medical product production are quality, functionality and hygiene properties. Namely medical binders have to keep their geometric dimensions and shape after repeated use and after washing; to have good air-permeability (breathability) and well moisture absorption, that create comfort; to provide the necessary therapeutic effect; to be convenient and easy using etc. Ensuring these properties is due to a construction of the product and to raw materials as well as to fabric interlooping.

The using of elastomeric threads and yarns is the way of providing functional properties of fabric. They affect the physical-mechanical properties especially the stretch characteristics. The using of elastic knitted fabrics for prevention goods manufacturing helps create comfortable using, good fitting to the human body, satisfy any aesthetic requirements. Knitted materials containing elastomeric yarns can reduce the number of cutting-sewing operations. provide the necessary physical-mechanical and hygiene properties through a variety of structures. [**Error! Reference source not found.**]. The feature this material lies in the fact that it is extensible, elastic and has the ability to restore their original dimensions after multiple loads. The quality of such fabrics is determined by the securing reliability of elastomeric yarns in the structure.

Elastomeric yarn in the knit structure can form a loop or tuck either be placed as filling yarn. The choice of the elastomeric yarn's fixing is caused by conditions of its processing on the knitting machine and by requirements that apply to the preventive goods. The main disadvantage of elastomeric yarns is a high friction which creates certain obstacles in contact with needles. From the other, their contact with the human body can cause allergic reactions. In case of using the elastomeric yarn as filling yarn her contact with the needles of the knitting machine are excluded, that allows the use raw elastomer. If ground interlooping is warp knit it is ensured reliable wrapping of elastic thread by ground loops. The elastic threads are positioning inside warp knitted structure, that exclude its contact with human body.

The necessary elasticity and extensibility of the knitted fabric are due to the pre-stretching of elastomeric threads before knitting [**Error! Reference source not found.**]. After knitting and relaxation of the elastomeric yarn that is in-laying in walewise direction the loops skeleton is turning in the coursewise direction. The tilt angle depends on the relaxation level of elastomeric yarn that is affected by interlooping and by pre-stretching level. The best result is occurred in knitted structure with chain as ground: the loop's skeleton of the next course turns in opposite direction to loop's skeleton of the previous course. As result loops in wale turn left and right and move walewise when pull. That is stretch properties of such knitted structure depend on chain loops positioning in walewise direction.

When used chain interlooping as a ground it is necessary to connect separate chains into the fabric by weft inserted (filling) threads [**Error! Reference source not found.**]. There are two variants of weft yarn insertion into the warp knitted structure. First one is by special feeder that used for weft yarn insertion for full width of fabric. The surface of this fabric is smooth with high cover factor. The second variant is by guide bar with partly drawing-in that used for weft yarn insertion according shifting repeat. The surface of this fabric is not smooth and has holes.

Usually the weft filling yarns are laid on both sides of elastomeric yarn and are positioned between the skeleton and the juncture of chain loop which firmly encircles them and securely hold in a knitted structure. Usually the thick yarn is used as weft filling yarn. Its linear density is several times more than the linear density of the elastomeric yarn and the ground yarn that allows to create a dense cover to prevent the contact of elastomeric yarn with human body.

Thus it is necessary to assume that the properties of knitted fabrics will depend on an interlooping repeat, especially weft filling yarn repeat, and a drawing-in of guide bars.

EXPOSITION

The goal of this research is to investigate the influence of variants of filling yarn on the structural parameters and physical-mechanical properties of warp elastic fabrics. To achieve this goal different variants of warp knitted fabric have been made on 14-gauge crochet knitting machine. The investigation of structure parameters and of strain characteristics of elastic fabric was carried out according to standard methods after 72-hour relaxation in normal climatic conditions.

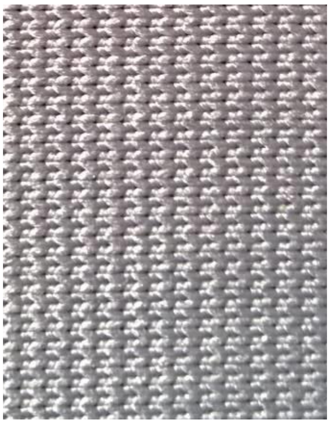
In order to provide the special requirements such as elasticity, extensibility and hygiene, warp knitted fabric that produced by four guide bars have been chosen for the production of elastic bands. Six variants of warp knitted elastic fabric were produced (Table 1)..

Table 1: *Production data of elastic warp knitted fabrics*

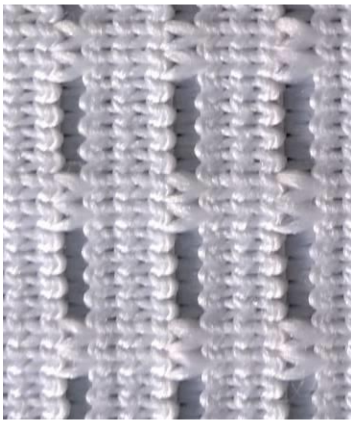
Variant	Linear density of yarn			Devices for weft yarn inserting	Weft yarn inserting	Drawing-in repeat			
	G1, G3	G2	G4			G1	G2	G3	G4
1	Polyester 33,4 tex x 4	Latex 0,6 mm	Polyester 16,7 tex	2 special feeders	Full width	-	Full set	-	Full set
2	Polyester 33,4 tex x 2			1 guide bar	According to repeat	-	3 in, 1 out	1 in, 3 out	3 in, 1 out
				1 special feeder	Full wide				
3	Polyester 33,4 tex x 4			1 guide bar	According to repeat	-	Full set	1 in, 1 out	Full set
				1 special feeder	Full width				
4	Polyester 38,4 tex x 3	Latex 0,8 mm	Polyester 18,8 tex	2 special feeders	Full width	-	Full set	-	Full set
5	Polyester 38,4 tex x 3			2 special feeders	Full width	-	2 in, 1 out	-	Full set

6	Polyester 38,4 tex x 2 + cotton 26 tex			2 guide bars	According to repeat	1 in, 5 out	Full set	1 in, 5 out	Full set

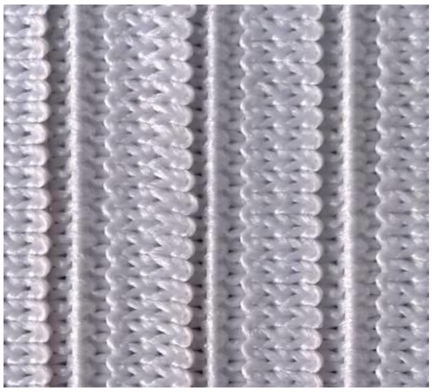
Chain is a ground interlooping that formed with full drawing-in of fourth guide bar (G4) except variant 3 that produced with partly drawing-in of guide bar. Elastomeric yarn is laying in second guide bar (G2) with full drawing-in for variants 1, 3, 4 and 6 and with partly drawing for variants 2 and 5. First (G1) and third (G3) guide bars or special feeders are using for weft yarn filling. Warp knitted fabrics of variants 1-3 as well as of variants 4-6 were made from ground yarn of same liner density as well as elastomeric threads of the same diameter. As showed at photos (Fig. 1) fabrics have different surface and cover factor.



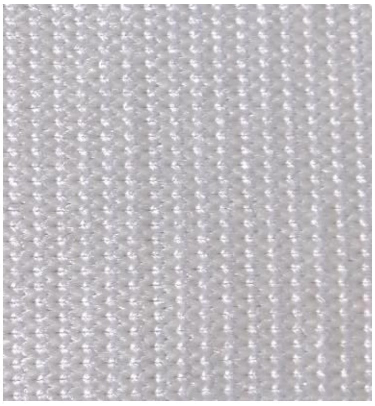
Variant 1



Variant 2

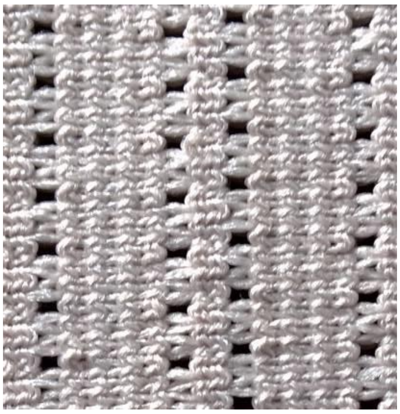


Variant 3



Variant 4

Variant 5



Variant 6

Fig. 1 *Photos of elastic warp knitted fabric*

The experimental results of structural parameters are presented in Table 2. It's obvious that loop's length of chain is reducing up to 45 % from variant 1 to variant 3. The same trend is observed in the course height while the loop pitch is almost the same (value not exceeding 5%). It suggests that elements of knitted structure are positioned in the thickness. The difference between the warp yarn length per course and the course height demonstrates that elastomeric yarn does not fully relax and is in a stretched state in the knitted structure. But its stretch level is differing: from 125 % at variant 1 to 105 % at variant 3 that affects elastomeric yarn diameter as well as fabric thickness. All these causes in combination with different drawing-in of guide bars directly leads to the difference in basis weight.

The knitted fabrics of variants 4, 5 and 6 have different structural parameters also. So the basis weight of variant 4 is biggest because of full drawing-in of guide bars and of filling of weft yarn to full width of fabric. The fabric of sixth variant has a higher basis weight compared to fifth although it was made from weft yarn of smaller linear density but it was produced with full set of guide bar G3. The thickness of variant 5 fabric is smallest because it is produced with partial laying of elastomeric yarn. In addition, loop length of this fabric is highest and the threads in weft filling yarn can be located one over other along the elastomeric yarn that leads to reducing of basis weight. The thickness of variant 6 fabric is highest because of using cotton yarn as part of weft filling yarn but in combination with weft yarn shifting repeat on both side of elastomeric yarn this fabric has the good value of basis weight.

Generally, it seen that weft yarn filling according to repeat as well as partially drawing-in of guide bars effect the material consumption towards its reduction.

The research of strain properties has the particular importance for such health care products as an abdominal binders and a compression clothes. The alternating of stretch processes with the unloading and rest affect the structure parameters by deforming and changing the original shape and size. The full stretch of warp knitted fabrics and its components as well as quotas of parts was calculated on the experimental data (Table 3).

***Table 2**: Structural parameters of elastic warp knitted fabrics*

Variant	Average length, mm			Loop pitch A, mm	Course height B, mm	Thickness, мм	Basis weight, m_s , g/m^2
	loop, l_4	warp yarn, l_2	weft yarn, l_1 & l_3				
1	8,66	0,45	1,75	1,76	0,58	1,80	986,0
2	5,40	0,53	1,71	1,72	0,56	1,66	882,3
3	4,80	0,50	1,72	1,73	0,52	1,54	844,0
4	5,60	0,54	1,73	1,72	0,59	1,60	913,2
5	7,20	0,45	1,75	1,74	0,47	1,51	716,0
6	7,00	0,60	1,70	1,70	0,70	1,67	770,0

***Table 3**: Strain characteristics of elastic warp knitted fabrics*

Variant	Full stretch ε, %	Parts of full stretch, %			Quota of part		
		Elastic, ε_1	Plastic, ε_2	Residual, ε_3	Elastic, $\Delta\varepsilon_1$	Plastic, $\Delta\varepsilon_2$	Residual, $\Delta\varepsilon_3$
1	179,0	171,0	5,0	3,0	0,960	0,028	0,017
2	145,0	138,0	5,0	2,0	0,952	0,034	0,014
3	152,0	144,0	5,0	3,0	0,947	0,033	0,020
4	108,0	101,0	5,0	2,0	0,935	0,046	0,019
5	185,0	177,0	4,0	4,0	0,957	0,021	0,021
6	158,4	154,2	2,8	1,4	0,910	0,040	0,050

During the investigation it was found that the strain characteristics of warp knitted fabric depend on the loop length of the chain and tilt of loop skeleton. So full strain or variant 1 fabric is biggest among first three variants. And the full strain of variant 4 fabric is less than 5 and 6 because loop length of chain in this structure is smallest.

Elastic strain is the greater quota of full strain of warp knitted elastic fabric of all variants. it is evidence of the rapid stress relaxation in fabric with elastomeric yarn. The quota of residual strain is within 0.05 that mean dimensional stability. These figures point to the possibility reusability because they have a high elasticity and can quickly restore their dimensions.

According to the standards the minimum strain of elastomeric products should not be less than 80%. The research results accurately show that all variants of fabric can be used in health care products such as abdominal binder.

CONCLUSION

The experimental data showed that using of guide bar with partly drawing-in for weft yarn incerction into the elastic warp knitted fabrics have leads to decrease of fabrics basis weight while provides the necessary extensibility (140 ÷ 160%) with low residual strain (1.5 ÷ 3.0%). The warp knitted fabrics of variants 6 and 2 are recommended for the manufacture of health care and prophylactic products such as abdominal binder to reduce the weight of goods.

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