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FEATURES RESEARCH OF KNIT FOR MANUFACTURING FENCING SUITS

Purpose. *Produce quality knitted fabric for fencing suits with high strength of knit against perforation of blade of one of the sporting weapons' type*

Methodology. *In the work methods for experimental research and standardized methodologies of samples of weft double-layer knit with tuck connection of layers by main threads, which were developed on two needle bed circular machine 16 gauge with interlock arrangement of needles in cylinder and dial. Dynamometer for test of cloth resistance to perforation was used for research.*

Results. *Development of new special purpose double-layer knit with tuck connection of layers by main threads and the verification of the necessary strength of knit against perforation (penetration - test).*

Scientific novelty. *To identify ways of improving of quality of knitting of layers of weft double-layer knit for fencing suits; were defined and justified demands of against the puncture strength (perforation) of blade of one of the sporting weapons' type*

Practical value. *Research of production for knitting process, which provides normal flow of process of stitch formation and reception of the counterbalanced structure of weft double-layer knit with predicted properties; research of knit on resistance against perforation*

Keywords: *double-layer knit, knit for fencing suits, sports knit, resistance against perforation.*

Introduction. The most important function of a fencing suit is to protect the athlete's body in the event of weapon's breakage. This is common, because modern fencing is a very athletic sport, and the weapons' blades are not always flexible enough to withstand the pressure put on them during the collision athletes.

Fig 1**. Collision athletes close-in fighting fencing duel with the bending of the blade arms**

In Figure 1, we can see the convergences in a duel between world class athletes. Very high voltage tests blade weapons and, of course, can break. That is why the suit athlete must be strong to such pressures [1,2]

Objectives. There are mandatory requirements of the International Federation of fencing

(FIE) to the resistance of textile materials [3], which the fencing suits are made of, against the puncture strength (perforation) of blade of one of the sporting weapons' type. The international tournament of category A (the highest category, which include the World Championships, the European and Olympic Games) for the manufacture of fencing clothing it is obligatory to use material which is able to resist perforation by a force of at least 800 Newtons [6]. These requirements apply for the three major components of a fencing suit, namely fencing jacket, breeches and under plastron (fig.2). All manufacturers of these products must send fencing suits' material samples to the certified laboratories and research institutes for confirmation of strength of the suits and their subsequent labeling. These institutions must be allowed to conduct such examinations; the main one is located in the home of the Fencing Federation in Germany – DITF German institutes for textile and fiber research Denkendorf [4]).

Fig 2**. Elements of fencing clothing which are made of double-layer knit**

At manufacturing double-layer weft knitted fabrics for fencing suits, for formation of their layers are used conventional, and nonconventional for a knitwear manufacture kinds of raw materials that substantially influences process of stitch formation. One of the basic problems of manufacturing double-layer weft knit is choice of parameters of knitting which provide reception of the counterbalanced structure of its layers. The work purpose is the research of production for knitting, which provides normal flow of process of stitch formation (of interlooping) and reception of the counterbalanced structure of weft double-layer knit with predicted properties.

Weft double-layer knit is widely applied to knitting of articles which should possess different physical-mechanical properties. Owing to change of kinds of raw materials and parameters of looping structure of double-layer knit we can knit various on properties layers of knit and receive multifunctional knitted fabrics. The fabric projected by us was made for manufacturing of suits for fencing. The special protective clothes are required for fencer, which protect a body of the person from blows lame and cutting surfaces, in case of breakage of the weapon during fight. All clothes and equipment for fencing should correspond to requirements FIE. In particular, cloths for manufacturing of a jacket, breeches and plastron, first of all, should possess high stability to punching of lame the sports weapon, and also the set physical-mechanical properties of quality which are should possess to sportswear. Thus, before the manufacturer of knitting fabrics there is a following problem: on the one hand these cloths should protect a body of the sportsman from blows

lame and cutting surfaces, that is to have protective properties, and with another, to have properties of sportswear for comfort of fencers.

So, fabric for fencing suits should possess two basic properties simultaneously: to protect a body of the sportsman and to provide a comfortable condition of the sportsman during physical activities throughout duels. Therefore use of weft double-layer knit is expedient as its each layer is independent fabrics which are connected in the process of knitting [5]. One layer which adjoins to a body of the sportsman should correspond to the hygienic requirements shown to sportswear; the second layer – should possess high degree of stability to punching action.

In order to check the strength of the knitted fabric to puncture, it is necessary to study the process, about which there can occur during deformation suit fencing bout. Figure 3 shows the types of weapons and their cross section. As we can see, the weapon has a different cross-sectional shape. In case of breakage of the blade arms cutting surfaces will be different. Their appearance, shape, taper angle may be different depending on the type of weapon and the speed of convergence conditions of athletes.

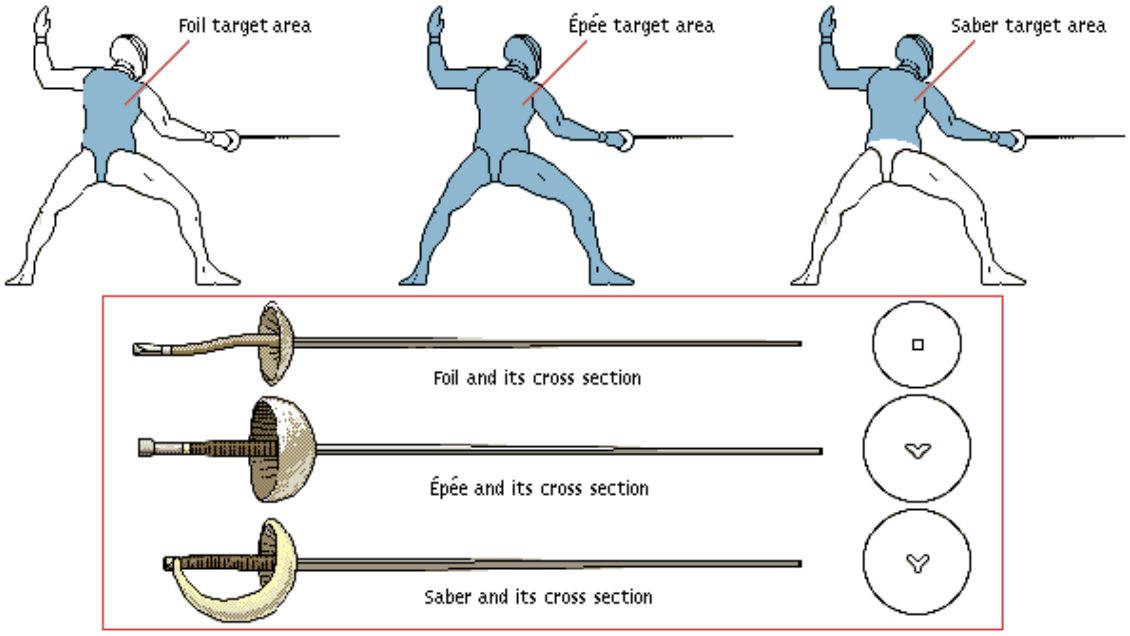


Fig 3**. The types of weapons and cross section**

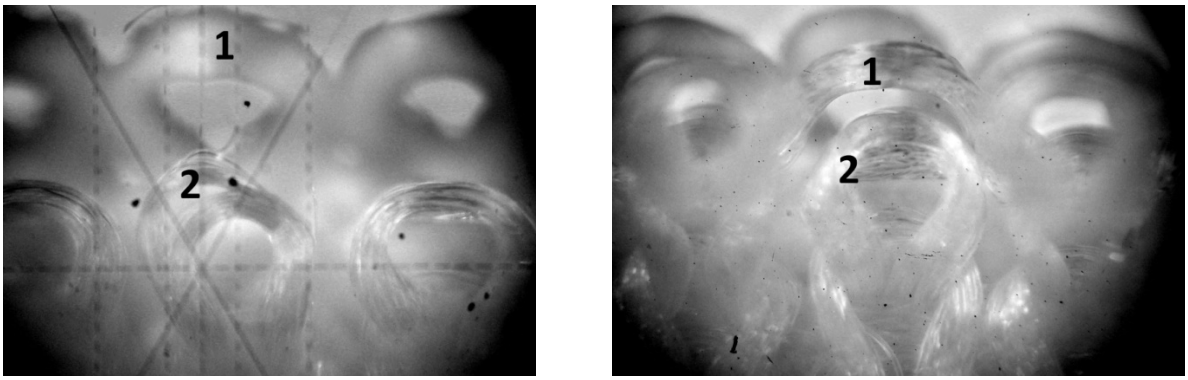
When cutting impacts most frequent fracture: a break and crack the surface layer of the material, through tears, the destruction of the entire thickness of the material [8]. To check the strength of the fabric to puncture, it is necessary to use a special unit, which will help to approximate the conditions of the fight for testing knitted fabric.

Research results. During the analysis of known structures weft knit the structure weft double-layer knit with tuck connection of layers by main threads (tuck lace) is developed for manufacturing of fabric of sports destination. The general for all structures of knit with tuck connection by main threads is presence of the tucking (tuck stitches) formed of threads of one of layers. These tucking lie on floats (junctures) an opposite raw of loops.

As the knitted fabric projected by us has a certain special-purpose designation, namely for use as a textile material for manufacturing fencing suits also the basic requirement shown to it, was minimization of sizes of a micropore in its looping structure. The size of a micropore depends on

superficial and volume filling of knit and defines degree of stability of a textile material to punching action. The maximum superficial filling with other things being equal in process of knitting can be reached by increase of density of knitting. However the increase this parameter leads to increase of weight of meter of a square fabric and deterioration of its extensibility, that is very important factor at a choice of a textile material for manufacturing fencing suits. Therefore it is offered to knit both layers of fabric a stitch of derivative jersey for the purpose of decrease of sizes of a micropore. Provided that tucking for connection of layers it is offered to have in everyone course through wale on dial needles from a thread of backing (reverse) layer of knit.

It is experimentally established that a choice of parameters of a mode of knitting of layers of weft double-layer knit, recognizing that they represent single weft knitted fabric of a certain stitch, does not provide normal of process of its knitting in case of use tuck connection of layers by main threads. The size of connecting tucking substantially influences on normalization process of stitch formation. In the process of knitting of such knit is found out of interaction of layers in a knit plane. Such knit can be named by unbalanced or strained as elements of its structure occupy the form not peculiar to them in single knit at its free condition. These elements are deformed in a certain direction by other elements of structure that is loops of another layer. Change of the form of loops and structure of knit as a whole leads to change of process of its knitting. Therefore a important aspect of manufacturing of weft double-layer knit with predicted properties is optimization of process of its knitting.



a) *b)*

a) 1 – row of loops of a face layer, 2 – row of loops of a backing layer
b) 1 – tuck connecting stitch from a thread of a backing layer, 2 - loops of a face layer

Fig 4. **The arrangement of elements of looping structure of weft double-layer knit**

Samples of weft double-layer knit with tuck connection of layers by main threads were developed on two needle bed circular machine 16 gauge with interlock arrangement of needles in cylinder and dial. The specified arrangement of needles provides reception in the process of knitting line coverage of face and reverse (backing) surfaces of knit, despite presence tuck connecting stitches from a thread of one of layers which in an is conditional-equilibrium condition aspire to move apart the next wales. As raw materials for its manufacturing were used multifilament texturing polyester yarn by a linear density 150 den (a backing layer of knit on cylinder needles) and 450 den (a face layer of knit on dial needles). Placing of loops of one layer of knit concerning another in knitted fabric is shown in a photo of macro shooting of looping structure of weft double-layer knit (fig. 4,a).

Is shown on fig.4,a, loops of opposite layers are located one opposite to another because of arrangement of needles in a interlock. From behind of knitting of a derivative jersey on different needles in each following knitting system is received the texture which in each layer have wales are pull together closely one to another and no intervals between the next needle wales. Is shown on fig.4,a loops of opposite layers 1 and 2 are located one opposite to another because of arrangement of needles in interlock and to knitting of a derivative jersey on different needles in each following knitting system. Thus, loops of both layers of knit will resist to action of punching effort. In other photo (fig. 4,b) we see an arrangement tuck connecting stitch 2 in structure of weft double-layer knit which as already it was marked earlier, aspire to move apart the next wales which directly connected to them.

The prime problem of manufacturing weft double-layer knit of such refueling, first of all, consists in a considerable difference in a linear density of the threads forming face and backing layers of knit (a linear density of a thread of a face layer three times more backing). The increase of a linear density of the thread forming a face layer of knit, allows to reach necessary level of stability of a material to punching action. It in turn demands a choice of parameters of a mode of the knitting, providing normal course of process stitch formation. The interrelation determination between draw lever at formation of loops in the cylinder and a dial, and also in a dial at formation of tucking with the account of a kind and a linear density of raw materials and design data of the knitting equipment will allow to normalize process stitch formation and to receive the counterbalanced structure weft double-layer knit with tuck connection of layers by main threads [12].

The developed double-layer knit, the must pass verification of the necessary strength of knit against perforation (penetration - test). A special setting was used to check the canvas for the strength measure [6]. To imitate the conditions of the puncture of knit during a fight the special blade puncture conditions were developed at the facility for this study.

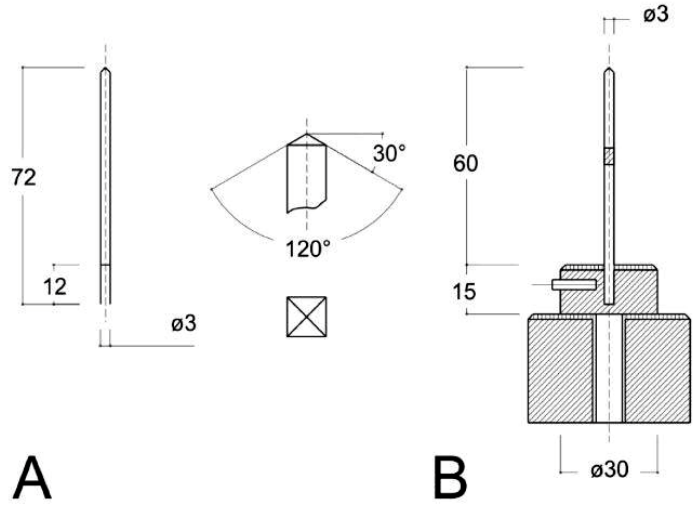


Fig 5**. Dynamometer for test of cloth resistance to perforation**

Figure 5 presents circuit device for research of knit on resistance against perforation. Method of work for the study: the sample material is placed in the clamp with a hole of 25 mm and fixed spring ring. Sample holder is mounted on the platform lever cargo handling system, which

with a given initial load of 2.3-2.5 kg presses the sample. Rod to puncture at a speed of 720-750 mm / min until the sample is moving until the sample will puncture. As soon as a puncture leaf, stem stops and on the scale of the installation will be fixed load and deflection of the sample before the break. In conducting the study, we also examined what deformation on the sample during the experiment. From the standpoint of the nature of the contact deformation of the material in the zone of interaction with the cutting surfaces is difficult to distinguish the predominant deformation.

To imitate the conditions of the puncture of knit during a fight the special blade puncture conditions were developed at the facility for this study. The synchronization of the activity at the facility with the computer provided us with the graphs of pressure – deformation, which allows studying the process of fabric puncture over time. It gave us the opportunity to study in detail the process puncture of knitted fabric for improving the strength of knit.

References

1. Fencing suits in tournament. – [Elektronnyi resurs]. – Rezhym dostupu: **Ошибка! Недопустимый объект гиперссылки.**
2. Fencing sportsman. – [Elektronnyi resurs]. – Rezhym dostupu: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcRIf5O4BWiAx73sradi1zBo1AFmZ6zsLsPUeAzTRUu0VbwX-K7Rg
3. Rules for competition. Material rules by FIE. Updated February 2016. – [Elektronnyi resurs]. – Rezhym dostupu: http://static.fie.org/uploads/8/44439-book%20m.pdf.
4. Research by DITF German institutes for textile and fiber research Denkendorf. – [Elektronnyi resurs]. – Rezhym dostupu: https://www.ditf.de/en/index/technologies/webs-and-structures.html
5. Pospelov E.P.Double-layer knit. – M.: Light and the food-processing industry, 1982: pp. 151-154.
6. Bendik N., Stankevich V.: Double-sided knitted fabric: declarative patent on the model, Kyiv, Ukraine, 2004.
7. Higginson S.,Jacobs P.,Smith P.: Chapter 2: Equipment and clothing. In The FIE rules for competitions, Edited by British Fencing Association Ltd, Place: London 2010, pp. 1-92. – [Elektronnyi resurs]. – Rezhym dostupu: https://www.fie.ch/download/rules/en/book_m_16.1.pdf.
8. Yaroshchuk O.V. Development of methods for evaluating the protective properties of special materials that are exposed to the cutting surfaces: diploma – Leningrad, 1990. – pp.42-99.
9. Motovylovets N.V., Halavska L.Ie. Weft double-layer knit: patent on the model number 51029. Kyiv National University of Technologies and Design, Ukraine, 2010.
10. Motovylovets N.V.,Halavska L.Ie. Especially manufacturing knitted fabric for fencing suits. International Scientific and Technical Conference "Modern technologies and equipment for textile industry Textile 2009": book of abstracts, Edited by Moscow State Textile University, Russian Federation: November, 2009, pp. 71.
11. Beskin N.V., Halavska L.Ie. Research of knit for fencing suits on resistance against perforation, Book of abstracts of 47th International Federation of knitting technologists congress, 25-26 september 2014 Izmir-Turkey, pp.42-43.
12. Motovylovets N.V., Halavska L.Ie Normalization of process of knitting weft double-layer knit on two needle bed circular machine Book of abstracts of 45th International Federation of knitting technologists congress, 27-29 May 2010, Ljubljana, Slovenia, pp.193.

Список використаної літератури

1. Fencing suits in tournament. – [Електронний ресурс]. – Режим доступу: **Ошибка! Недопустимый объект гиперссылки.**

2. Fencing sportsman. – [Електронний ресурс]. – Режим доступу: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcRIf5O4BWiAx73sradi1zBo1AFmZ6zsLsPUeAzTRUu0VbwX-K7Rg

3. Rules for competition. Material rules by FIE. Updated February 2016. [Електронний ресурс]. – Режим доступу: http://static.fie.org/uploads/8/44439-book%20m.pdf.

4. Research by DITF German institutes for textile and fiber research Denkendorf. – [Електронний ресурс]. – Режим доступу: https://www.ditf.de/en/index/technologies/webs-and-structures.html

5. Поспєлов В.П. Двошаровий трикотаж. – М.: Легка і харчова промисловість, 1982. – с. 151-154.

6. Бендік Н., Станкевич В., Двосторонній трикотаж: деклараційний патент на корисну модель 20040705288, Київ, Україна, 2004

7. Higginson S.,Jacobs P.,Smith P.: Chapter 2: Equipment and clothing. In The FIE rules for competitions, Edited by British Fencing Association Ltd, Place: London 2010, pp. 1-92. – [Електронний ресурс]. – Режим доступу: https://www.fie.ch/ download/ rules/en /book_m_16.1.pdf.

8. Ярощук О.В. Разработка метода оценки защитных свойств специальных материалов, подвергающихся воздействию режущих поверхностей: Дисс… канд. техн. наук: / Л., 1990. – с. 42-45

9. Галавська Л.Є, Мотовиловець Н.В., Кулірний двошаровий трикотаж: патент на корисну модель № 51029. Київський національний університет технологій та дизайну, Україна, 2010

10. Motovylovets N.V.,Halavska L.Ie. Especially manufacturing knitted fabric for fencing suits. International Scientific and Technical Conference "Modern technologies and equipment for textile industry Textile 2009": book of abstracts, Edited by Moscow State Textile University, Russian Federation: November, 2009, pp. 71.

11. Beskin N.V., Halavska L.Ie. Research of knit for fencing suits on resistance against perforation, Book of abstracts of 47th International Federation of knitting technologists congress, 25-26 september 2014 Izmir-Turkey, pp.42-43.

12. Motovylovets N.V., Halavska L.Ie Normalization of process of knitting weft double-layer knit on two needle bed circular machine Book of abstracts of 45th International Federation of knitting technologists congress, 27-29 May 2010, Ljubljana, Slovenia, pp.193.

ОСОБЛИВОСТІ ДОСЛІДЖЕННЯ ТРИКОТАЖУ ДЛЯ ВИГОТОВЛЕННЯ ФЕХТУВАЛЬНИХ КОСТЮМІВ

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Мета. *Виготовлення високоякісного трикотажного полотна для фехтувальних костюмів з високими показниками міцності до сили проколу (перфорації) клинком одного з видів спортивної зброї*

Методика. *Використано методи експериментального дослідження за існуючими стандартизованими методиками зразків двошарового кулірного трикотажу, виробленого на двофонтурній круглов'язальній машині 20-го класу з інтерлочним розташуванням голок. Для випробування полотна на стійкість до проколу використано динамометр.*

Результати. *Розроблено нову структуру та технологію в'язання двошарового кулірного трикотажу спеціального призначення з пресовим з'єднанням шарів основними нитками; на спеціальній установці перевірено стійкість трикотажу до перфорування.*

Наукова новизна. *Визначено шляхи поліпшення процесу в'язання шарів кулірного*

двошарового трикотажу для виготовлення фехтувальних костюмів; визначено й проаналізовано вимоги до полотен щодо їх стійкості до сили проколу (перфорації) клинком одним з видів спортивної зброї.

Практична значимість. *Встановлено режими в'язання, які забезпечать нормальний перебіг процесу петлетворення й отримання врівноваженої структури кулірного двошарового трикотажу із заданими властивостями; розроблене трикотажне полотно перевірено на відповідність показникам міцності до сили проколу (перфорації).*

Ключові слова*: двошаровий трикотаж, трикотаж для фехтувальних костюмів, спортивний трикотаж, стійкість до проколу.*

ОСОБЕННОСТИ ИССЛЕДОВАНИЯ ТРИКОТАЖА ДЛЯ ИЗГОТОВЛЕНИЯ ФЕХТОВАЛЬНЫХ КОСТЮМОВ

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Цель. *Изготовление высококачественного трикотажного полотна для фехтовальных костюмов с высокими показателями прочности к силе прокола (перфорации) клинком одного из видов спортивного оружия.*

Методика. *Использованы методы экспериментального исследования по существующим стандартизированными методиками образцов двухслойного кулирного трикотажа, изготовленного на двофонтурной кругловязальной машине 20-го класса с интерлочным расположением игл. Для испытания полотна на стойкость к проколу использован динамометр.*

Результаты. *Разработана новая структура и технология вязания двухслойного кулирного трикотажа специального назначения с прессовым соединением слоев основными нитями; на специальной установке проверено устойчивость трикотажа к перфорации.*

Научная новизна. *Определены пути улучшения процесса вязания слоев кулирного двухслойного трикотажа для изготовления фехтовальных костюмов; определены и проанализированы требования к полотнам по их устойчивости к силе прокола (перфорации) клинком одним из видов спортивного оружия.*

Практическая значимость. *Установлены режимы вязания, которые обеспечат нормальное течение процесса петлеобразования и получения уравновешенной структуры кулирного двухслойного трикотажа с заданными свойствами; разработанное трикотажное полотно проверено на соответствие показателям прочности к силе прокола (перфорации).*

Ключевые слова*: двухслойный трикотаж, трикотаж для фехтовальных костюмов, спортивный трикотаж, устойчивость к проколу.*