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COMPOSITION, STRUCTURE, AND PROPERTIES OF WATER-SOLUBLE CHEMICAL YARNS USED IN THE PRODUCTION OF PILE FABRICS FROM COMBINED YARNS AND INNOVATIVE FABRIC MANUFACTURING TECHNOLOGY



Doniyorov Bektosh Bahodirovich
Candidate of Technical Sciences, Associate Professor, Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan
E-mail: bektosh.doniyorov776@gmail.com
ORCID ID: 0000-0003-0692-4354
Science ID: FTV-0226-0025



Razzoqov Ja'far Abduvali ugli
Assistant, Jizzakh Polytechnic Institute, Jizzakh, Uzbekistan
E-mail: jafarrazzoqov93@gmail.com
ORCID ID: 0000-0003-4403-7545
Science ID: MJZ-0825-0020

Abstract. *This article investigates the composition, structure, and physicomechanical properties of water-soluble chemical yarns used in the production of pile fabrics from combined yarns, as well as an innovative technology for manufacturing such fabrics. The main objective of the study is to improve the technology for producing low-twist combined yarns by incorporating water-soluble Mintval chemical yarns with cotton yarns and to evaluate their influence on the quality characteristics of pile fabrics. The linear density, breaking strength, and elongation at break of three types of Mintval chemical yarns, RS56T6, RS38T6, and RS41T6, were analyzed. Experimental results demonstrated that the specific breaking tenacity of the investigated chemical yarns ranged from 2.0 to 2.1 cN/dtex. Furthermore, a comparative analysis was conducted to evaluate the capillary properties of warp yarns produced using the proposed technology and those manufactured under conventional industrial conditions. The experimental findings showed that the capillary rise height of the proposed sample reached 90 mm after 30 minutes, whereas the corresponding value for the conventional industrial sample was 51 mm. These results indicate that combining cotton yarns with water-soluble chemical yarns can improve the moisture absorption characteristics of warp yarns. The findings have practical significance for improving pile fabric production technology, enhancing product quality, and expanding the range of textile products with improved capillary properties.*

Keywords: *pile fabrics, combined yarns, water-soluble chemical yarns, Mintval, cotton yarn, yarn structure, physicomechanical properties, yarn twist, capillarity, innovative manufacturing technology.*

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СОСТАВ, СТРУКТУРА И СВОЙСТВА ВОДОРАСТВОРИМЫХ ХИМИЧЕСКИХ НИТЕЙ, ПРИМЕНЯЕМЫХ ПРИ ПРОИЗВОДСТВЕ ВОРСОВЫХ ТКАНЕЙ ИЗ КОМБИНИРОВАННЫХ НИТЕЙ, И ИННОВАЦИОННАЯ ТЕХНОЛОГИЯ ИХ ПРОИЗВОДСТВА

Дониёров Бектош Баходирович
Кандидат технических наук, доцент, Джизакский политехнический институт, Джизак, Узбекистан

Раззоков Джафар Абдували угли
Ассистент, Джизакский политехнический институт, Джизак, Узбекистан

Аннотация. *В статье исследованы состав, структура и физико-механические свойства водорастворимых химических нитей, применяемых при производстве ворсовых тканей из комбинированных нитей, а также инновационная технология изготовления таких тканей. Основная цель исследования заключается в совершенствовании технологии получения комбинированных нитей с пониженной круткой путём соединения хлопчатобумажной пряжи с водорастворимыми химическими нитями Mintval и оценке их влияния на показатели качества ворсовых тканей. В работе проанализированы линейная плотность, разрывная прочность и относительное удлинение химических нитей Mintval марок RS56T6, RS38T6 и RS41T6. По результатам экспериментальных исследований установлено, что удельная разрывная прочность исследованных химических нитей находится в пределах 2,0–2,1 сН/дтекс. Кроме того, проведено сравнительное исследование капиллярных свойств основных нитей, полученных по предложенной технологии, и образцов традиционного промышленного производства. Установлено, что через 30 минут высота капиллярного подъёма жидкости в предложенном образце достигла 90 мм, тогда как в образце предприятия данный показатель составил 51 мм. Полученные результаты свидетельствуют о возможности улучшения влагопоглощающих свойств основных нитей при совместном использовании хлопчатобумажной пряжи и водорастворимых химических нитей. Результаты исследования имеют практическое значение для совершенствования технологии производства ворсовых тканей, повышения качества продукции и расширения ассортимента текстильных изделий с улучшенными капиллярными свойствами.*
Ключевые слова: *ворсовые ткани, комбинированные нити, водорастворимые химические нити, Mintval, хлопчатобумажная пряжа, структура нитей, физико-механические свойства, крутка пряжи, капиллярность, инновационная технология производства.*

ARALASH IPLARDAN MOMIQ MATOLAR ISHLAB CHIQARISHDA QO‘LLANILADIGAN SUVDA ERUVCHAN KIMYOVIY IPLARNING TARKIBI, TUZILISHI VA XOSSALARI HAMDA INNOVATSION ISHLAB CHIQARISH TEXNOLOGIYASI

Doniyorov Bektosh Bahodirovich
Texnika fanlari nomzodi, dotsent, Jizzax politexnika instituti, Jizzax, O‘zbekiston

Razzoqov Ja’far Abduvali o‘g‘li
Assistent, Jizzax politexnika instituti, Jizzax, O‘zbekiston

Annotatsiya. *Ushbu maqolada aralash iplardan momiq matolar ishlab chiqarishda qo‘llaniladigan suvda eruvchan kimyoviy iplarning tarkibi, tuzilishi va fizik-mexanik xossalari hamda mato ishlab chiqarishning innovatsion texnologiyasi tadqiq etilgan. Tadqiqotning asosiy maqsadi paxta iplarini suvda eruvchan Mintval kimyoviy iplari bilan birlashtirish orqali kam eshilgan aralash iplar tayyorlash texnologiyasini takomillashtirish va ularning momiq matolar sifat ko‘rsatkichlariga ta’sirini baholashdan iborat. Ishda RS56T6, RS38T6 va RS41T6 markali Mintval kimyoviy iplarining chiziqli zichligi, uzilishdagi mustahkamligi va nisbiy uzayishi tahlil qilingan. Tajriba natijalariga ko‘ra, mazkur*

kimyoviy iplarning nisbiy uzilish mustahkamligi 2,0–2,1 cN/dtex oralig‘ida ekanligi aniqlangan. Shuningdek, aralash iplarni tayyorlashning taklif etilgan texnologiyasi asosida olingan tanda iplarining kapillyarlik xossalari an’anaviy ishlab chiqarish namunasi bilan taqqoslangan. Kapillyarlik sinovlari natijasida 30 daqiqada taklif etilgan namunaning kapillyar ko‘tarilish balandligi 90 mm ni, korxona namunasida esa 51 mm ni tashkil etgan. Olingan natijalar paxta va suvda eruvchan kimyoviy iplarni birgalikda qo‘llash tanda iplarining namlikni shimish xususiyatlarini yaxshilash imkonini berishini ko‘rsatadi. Tadqiqot natijalari momiq matolar ishlab chiqarish texnologiyasini takomillashtirish, mahsulot sifatini oshirish va yuqori kapillyarlik xususiyatlariga ega to‘qimachilik mahsulotlari assortimentini kengaytirishda amaliy ahamiyatga ega.

Kalit so‘zlar: *momiq matolar, aralash iplar, suvda eruvchan kimyoviy iplar, Mintval, paxta ipi, iplarning tuzilishi, fizik-mexanik xossalar, eshilish darajasi, kapillyarlik, innovatsion ishlab chiqarish texnologiyasi.*

Introduction. Today, the demand for textile products is growing day by day. The number of spinning, knitting, and weaving enterprises in Uzbekistan is increasing year by year, which is contributing to the increase in the share of the textile industry in the national economy. The introduction of textile cluster systems requires an increase in the production of competitive products in Uzbekistan.

One of the leading and promising sectors of the world economy is textile and light industry. Special attention is paid to the production of high-quality and competitive cotton fabrics in the world textile market and the use of new techniques and technologies in the implementation of these processes.

Scientific research is being conducted to produce a new range of downy fabrics, expand the scope of processing and using local natural raw materials, as well as to determine the quality indicators of downy fabrics, the physical and mechanical characteristics of downy fabrics, and to investigate changes in capillarity, water absorption, and dimensions, which are the main properties of downy fabrics. In this direction, research is considered a priority, including expanding the range of ring-spun fabrics, offering new types of weaving, and improving the consumer properties of the fabric by studying quality indicators.

Literature review. Researchers of our country and foreign scientists have conducted a number of studies and scientific works on the topic of scientific research:

In particular, one of the researchers from my country, U. Jabborov, in his dissertation entitled «Optimization of technological indicators of the preparation of spun yarn for felt», provided information on the technological indicators of felt-yarn preparation, types of yarn processing, yarn-spinning technology, and yarn defects and shortcomings [1].

Another scientist from our country, A. Dolimov, in his scientific work entitled “Optimization of the technological process of producing loop-pile fabrics using water-soluble yarns”, provided information on cotton-yarn and chemical (Mintval) yarn-spinning technologies aimed at increasing fabric softness [2].

The foreign scholar Eve Tokens, in her article «Exploring the Cozy World of Different Fluffy Fabric Types», classified the types of fluffy fabrics and provided extensive information about their fiber composition and the factors that should be considered during the sewing process [3]. Another researcher, Shikha Kumar, in her article «The Manufacturing Process of Baby Clothes», studied children’s clothing made of fluffy fabrics and its characteristics [4].

The purpose of this research is to develop an innovative technology for producing fluffy fabrics based on blended yarns.

Naturally, specific problems arise when cotton and Mintval yarns are combined. The cotton yarn used in the combination has a medium linear density, whereas the Mintval yarn is several times finer. When yarns with different linear densities—particularly yarns with significantly different thicknesses—are combined, inconsistencies in tension may occur. This is because the Mintval chemical yarn can stretch during the combining process. Such stretching is almost nonexistent in cotton yarn; therefore, it remains under constant tension. The two types of yarn also have different

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strengths, meaning that their resistance to mechanical воздействия differs. In addition, the hairiness of cotton yarn gives it a much higher coefficient of friction than that of Mintval yarn, which has a smooth surface and high elasticity.

The objectives of the research are as follows:

- to analyze the technology of combining cotton yarn with water-soluble chemical yarn of the «Mintval» brand for the warp yarns of fluffy fabrics and to study its properties;
- to improve the technology for preparing mixed yarns for fluffy fabrics and determine the possibility of using water-soluble yarn;
- to produce fluffy fabrics of mixed composition and study their physical and mechanical properties;
- to analyze the quality indicators of fluffy fabrics woven from mixed yarns.

The scientific novelty of the research is as follows:

- a new type of fluffy fabric with modified physical and mechanical properties was developed on the basis of mixed yarns;
- fluffy fabrics woven from low-twist yarns that meet the requirements of international standards were produced;
- by optimizing the technological process for preparing warp yarns for weaving, it became possible to use cotton yarn in combination with «Mintval» water-soluble chemical yarn;
- a new range of fabrics with high capillarity was produced using low-twist yarns as the warp yarns in cotton fabrics.

The practical results of the research are as follows:

- the yarn strength was optimized using twisted water-soluble chemical yarn;
- the research demonstrated that the physical, mechanical, and capillary properties of the fluffy fabric woven from yarn produced by the new method were high;
- a mathematical model of the capillary properties of fabric woven from yarn produced by the new method was developed;
- the proposed method is based on shortening the warp-yarn winding process, combining the warp yarns of cotton fabric with «Mitval» chemical yarn, and producing fluffy fabrics from the yarn obtained by twisting;
- high-quality fabrics that comply with applicable standards were produced on the basis of the recommended technological processes.

Research methodology. In the production of new products, increasing attention is being paid to yarn quality. In particular, the process of yarn interlacing is highly important in the production of pile fabrics.

Currently, fabrics made from two or more interlaced yarns are in high demand. In the production of pile fabrics, the twist level of spun yarns is highly important, as it is a factor that characterizes their properties. Pile fabrics may be single-sided or double-sided. Owing to their rapid moisture absorption, pile fabrics are used to produce towels, homewear, swimwear, and other garments.

Two yarn systems are used in the production of pile fabrics: one forms the ground fabric, while the other serves as the pile yarn. Yarn tension and its variation are particularly important in the spinning process, as their values determine the stability of the spinning process. To improve the properties of pile fabrics, the fibers contained in the yarn are also subjected to additional treatment.

During chemical modification, the chemical composition of the fibers is partially altered. As a result of this modification, fibers with new properties are obtained. Polyvinyl chloride fibers are produced from ethyl or acetyl chloride. Chloride fibers are elastic and resistant to water, acids, alkalis, and oxidizing agents; they do not rot and are not damaged by mold.

Since cotton–Mintval yarn is used in the production of pile fabrics, the weaving process is omitted from the sequence of technological operations (Fig. 1).

As a result of the innovative technology introduced in the production of cotton fabrics, the water-absorption capacity of the fabric is increased by chemically twisting the cotton yarn in the opposite direction, thereby enhancing the softness and water-absorption capacity of the fabric.

Since the «Mintval» chemical yarn consists of a single type of polymer, it can be easily spun or used in combination with natural fibers.

The “Mintval” chemical yarn can be combined with other yarns to produce low-twist yarns. It can also be used to manufacture pile fabrics, suiting fabrics (wool and cashmere),

shirting and knitted fabrics, as well as various industrial fabrics. After the melting process of Mintval yarn, a new appearance can be created in the fabrics produced from it. The second yarn combined with the Mintval chemical yarn can retain its fineness.

The Mintval chemical yarn imparts strength to the yarn with which it is combined. During the dyeing and finishing of the fabric, the yarns in the fabric become softer as a result of the release of the Mintval chemical yarn. The Mintval chemical yarn can preserve 100% of the natural elongation of the yarn with which it is combined. When cotton yarn is blended with Mintval chemical yarn and the latter is melted during the finishing process, the properties of the cotton yarn remain unchanged (Table 1).

Table 1.

Mechanical properties of "Mintval" chemical yarn

Type	RS56T6	RS38T6	RS41T6
Nominal yarn number	175 (57 dtex/6ff)	256 (39 dtex/6ff)	244 (41 dtex/6ff)
Relative breaking strength (cN/dtex)	2.0	2.0	2.1
Tenacity (cN)	114	78	86
Elongation at break (%)	49	47	42
Weight of yarn wound onto bobbins (kg)	2,5	1,5	2

All the Mintval chemical yarns selected for testing consist of six filaments; however, the total linear density of the Mintwal yarns differs because of the different linear densities of the filaments. The relative breaking strength of the RS56T6 and RS38T6 yarns, with nominal numbers of 175 and 256, respectively, is 2 cN/tex. The specific breaking strength of the RS41T6 yarn, with a nominal number of 244, was 5% higher than that of the first and second yarn samples. However, the highest strength value, 114 cN, was recorded for the RS56T6 yarn, whereas the lowest strength was recorded for the RS38T6 yarn. A strength of 86 cN was recorded for the RS41T6 yarn, with a nominal number of 244. Nevertheless, the elongation at break of the RS41T6 Mintval yarn was the lowest, at 42%. It was observed that the elongation at break of the six-filament Mintval yarns with linear densities of 57 dtex and 39 dtex was 12.5% higher than that of the 41 dtex yarn.

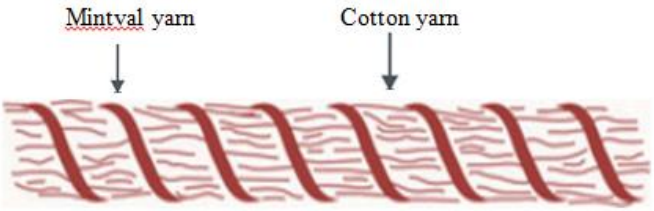


Fig.1. Structure of a low-twist yarn.

The technological process of fabric production varies depending on the fiber composition, weaving method, and fabric structure. In general, fabrics are produced through a sequence of five processes: picking, combing, weaving, drawing, and weaving. However, in the production of cotton fabrics, these processes change because chemical yarns are used. The sequence of processes in cotton fabric production is shown in Fig. 2.

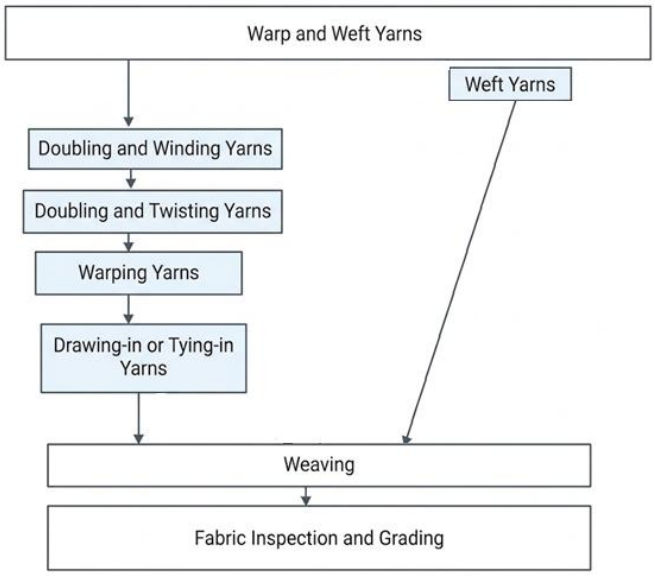


Fig.2. Stages of the fluffy fabric production process.

The capillary properties of the fabric are standardized according to GOST 11027-2014, which requires the moisture absorption height to reach 80 mm within 30 minutes. Capillarity is determined by measuring the height of rise in a 1% potassium chromate solution after 30 minutes. To determine the capillary properties of the fabric, samples measuring 300 mm in length and 50 mm in width were cut from the specimen. A bundle of hair strands, with 10 strands in each bundle, was taken from eight locations along the entire width of each sample at equal distances from one another. The length of the strands in each bundle was 600 mm.

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Fig. 3.



Fig.3. The process of testing the capillary properties of fabrics.

Analysis and results. It can be seen that the moisture absorption height of the warp yarns taken from the sample increased to 90 mm within 30 minutes.

Table 1 shows the moisture absorption height of the warp yarns taken from the sample at five-minute intervals.

Table 2

Capillary moisture absorption height of warp yarns at 5-minute intervals

Sample types	Capillary height h (mm)					
Time	5 minutes	10 minutes	15 minutes	20 minutes	25 minutes	30 minutes
Proposed sample	28	44	56	68	77	90
Company sample	12	25	31	38	43	51

It can be seen that the moisture absorption height of the cotton yarns taken from the sample increased to 90 mm within 30 minutes.

Table 1 shows the moisture absorption height of the cotton yarns taken from the sample at 5-minute intervals.

Finishing is a technical processing method that imparts color, shape, and functional effects to fabrics. Fabric finishing is a process of improving the appearance and handfeel of fabrics, enhancing their wear resistance, or imparting special properties through chemical or physical methods.

There are many types of fluffy fabrics, which differ in their intended use, fiber composition, and fabric surface density. The most popular types of fluffy fabrics are listed below.

Minky fabric is a soft microfiber fabric with a short, very fine pile. It is often used for children's blankets and clothing because of its hypoallergenic properties and ability to retain its shape.

Fleece fabric is a dense synthetic polyester fabric with a pile that is warm, quick-drying, and breathable.

Bouclé fabric is characterized by knots and loops that create a soft, voluminous texture. It is usually used for coats and jackets.

Plush is a fabric with a long, dense pile (3–16 mm), usually made from fibers such as cotton, silk, or wool.

Flannel is a fabric usually covered on one or both sides with a light, fine pile. It is very soft and retains heat well, so it is often used for bedding and shirts [5].

Blankets are produced using weaving and knitting methods. The blanket production process includes yarn production; knitting or weaving; intermediate quality control; raising; brushing; shearing; stitching and edge finishing; final quality control; and labeling and packaging. The primary yarn types used in blanket production are wool, cotton, acrylic, and polyester. Lamb, camel, cashmere, and angora wool are used as wool yarn types. Wool fibers are used in winter blankets because they provide warmth; however, they are heavy. Cotton blankets keep the body less warm than wool blankets. Acrylic blankets are lighter than cotton and wool blankets and also retain body heat. The application and individual preferences influence the selection of fibers for blankets. Warp and weft threads used in blanket production have different counts and characteristics.

Generally, warp threads are open-end yarns, whereas weft threads are stray-hair wool yarns. Raising is the process of bringing fibers from within the yarn structure to the surface of the blanket. This effect is achieved using a raising machine, depending on the desired fluffing effect. Through this process, blankets generally extend by approximately 2–3% in the lengthwise direction and shrink by approximately 22–25% in the widthwise direction. This process produces such effects as increased volume, a softer hand, thermal comfort, and the desired appearance. It also leads to a decrease of approximately 1.15–13.1% in fabric basis weight. Weight loss during brushing and shearing can range from 2.4% to 7.3%. Raising is an important process for imparting the desired appearance, handfeel, and thermal characteristics to

blankets. During this process, the fluff layer is formed, while the aesthetic appearance is achieved through additional treatments, such as laying down, raising, and cutting the naps on the surface. Due to the voluminous structure of blankets, air is trapped between the gaps, thereby enhancing thermal insulation [6].

In addition, various finished products are made from cotton fabric. Soft clothing for children is made from cotton fabric. These fabrics are in good contact with a young child's body, provide softness, do not cause allergies, and are well ventilated, thereby preventing children from sweating. Soft towels are also made from cotton fabric. Owing to their good water absorption, these towels dry quickly; because they are soft, they maintain good contact with the human body and create a pleasant feeling.

By combining and twisting several single yarns, it is possible to increase their breaking strength; ensure uniformity in linear density; improve resistance to stretching and friction; enhance elasticity; and create a relief appearance in the fabric.

The productivity of a weaving machine depends on the frequency of stoppages that occur for various reasons. These stoppages are mainly associated with the elimination of warp-yarn breakage; therefore, it is necessary and important to take all possible measures to reduce warp-yarn breakage.

The difference between the designed and actual speeds in warping is taken as an indicator of the reduction in warping speed. Based on the formula used to determine this difference, it was established that, in order to increase the warping speed, warp-yarn breakage must be minimized.

The largest proportion of waste generated during warp-yarn preparation occurs in the slashing process, which accounts for 65% of the total waste in weaving.

Instead of slashing the warp yarns, studies were conducted to increase their strength by adding cotton yarns to the water-soluble "Mintval" chemical yarn.

Conclusion. In conclusion, it is currently necessary to produce products that fully comply with international standards and are competitive in the global market. Therefore, the further development of the textile industry is advisable. In light of the innovative technologies and modern approaches introduced into the production of fluffy fabrics, research into the production of new assortments and resource-saving products with improved quality indicators is currently relevant. Changing the fiber composition and properties of the yarns used in the production of fluffy fabrics provides an alternative solution. A change in fiber composition leads to changes in the technological process. Based on the product requirements for the production of fluffy fabrics, the possibility was established of using the water-soluble «Mintval» chemical yarn in combination with cotton yarn to improve the preparation and weaving technology of fluffy fabrics. The capillary properties of fluffy fabrics woven from yarns with the new composition were also improved. The practical significance of the research results lies in the fact that the physical, mechanical, and capillary properties of fluffy fabrics produced from new types of plied yarns can meet international standards.

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