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ANALYSIS OF THE INFLUENCE OF YARN PROPERTIES ON THE PROPERTIES AND CHARACTERISTICS OF TERRY FABRICS

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Abstract: The article analyzes the properties and characteristics of terry fabrics, which are currently in high demand and widely used, as well as the studies of scholars engaged in theoretical and practical research in the field of fabric production. Based on the analyses carried out, conclusions were drawn regarding the prediction of yarn properties for the production of loop-pile fabrics and the proper selection of yarn production technology.

Keywords: loop, terry, properties, characteristics, fabric, deformations, yarn.

Fabric is produced as a result of the interlacing of warp and weft threads. Weaving structures are classified into four groups: simple, complex, small-patterned, and large-patterned (jacquard) weaves [1].

Complex weaves are formed through various combinations of three or more systems of warp and weft threads. The most common types are double-layered, pile, and lace weaves.

Pile weaves are obtained by interlacing three thread systems: two form the fabric base, while the third creates the pile surface. There are fabrics with cut and loop piles. Velvet, plush, artificial fur, and corduroy are examples of cut-pile fabrics, which are distinguished by their high wear resistance and aesthetic qualities. Fabrics with loop piles produce terry fabrics and related items such as towels, bathrobes, bed sheets, etc., which have excellent moisture-absorbing properties.

A loop fabric is a linen or cotton fabric whose surface, on one or both sides, is covered with pile loops of warp threads. Unlike pile fabrics, in which the pile is formed under tension, in terry fabrics it is created by the free feeding of slightly tensioned warp threads. The pile of terry fabrics is less uniform and durable, lying closer to the fabric surface. Terry fabrics are usually less dense than pile fabrics. Due to their softness and ability to absorb large amounts of moisture, terry fabrics are widely used in the production of towels, bath sheets, bathrobes, rugs, and similar items [2].

A significant share of the products manufactured and exported in our republic consists of ring-spun items: various towels, tablecloths, furniture covers, decorative products, carpets, and others. In 2024, the production volume of ring-spun pile fabrics across the republic is presented below (Table 1). It should be noted that nearly 60 percent of this output falls to the share of Namangan region.

Table 1

Annual Production Capacity and Export of Terry Products in the Republic of Uzbekistan[3]

№	**Regions**	Annual capacity (ton)
1.	Republic of Karakalpakstan	2 500
2.	Andijan	400
3.	Bukhara	1005
4.	Jizzakh	150
5.	Namangan	22130
6.	Samarkand	1920
7.	Sirdarya	1500
8.	Fergana	4820
9.	Tashkent	2600
10.	Tashkent city	2600
	By republic	**39 625**

Despite the research conducted by scientists and scholars, the physico-mechanical properties of yarns used in the production of terry fabrics—particularly the dependence of yarn stiffness coefficients on their length during testing, which in turn affects the size of the warp on the loom, as well as the pressing issues of increasing warp tension and warp parameters—have not been sufficiently studied.

Based on the above, the aim of the research was defined as follows: considering the intended use of terry fabrics, the properties and characteristics of yarn are developed with the purpose of preparing them for twisting, improving spinning and twisting technologies through mathematical modeling, and creating an efficient technology.

In the production of new types of fabrics, increasing attention is being paid to the quality of yarn. This is especially important in the production of ring-spun items, where the process of yarn preparation, including winding, plays a significant role in ensuring that yarn exhibits various properties and characteristics. At present, in the production of loop-pile fabrics, yarn consisting of two or more twisted strands is in high demand. For pile and floor coverings, two or more yarn strands are used. The twist number of the yarn is of great importance in the production of ring-spun fabrics, as it is a factor characterizing their properties.

Researcher Abdulla al-Farukhi [4] and others provide analytical insights in their scientific works devoted to the detailed study of ring-pile towels, which are currently in growing demand among consumers. A viewpoint is expressed on the influence of chemical processes applied in the production of terry towels on fabric properties. Today, the textile industry is introducing various methods to enhance the absorbency and softness of terry towels.

The author's conclusions indicate that the softness of a fluffy towel depends on the softness of the pile. It has also been scientifically proven that the softness of woolen yarn mainly depends on two factors: the type and properties of the fiber, and the number of twists in the yarn. This, in turn, is confirmed as a key factor directly influencing the functional properties of pile towels. Parallel studies have shown that reducing the number of twists in pile fibers increases water absorbency and softness of terry towels [5].

In the existing scientific literature on the influence of the deformational properties of physico-mechanical characteristics on product quality in the textile industry, a significant contribution has been made by a number of well-known foreign scholars. Their studies have focused on how the properties of elasticity, elongation, and plasticity of yarns dynamically change at different stages of technological processes and how these changes affect product quality. Among these researchers are Vieira C., Chen J., Chidambaram A., Hossain M., Wu X., Miller R., Jiang H., Pathullayev S., Kawabata S., Mishra S., and others.

The deformational properties of yarns and the dynamics of their changes during weaving have been studied in detail in the scientific works of prominent Uzbek scholars such as E. Alimbaev, R. Karimov, A. Daminov, G. Valiev, O. Akhunboboev, S. Rakhimkhodjaev, B. Boimuratov, U. Abdullaev, and D. Alieva. As a result of their research, both theoretical and practical foundations for the production of high-quality textile products from woven fabrics have been developed. Their studies analyzed elastic and plastic types of deformation in weft and pile yarns of loop-pile fabrics, as well as single-cycle and multi-cycle deformations. Significant progress has been achieved in demonstrating that mathematical models make it possible to predict the deformational behavior of yarns and its influence on process conditions. This approach contributes to reducing defects in production and optimizing technological processes [6].

Fabrics produced from yarns and threads of various fiber compositions, weaves, and finishes differ significantly from one another in their properties. Fabric properties are understood as their characteristics—such as thickness, strength, etc. Each property is expressed by one or more parameters. For example, the strength of a material is described by breaking load and breaking elongation. The numerical expression of a parameter is called an index. The diversity of fabric properties is generally divided into the following main groups: geometrical, mechanical, physical, shrinkage, and formability under wet-heat treatment, as well as wear resistance[7].

During the use of clothing, as well as during processing, fabrics are subject to various mechanical effects. Under these effects, fabrics stretch, bend, and experience friction.

The ability to stretch, bend, and change under the action of friction are the main mechanical properties of fabrics. Each of these properties is described by a number of characteristics:

stretching - tensile strength, breaking elongation, endurance, etc.;

bending - rigidity, drape, replaceability, etc.;

change under the action of friction - thread spreading, fraying, etc.

The tensile strength of a fabric is determined by the load at which the fabric sample breaks. This load is called the breaking load, it is a standard indicator of fabric quality.

Simultaneously with the strength on a tensile testing machine, the elongation of the fabric is determined, which is called the elongation at break, or absolute breaking elongation. It shows the increment in the length of the tested fabric sample at the moment of rupture, i.e.

Relative breaking elongation is the ratio of the absolute breaking elongation of the sample to its initial clamping length, expressed in %.

Breaking elongation (absolute and relative), as well as breaking load, is a standard quality indicator.

Total elongation is considered to be the elongation that occurs under the action of a load close to breaking. In the composition of total elongation, shares of elastic, elastic and plastic elongation are distinguished. Total elongation and the ratio of shares of elastic, elastic and plastic elongation depend on the fiber composition and structure of threads (yarn), weave, phases of fabric structure and fabric finishing.

In fabrics from a mixture of fibers, the ratio of elastic, elastic and plastic elongations depends on the ratio in the mixture of fibers of different origins.

A characteristic feature of fabrics is their easy bendability. Fabrics bend, forming wrinkles and folds, under the influence of a small load or even their own weight. The main characteristics of bending are rigidity, drapeability and changeability.

Rigidity is the ability of a fabric to resist changes in shape. Fabrics that easily change shape are considered flexible. Flexibility is the opposite characteristic of rigidity. The rigidity and flexibility of a fabric depend on the fiber composition, fiber structure, structure and degree of twist of the yarn (threads), type of weave, density and finishing of the fabric. The rigidity of a fabric increases with an increase in the twist of the threads, its thickness and density.

Drapability is the ability of a fabric to form soft rounded folds. Drapability is associated with the mass and rigidity of the fabric. The use of monofilaments, metallic threads, highly twisted yarns and threads, increasing the density of the fabric, finishing, varnish finishing, and the application of film coatings increase the rigidity of the fabric and, consequently, reduce its drapeability. Creasability is the ability of fabrics to form wrinkles and folds under bending and compression, which can only be eliminated by wet-heat treatment. The cause of crumpling is the occurrence of plastic deformations of fibers under bending and compression. Creasability spoils the appearance of products and reduces their strength due to frequent wet-heat treatments. Creasability depends on the ratio of elastic, flexible and plastic deformations. The fibrous composition, structure and finishing of fabrics also determine its crumpling. Increasing the twist of the yarn, increasing the density of fabrics prevent the displacement and deformation of fibers during twisting and compression, therefore reducing the creasability of fabrics.

Fraying is the phenomenon of displacement and loss of threads from open sections of fabric. Fraying depends on the same factors as spreading. Fraying is higher in fabrics with long overlaps in the weave. The twist of the threads affects fraying, although it does not affect spreading. Threads with a higher twist fray more easily. Large spreading and fraying of fabrics worsen the processes of sewing production, complicate the processing of the material, and increase the consumption of fabric per product.

Physical properties of fabrics are divided into hygienic, heat-protective, optical and electrical.

Hygienic properties of fabrics are considered to be those that significantly affect the comfort of clothing made from them and its heat-protective properties. These properties include hygroscopicity, air permeability, vapor permeability, water resistance, dust capacity, electrification. They depend on the fibrous composition, structural parameters and nature of the finishing of the fabrics.

Heat-protective properties are the most important hygienic properties of winter products. These properties depend on the thermal conductivity of the fibers that form the fabric, on the density, thickness and type of finishing of the fabric. The "coldest" fiber is considered to be flax, as it has high thermal conductivity, the "warmest" is wool. The use of thick yarn, increasing the linear filling of the fabric, the use of multi-layer weaves, felting, napping increase the heat-protective properties of the fabric.

Optical properties of fabrics are their ability to evoke in a person visual sensations of color, shine, whiteness and transparency. The color (coloring, dyeing) of the fabric depends on what part of the spectrum the surface of the fabric reflects.

Hue is the main qualitative characteristic of the sensation of color, which makes it possible to compare the color sensations of a material sample with the colors of the solar spectrum.

Saturation is a qualitative characteristic of the sensation of color, which allows one to distinguish different degrees of chromaticity within one hue.

Lightness is a quantitative characteristic of the sensation of color when comparing it with white. Under the influence of a number of factors (light, water, temperature, detergents), color changes sometimes occur, which can be reversible or irreversible. For example, fading from exposure to light is irreversible, and the color changed during wet-heat treatment can be restored upon cooling.

The shine of a fabric depends on the degree of specular reflection of the light flux. Shine is directly related to the nature of the fabric surface, which is determined by the structure of the threads, their twist, the type of weave, and the nature of the finish of the front side. The use of smooth, profiled (flat and triangular) metal threads, weaves with extended overlaps (satin, satin, basic twill), pressing, calendering, finishing to give a glossy and silver surface, varnish finishing, and metallization increase the shine of fabrics.

Transparency characterizes the ability of a fabric to transmit light rays, causing a sensation of a light stream passing through the fabric, and gives an idea of the thickness of the material. The transparency of a fabric depends on the transparency of fibers and threads, the density of the fabric, the presence of through pores in it through which the light stream passes without changing its direction.

Whiteness is determined by comparing the fabric in question with an absolutely white surface. It is associated with the ability of the fabric to reflect the light stream.

Electrical properties. Electrification is the ability of fabrics to accumulate static electricity on their surface. When in contact and especially when rubbing materials, which inevitably occurs when using textiles and dry cleaning them, a process of generation and dissipation of electric charges is constantly taking place on their surface. If the balance between the occurrence of charges and their dissipation is disturbed, a certain electric potential is created on the surface of textile materials - electrification occurs. Electrification is directly related to the nature of the fibers forming the material, their structure, and humidity. With increasing humidity, electrification decreases, as electrical conductivity increases. Synthetic fibers, which have low hygroscopicity, have the ability to become highly electrified. Clothing made of synthetic fibers can disrupt a person's metabolism, change their blood pressure, contribute to a feeling of discomfort, increase fatigue, irritability, i.e. have a negative impact on health. To reduce electrification, it is recommended to treat products made of acetate, triacetate and synthetic fibers with surface-active antistatic agents (antistatics), which increase the electrical conductivity of textile materials, reduce dust capacity and dirtiness. When developing new textile materials, electrification can be reduced by rational selection of components included in the fiber mixture. The combination of hydrophilic and hydrophobic fibers - fibers that accumulate charges of the opposite sign - reduces electrification.

Based on the above arguments and analyzing the scientific works of applicants, we can draw conclusions and define the tasks:

1. When producing terry fabrics, based on its properties, it is necessary to predict and design in advance the properties and characteristics of the warp and weft threads, based on the study of their deformation state;
2. Development and implementation of an effective technology and method of spinning, preparing and twisting yarn for the pile warp, warp and weft threads of terry fabrics;
3. Forecasting and determining the number of twists depending on the type of yarn and developing a mathematical model of water absorption and sorption states in loop pile fabrics;
4. Based on the purpose and scope of use of the loop pile fabric, design and set in advance the inherent and deformation characteristics for the pile warp, warp and weft threads.

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