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THE THEORETICAL ANALYSIS OF THE DYNAMICS OF THE TENSION FORCE OF THE YARN PRODUCED IN THE WORKING MACHINES DURING THE WEAVING PROCESS

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Abstract. *In the weaving process, yarns are typically used in a processed and sized form. High-quality woven fabrics are widely used across various industries, including textiles, transportation, construction, and other industrial sectors. Therefore, it is crucial to accurately define and study the mechanical properties of the yarns. Calculating the resistance forces that arise during the weaving process and analyzing them under different conditions is one of the main and urgent issues in the textile industry. During the weaving process, the tension force of the yarn increases significantly due to the opening of the warp, which may lead to the breakage of the yarn. To reduce the increase in tension force, spring-like mechanisms are employed. This article develops a dynamic model of the forces acting on the weaving yarn and formulates the corresponding differential equation. The resulting differential equation is solved analytically, its graph is plotted, and the mechanical meaning of the solution is discussed in detail.*

Keywords: *Yarn, resistance force, speed, expression, load, elasticity, deformation, breakage force, tension, weaving, differential equation, tension force.*

Introduction. In developed countries, including worldwide, the demand for high-quality products produced each year is steadily increasing. Especially in textile and light industry enterprises, the importance of product quality is becoming increasingly significant. Ensuring product quality, reducing costs, and enhancing efficiency are among the most pressing tasks in these industries. Therefore, it is necessary to continuously monitor and optimize the yarn's tension and moisture levels during the weaving process. Full control over the quality indicators of the yarn and its mechanical properties is a critical factor in effectively managing the process under consideration.

The importance of yarn tension and optimal winding during the weaving process is significant. The tension of the yarn not only affects the quality of the product but also influences the efficient operation of the weaving machine. An increase in tension may lead to the loss of elasticity in the yarn, which negatively impacts the quality of the weaving process. Additionally, excessive tension can cause the yarn to stretch and lose its elastic resilience. As tension increases, the risk of yarn breakage also rises, leading to an increase in the number of interruptions during the weaving process. This situation reduces the efficiency of the weaving process and results in a decline in product quality. Therefore, maintaining optimal yarn tension is crucial for ensuring efficient production in the textile industry.

Globally, with the development of the textile industry and the introduction of new technologies, the need for automated control systems to optimize yarn quality has increased. High-tech devices and systems based on automation are being developed to control yarn tension during the weaving process. Automated systems not only improve product quality but also enable faster production processes and reduce errors caused by human factors. The implementation of such systems

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makes it easier to monitor and control the process continuously, leading to increased efficiency and improved product quality.

Another approach to improving yarn quality and increasing productivity in the textile industry is the optimization of the parameters of technological equipment. To ensure the effective operation of machines, their technical characteristics must be constantly updated. The improvement of textile machines primarily focuses on considering the mechanical properties of the yarn. In high-speed textile machines, various mechanical effects (such as rotation, bending, twisting, tension, and vibration) may act on the yarn. These effects directly influence the operation of the machine. Therefore, understanding the mechanical properties of the yarn in full and analyzing the changes in its operational process is of utmost importance.

There are ongoing innovations and new approaches to controlling yarn tension and optimizing its quality in the textile industry. As a result, production efficiency continues to increase, and the quality of textile products improves. At the same time, technological innovations and automation enable even greater achievements in the textile industry. To successfully compete in developed countries and the global market, textile enterprises continue to implement these innovations, which help improve product quality and production efficiency.

Methods. In the rewinding process, special tensioning devices are used to achieve and control the required yarn tension. The following requirements are set for tensioning devices:

1. Ensuring uniform stoppage of the yarn.
2. Easy adjustment for setting the required tension.
3. Prevention of accumulation of various impurities such as lint, dust, and dirt during the working process, with ease of cleaning.
4. The operation of the tensioning device must be reliable and durable.

In all tensioning devices, additional tension in the yarn is generated due to the frictional forces. Tensioning devices with different constructions implement various methods for controlling the tension of the yarn, including spring force, gravitational force, magnetic or electromagnetic effects, pneumatic methods, and other complex forces. Frictional forces play a significant role in controlling yarn tension, as they contribute to increasing the tension. During the rewinding process, the yarn passes through disks, gaining the required tension due to friction. Uniform tension in the yarn improves product quality and simplifies the process, while also enabling high-speed production. The selection and adjustment of the tension control device are crucial for improving the quality of the rewinding process. Additionally, the necessity of studying the mechanical properties of yarns during the finishing process is emphasized. Ensuring uniform tension in individual yarns reduces their unevenness, increases their resistance to friction, and enhances their durability. The study and management of the mechanical properties of yarns during the finishing process are essential for producing high-quality products and are a key factor in the design of modern equipment.

Problem Statement. According to the results of the scientific work, plastic and elastic deformations occur as a result of forces acting on the yarn. These deformations occur at different speeds in the yarn, meaning that viscous deformation happens rapidly, while elastic deformation increases over a specific period. After the force acting on the yarn is reduced, the return of deformation also occurs in a similar manner: viscous deformation recovers in a short time, while elastic deformation takes longer to return. It is known that during the stretching and compression of the yarn, a shifting state also occurs on its inclined surfaces. Under tensile forces, pure sliding of the yarn occurs in a stressed state. As a result of pure sliding, the shape of the yarn changes, and relative deformations appear, which affect the mechanical properties of the yarn. From this perspective, it is necessary to theoretically analyze the resistance force generated when a stretchable yarn moves along its length. A special equation must be formulated to describe the relationship between the tension force of a stretchable yarn and the distance it stretches. This equation allows the study of the connection between the yarn's elongation and the forces acting on it, providing a deeper understanding of the yarn's mechanical properties and its operational conditions.

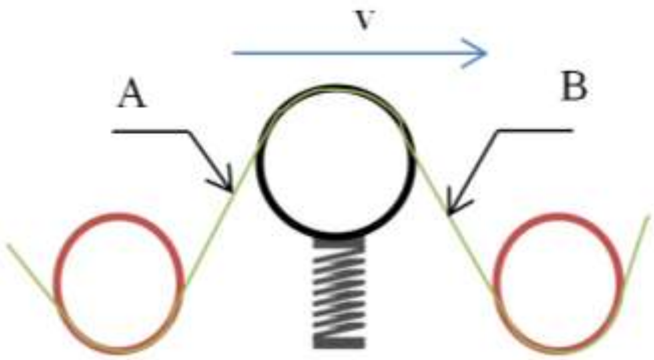

Figure 1. Control device affecting the yarn during the weaving process.

Mechanical-Modeling Approach: As shown in Figure 1, the yarn is moving to the right. A force (1) acts on point A, located on the left side of the yarn in the tension zone, while a force (2) acts on point B. By using the dynamic equilibrium of these forces and Newton's second law, we derive equation (3) [5].

$$T_1 \quad (1)$$

$$T_1 + T_0 \sin \omega t \quad (2)$$

$$T_1 + T_0 \sin \omega t - T_1 - kx - cv_{pr}t = ma \quad (3)$$

Or

$$T_0 \sin \omega t - kx - cv_{pr}t = ma \quad (4)$$

Here:

T_1 – The constant tension force acting on the yarn during the weaving process; T_0 – The maximum force generated when the warp is opened; k – The elasticity coefficient resulting from the force applied to the yarn; m – The mass of the yarn; c – The spring constant; v – The average speed of the spring; x – The distance traveled by the yarn during the operation process; a – The acceleration experienced by the yarn due to the forces applied; f – The cyclic frequency during the operation of the warp.

Derivation of the Differential Equation: By simplifying equation (4) and using the following equation, we obtain equation (5).

$$\ddot{x} + \frac{k}{m}x = \frac{T_0 \sin \omega t}{m} - \frac{cv_{pr}}{m}t \quad (5)$$

Equation (5) is referred to as a second-order non-homogeneous linear differential equation with constant coefficients [6]. Solving this equation gives us the following general solution (6).

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$$x(t) = C_1 \cos\sqrt{\frac{k}{m}}t + C_2 \sin\sqrt{\frac{k}{m}}t + \frac{T_0 \sin\omega t}{k - m\omega^2} - \frac{cv_{pr}}{k}t; \qquad (6)$$

$$x(0) = 0, \quad \dot{x}(0) = 0, \qquad (7)$$

In the initial state, before any forces act on points A and B, the value of the force and the velocity of the yarn are both equal to zero. Using this, we can write the condition (7).

The general solution to the Cauchy problem: Equation (5) with the initial condition (7) is referred to as the Cauchy problem. Solving this problem, we determine the constant coefficients C1 and C2. Substituting these values into equation (6), we obtain the solution (8).

$$x(t) = \sqrt{\frac{m}{k}}\left(\frac{cv_{pr}}{k} - \frac{T_0\omega}{k - m\omega^2}\right)\sin\sqrt{\frac{k}{m}}t + \frac{T_0 \sin\omega t}{k - m\omega^2} - \frac{cv_{pr}t}{k}; \quad (8)$$

$v_{pr} = 0{,}4\, m/s$ T_0=3 N; k=1200 N/m; m=0,0001 kg; c=150 N/m; $\omega = 10\frac{rad}{s}$.

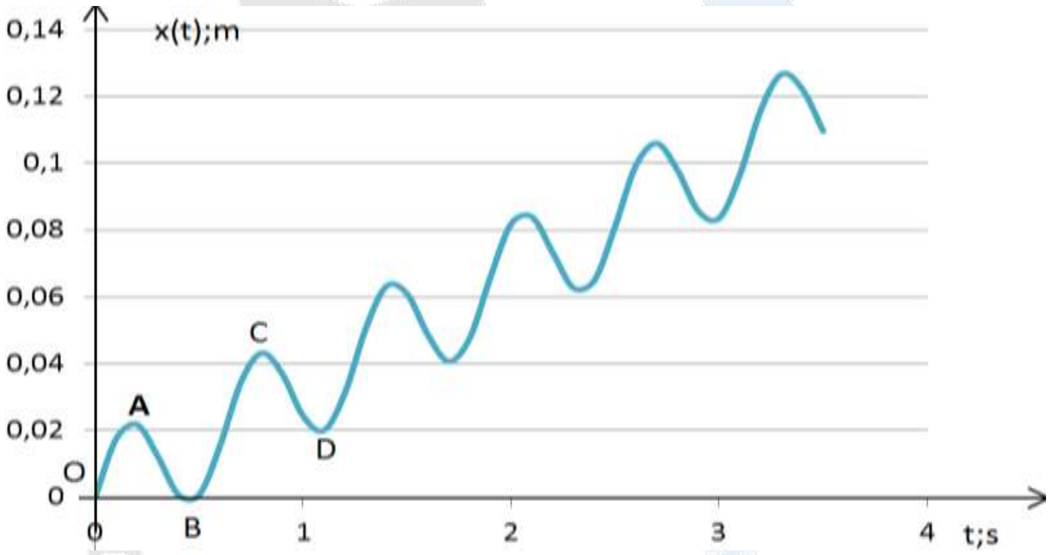

Figure 1. The graph showing the relationship between the path and time during the yarn weaving process.

Results: Using the solution of equation (5) and the practical values of the required constants, we obtain **Figure 1**. The graph is divided into the segments OA, AB, BC, and CD. We will analyze the mechanical processes in each segment.

OA Process: In this section of the graph, the process of the beginning of the weaving is depicted, where the force acting on the yarn is initially zero, and the total resistance force sharply increases. The main reason for this is the increase in the elastic force as the yarn stretches, along with the resistance force generated by the opening of the warp.

At point A: The sum of the resistance forces reaches its maximum value.

AB Process: The yarn's holding limit is released, meaning the yarn undergoes relaxation. The yarn starts passing through the rollers, reducing the friction surface and the resistance force to movement. As the yarn relaxes, its elastic force decreases, leading to a reduction in the overall resistance force.

At point B: The force acting on the yarn becomes zero, resulting in the yarn stopping.

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BC Process: In this stage, the force acting on the yarn begins to increase again.

CD Process: In this process, the cycle continues as described above.

Conclusion. The process under study demonstrates that in-depth analysis of the mechanical properties of fabrics leads to improvements in both technical and scientific approaches. This, in turn, not only enhances scientific research but also broadens the possibilities for using fabrics more effectively in the textile industry and other fields. Such analysis and research help reduce uncertainties that arise during fabric production and usage. By studying the mechanical properties, it is possible to determine how fabrics perform under various conditions and which parameters should be prioritized. Thus, theoretical analysis and calculations serve as an important tool in ensuring fabrics' reliable and long-lasting performance.

These approaches help ensure high quality and stability during the fabric manufacturing process by accounting for all necessary mechanical properties. Based on mechanical principles, they allow us to determine primary and secondary resistance forces for fabrics. This process also contributes to the production of higher-quality fabrics, extending their lifespan, and enabling their effective use under various conditions. For example, it helps identify what modifications are necessary to use fabrics in extreme conditions (such as high temperatures, cold, or high/low pressure), thus optimizing technological processes and improving production efficiency.

The results obtained in this paper can be applied not only in scientific research but also in industrial practice, which will enhance the efficiency of technological processes. Understanding and analyzing the mechanical properties of fabrics and calculating resistance forces help ensure durable and safe material performance. This approach not only improves the production process but also allows for the monitoring of fabric compliance with technical requirements. For example, by applying specific formulas and methods during fabric production, it is possible to improve the quality of the final product.

From the analysis results, we can observe that research aimed at analyzing fabric strength is quite limited in its mechanical and mathematical modeling. Although many scientific works and studies are focused on developing new methods for fabric analysis, the necessary equations for identifying the resistance forces acting on yarn and the factors influencing them are not yet fully formulated. The equations of resistance force and their solutions, dependent on the given parameters, are still under study, and this field is evolving. Further research should lead to the development of more comprehensive and intricate models of this process.

In this paper, the general resistance force equation for yarn moving through rollers is derived based on Newton's second law. This approach allows for more accurate measurement of the impact of force and mass and enables a more detailed mathematical analysis. The derived equation is solved based on differential equation theory, and the relationship between the yarn's travel distance x(t), force, and time (t) is presented in a graph. This graph helps to clearly and comprehensively represent the analyzed mechanical process. Additionally, using the graph, we can gain practical insights into the relationship between yarn movement and the forces acting upon it.

The obtained graph provides a complete representation of the studied mechanical process and allows for tracking its changes. The practical applicability of this solution can be observed through the graph, where the changes in the yarn's movement and the forces acting on it can be monitored, which plays a crucial role in improving the performance characteristics of yarns in practice. Thus, this scientific approach aids in making data-driven decisions for fabric production and usage. This analysis helps to maximize the efficiency of fabric usage and improve their physical and mechanical properties.

Furthermore, it is of great significance for the development of new technologies, industrial production, and material science.

References:

1. Gulyamov, G., & Sharibaev, N.U. (2011). Determination of the density of surface states at the semiconductor-insulator interface in a metal-insulator-semiconductor structure. Semiconductors, 45, 174-178. https://doi.org/10.1134/S1063782611020084

1. 2. Mamadaliyeva D, Karimov.R, Aliyeva D.G, "Increasing the strength of the pile in terry fabric by changing the weaving system", "Scientific and Technical Journal" Namangan Institute of Engineering and Technology Volume 7, p.p 57-61, Namangan 2022.

2. Sharibaev, E., et al. (2022). Experimental investigation of the relationship between raw shaft density and saw cylinder electric motor load current. Journal of Physics: Conference Series, 2388, 012174. https://doi.org/10.1088/1742-6596/2388/1/012174

3. Akramov, A.M. Optimization of Parameters for Producing Suitable Fabrics on a Weaving Machine. PhD Thesis, NamMTI, Namangan, 2022.

4. Gordeev, V.A. Weaving Patterns and Fabric Analysis: A Textbook. Moscow: Light Industry, 1969, 120 pp.

5. Nikitin, M.N. Artistic Design of Fabrics. Moscow: Light Industry Publishing House, 1971, 280 pp.