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POSSIBILITIES OF ENSURING WARP YARN TENSION IN THE WEAVING PROCESS

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Annotation. In this scientific article, the research results aimed at analyzing the physico-mechanical properties of Nm-34/1 yarns, which play an important role in the textile industry, as well as the tension levels of warp yarns during the weaving process, are presented. During the study, the breaking force, elongation, extensibility, and work at break of the yarns were determined under laboratory conditions, and their impact on the production process was comprehensively examined. At the same time, the fact that the coefficients of variation (CV%) ranged between 6–15% proved the existence of a certain degree of unevenness in the physico-mechanical properties of the yarns.

In general, the conducted studies show that an in-depth analysis of the physico-mechanical properties of Nm-34/1 yarns and the development of technological solutions for stabilizing warp yarn tension have significant practical importance in increasing production efficiency, reducing waste, and improving the quality of the finished fabric.

Key words: Tension, Friction, Breaking force / Tensile strength, Deformation, Yarn / Thread, Fabric / Cloth / Textile, Weaving reel / Beam, Scalo, heald, Elongation, Time, Unevenness

INTRODUCTION

The textile industry is considered one of the oldest and largest sectors of the global economy. It plays an important role not only in meeting the needs of the consumer market but also in shaping global trade, export–import volumes, and the labor market. Worldwide, more than 60 million people are employed in this industry, and in developing countries it is regarded as one of the socially significant sectors of employment. [1].

According to recent data, in 2022 the total export volume of textile and apparel products amounted to 903.1 billion USD, while imports exceeded 966.5 billion USD [2]. These figures confirm the significant role of this industry in international trade. China, India, Bangladesh, and the European Union countries continue to lead in the production and export of textile and light industry products.

The textile sector is recognized as a key direction in the economic development of many countries. For instance, in Bangladesh, this industry accounts for 79.7% of the country's exports and 7.5% of its gross domestic product (GDP). In Pakistan, these indicators constitute 54.7% and 3.4%, respectively [3]. This situation clearly demonstrates that the textile industry is one of the most crucial sectors for developing countries.

Central Asia, particularly Uzbekistan, also possesses great potential in the textile sphere. In 2023, more than 7,000 enterprises operated in the country, employing nearly 600,000 people. In the same year, Uzbekistan fully processed its raw cotton into fiber and significantly increased the export of finished products. As a result, the export of textiles and apparel reached 3.9 billion USD [4], which indicates Uzbekistan's increasingly active participation in the global textile market.

At the same time, the textile industry faces a number of challenges: water scarcity, environmental pollution, low levels of waste recycling, and intensifying international competition, among others [5]. However, these challenges can gradually be addressed through the introduction of innovations, technological modernization, and the widespread implementation of sustainable production principles.

Thus, the textile industry plays an important role not only in the global economy but also in the economic development of specific regions, including Uzbekistan. Therefore, studying its development trends on a scientific basis, analyzing existing problems, and identifying promising directions represent an urgent scientific and practical task.

Materials and Methods. In all tension-regulating devices, additional yarn tension arises under the influence of frictional forces. Different designs of tensioning mechanisms implement various methods of yarn tension control, including the use of spring force, the gravitational force of weights, magnetic or electromagnetic effects, pneumatic methods, and the impact of other combined forces. Frictional forces play an important role in yarn tension regulation, as they increase the overall tension of the yarn. Uniform yarn tension improves product quality, facilitates the process, and ensures high-speed production. Therefore, the selection and adjustment of the yarn tension control device are of great importance for improving the quality of the weaving process [6].

In this study, in order to maintain the stability of warp yarn tension during the weaving process, an additional device was used to reduce warp yarn tension. Furthermore, the physical and mechanical properties of yarns and fabrics were determined through laboratory test results.

The practical and experimental research was carried out at **"NT HOLDING HOME TEXTILE" LLC**, located in Namangan region. This company is one of the major textile manufacturers in Uzbekistan and is equipped with advanced technologies and modern machinery. The choice of this enterprise for research was deliberate, as all the main stages of textile production—spinning, fabric preparation, dyeing, and final product manufacturing—are established here. This provided broad opportunities for practical observations, experiments, and studying production-related challenges.

The research conducted at the enterprise mainly focused on warp yarn tension during weaving, their mechanical properties, fabric quality, and ways to improve production efficiency. In addition, existing technological processes were analyzed in cooperation with company specialists, and scientifically based proposals and solutions were developed. This ensured that the research results possess not only theoretical but also practical significance.

For practical and research purposes, various types of devices for measuring warp yarn tension of different constructions were used, and their classification is provided in this study. The tension measuring device is distinguished by its high sensitivity and consists of three rotating yarn-guiding rollers. The electronic circuit is integrated with a personal computer, which provides digital data output. Moreover, the device allows measuring either a single yarn or a group of yarns under actual operating conditions of the loom.

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Figures 1–3. Application of the tension measuring device and the process of determining yarn tension [7]

Using the developed device, the warp yarn tension was measured directly on the weaving machine operating at *"NT HOLDING HOME TEXTILE" LLC*. In order to increase the accuracy and reliability of the obtained results, measurements were carried out at multiple sections of the loom. Specifically, the warp tension was recorded at six different positions along the warp direction, as well as at two positions in the perpendicular direction: (i) from the weaving beam to the lease rods and (ii) from the lease rods to the drop wires.

The weaving beam under investigation contained a total of 3390 warp yarns. For representative evaluation, the tension was measured on selected yarns with the following numbers: 1, 500, 1000, 1600, 2500, and 3390. This selection made it possible to assess tension distribution both at the edges and in the central sections of the warp sheet.

The obtained data provided the basis for analyzing the uniformity of warp yarn tension under actual weaving conditions, thereby allowing an assessment of its influence on the mechanical properties of the yarns and the quality of the woven fabric.

Results and Discussion. The results can be observed in the following histogram. The graphical data provide a direct comparison between the previous condition and the outcomes obtained after installing the proposed device.

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Experimental results of warp yarn tension measured in the section from the warp beam to the lease rods show that, in the previous condition, the yarn tension was relatively high and distributed with significant variations. For instance, in some points, the tension reached up to 64.071 sN, while in others it decreased to as low as 44.421 sN. Such unevenness increases the probability of yarn breakage and leads to a reduction in the quality of the produced fabrics.

After installing the proposed new device, however, yarn tension was considerably reduced and stabilized within a relatively close range of values (20.411–34.504 sN). This result proves that the device protects warp yarns from excessive tension, ensures their stability, and improves the overall quality indicators of the technological process.

Specifically, the use of the new device reduced warp yarn tension to optimal values, eliminated irregularities in tension, and enhanced the quality of the woven fabric. Consequently, this contributes to increased production efficiency, reduced product cost, and a significant decrease in the number of yarn breakages [8].

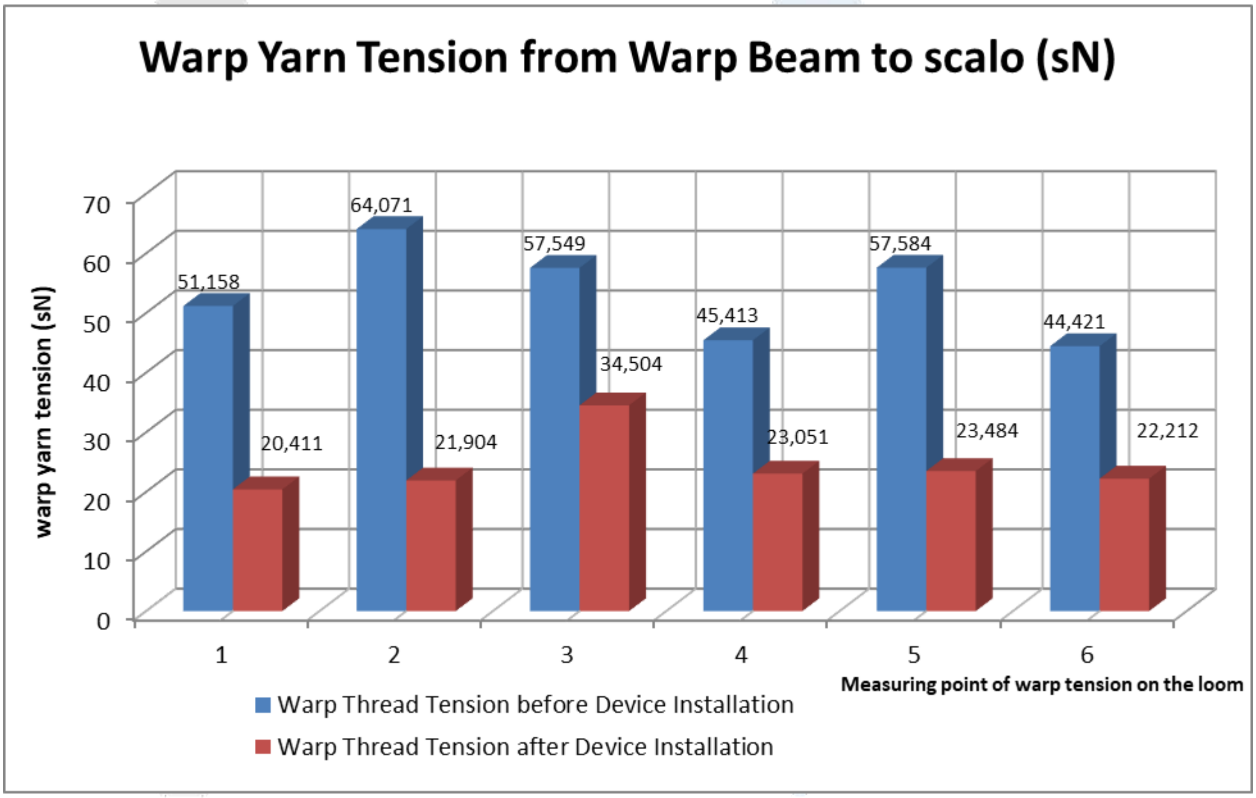

Figure 4. Experimental Results

In order to further supplement the practical studies and experimental results obtained in determining the warp yarn tension during the weaving process, as well as to obtain broader and more comprehensive data, the physical and mechanical properties of the warp yarns used in fabric production were also investigated. In this context, the main parameters such as yarn strength, elongation, elasticity, stiffness, and diameter were determined, and their influence on the warp tension during weaving was scientifically evaluated.

This additional analysis contributed to a more complete understanding of the yarn behavior within the technological process. Since the physical and mechanical properties of the yarns are directly related to warp tension during weaving, they determine the stable operation of the yarns without breakage, the quality of the woven fabric, and the productivity of the loom. Thus, by identifying the physical and mechanical characteristics of the yarns, not only the tension parameters but also more

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accurate and reliable conclusions regarding the efficiency of the entire weaving process and the quality of the final product could be drawn [9].

During the experiments, data were obtained on the breaking force, elongation at break, relative elongation, work at break, and time to break of Nm 34/1 yarns. These indicators make it possible to evaluate the physical and mechanical properties of the yarns and to determine their stability during the weaving process.

The results showed that the average breaking force of the yarns was 401.3 sN. The minimum value was 360 sN, while the maximum value reached 443 sN, with a coefficient of variation of 6.31%. This indicates that the yarns have relatively stable strength, sufficient for use in industrial production.

Analysis of the Physical and Mechanical Properties of Nm-34/1 Yarn

Physico-mechanical properties of Nm 34/1 yarn					
№	Break force (sN)	elongation (mm)	Elongation rate (%)	Break work (sN*mm)	time (sec)
1	380	17,9	3,58	35,76	2,15
2	425	19,7	3,94	46,24	2,36
3	402	17,1	3,42	37,43	2,05
4	436	18,9	3,78	44,62	2,27
5	401	16,1	3,22	31,41	1,93
6	376	15,9	3,18	31,68	1,91
7	360	18,3	3,66	34,83	2,2
8	370	17,7	3,54	35,3	2,12
9	419	20,4	4,08	46,52	2,45
10	407	18,5	3,7	40,63	2,22
11	372	15,5	3,1	31,09	1,86
12	403	16,7	3,34	37,09	2
13	443	21,2	4,24	48,87	2,54
14	423	18,5	3,4	40,63	2,22
15	407	17,3	3,46	37,56	2,08
medium	401,3	17,98	3,6	38,64	2,16
max	443	21,2	4,24	48.87	2,54
min	360	15.50	3,1	31.09	1,86
CV%	6,31	9,12	9,12	14,91	9,11

According to the experimental results, the average elongation length of the Nm 34/1 yarn was found to be 17.98 mm, with a relative elongation of 3.6%. The coefficient of variation (9.12%) indicates the presence of certain differences in elasticity among the samples; however, these deviations remain within the acceptable range for technological processes.

The work of rupture averaged 38.64 sN·mm, with the minimum and maximum values recorded at 31.09 sN·mm and 48.87 sN·mm, respectively. The coefficient of variation for this parameter was 14.91%, which is notably higher compared to other mechanical indicators. This suggests that the energy capacity of the yarn exhibits considerable variability, and the combination of strength and elasticity is not homogeneous across all samples.

The average breaking time was 2.16 s, and the results for different samples showed close agreement (coefficient of variation = 9.11%). Such results confirm the stability of the elongation process up to rupture, which is also supported by the graphical and tabular analysis presented. These findings provide evidence of acceptable uniformity in yarn behavior during tensile deformation [10].

Conclusion.

As a result of the conducted experimental studies, the physico-mechanical properties of Nm-34/1 yarns and the tension levels of warp threads during the weaving process were analyzed. The obtained results showed that the average breaking force of the yarns was 401.3 sN, elongation was 17.98 mm (3.6%), and the work of rupture amounted to 38.64 sN·mm. These physico-mechanical parameters indicate sufficient stability for application in production. However, the coefficient of variation (CV%) values within the range of 6–15% suggest a certain degree of irregularity in yarn strength and extensibility.

Experiments on warp yarn tension revealed that, under previously applied conditions, the yarn tension fluctuated between 44–64 sN. Such high tension levels can cause frequent yarn breakages, reduced process stability during weaving, and negative impacts on fabric quality. After the installation of the proposed device, the yarn tension was recorded in the range of 20–34 sN, which is considered a standard and stable value. As a result, yarn deformation decreased by 2–2.5 times, leading to a reduction in the number of breakages, an increase in machine productivity, and an improvement in fabric quality.

Overall, the experimental findings demonstrated that the proposed device effectively balances warp yarn tension during the weaving process, reduces yarn stress, and significantly enhances production efficiency.

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