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# ANALYSIS OF THE DEPENDENCE OF THE FLEXIBILITY AND PHYSICAL MECHANICAL PROPERTIES OF COTTON FIBER YARN ON THE DRAWING RATE

F. A. Kozakov
Namangan State Technical University, Namangan, Uzbekistan

D. G. Aliyeva
Doctor of Technical Sciences, Professor,
Namangan State Technical University, Namangan, Uzbekistan

R. Karimov
Candidate of Technical Sciences,
Associate Professor, Art soft texm LLC, Uzbekistan

A. A. Murodillayev
Master student of Namangan State Technical University,
Namangan, Uzbekistan

**Abstract**:
In this research work, the effect of the length of samples of yarns spun from cotton fiber with a linear density of Nm-34/1 on their mechanical properties was determined by breaking them in a semi-periodic manner on a YG026T device. Based on the determined values, the elasticity of the yarn was calculated using a formula and the results are presented in graphical form.

**Keywords:** Elongation, relative breaking strength, breaking strength, spun yarn, speed, deformation, yarn thickness, strength, structure, moisture, elasticity, speed, tension, elongation at break, elastic deformation.

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## Introduction

Tenacity and elongation of yarn. The breaking strength of a yarn is one of the most important indicators of its quality. The breaking strength of a yarn is understood as its resistance to external forces. The term breaking strength is often used instead of the term toughness. The minimum force sufficient to break a yarn of a certain length is called the breaking strength and is measured in Newtons (N). To determine the breaking strength, the yarn must be broken on a breaking machine. Absolute and relative quantities are used to express the breaking strength of a yarn. The breaking strength of a single or multiple (strand) yarns is an absolute quantity, while the breaking length in kilometers is a relative quantity. The breaking length (km) is equal to the ratio of the breaking strength to the linear density:

$$L=P/G \text{ (sN/teks)}$$

By determining the tensile strength of a yarn in a breaking machine, its elongation is also determined. The sample elongates during breaking. The elongation at break can be expressed in mm (absolute elongation) or as a percentage of the original length of the sample (relative elongation, E).

The requirements for yarns used in weaving are set out in yarn standards. The grade of yarn is determined by its density and evenness; it is divided into classes depending on its purity. According to the standard, for example, cotton yarn is divided into high, first, second, third and fourth grades. The standard tables indicate the values allowed for irregularities in the properties of the yarn. If all the properties of the yarn fully meet the requirements of the standard, it is considered high-quality yarn.[1]

During use, textile products often stretch in two directions simultaneously. The biaxial tensile test shows how well the product resists stretching along both yarn systems. Biaxial stretching in the plane of the sample is associated with the simultaneous deformation of elements in two mutually perpendicular directions, corresponding to the direction of the warp and weft yarns, and in knitting to the direction of the loops and rows of loops. The effects of tensions and deformations occurring in the warp and weft yarns are not the same, and the deformations depend on the structure and properties of the yarn, as well as the type of product being knitted. [2]

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The rate of stretching of the threads has a significant impact on the test results, which is explained by the specific characteristics of the deformation of polymeric materials.

Depending on the speed of stretching, the time for deformation to occur changes. As the speed increases, the deformation time decreases. As a result, many intermolecular bonds do not have time to break, cracks increase, or elastic and plastic deformations develop.

At low speeds, the result is the opposite, so that during the pulling process, with an increase in the pulling speed of the device, the breaking force increases and the total elongation in the thread decreases. The increase in the breaking force with a decrease in the exposure time is known from the theory of the dependence of force on time. Experimental data fully confirm the above ideas. As for the relationship between the speed of stretching and time during pulling, discrepancies are often found between the given rules and experimental data: the elongation sometimes remains unchanged or even increases with increasing stretching speed. This is due to the properties of the thread, the interaction of structural elements (polymers in fibers, fibers in threads, etc.), as well as tensile reinforcement. Although this issue has been studied by many authors (R. Meredis, M.D. Talyzin, E. Shukht, etc.), it is considered necessary to continue further research.

Due to the significant influence of the elongation rate (break duration) on the characteristic conditions of the half-cycle and similar indicators, a constant time is set for the break to occur.

Experimental data on the change in tensile properties depending on the elongation for different types of yarns obtained as a result of the tests were obtained. The experimental work was determined by breaking in a half-cycle method on a YG026T device. [3]

In the experimental work, experiments were conducted on yarn spun from 100% cotton fiber with a linear density of Nm-34/1 at the enterprise “Papfen tex” LLC at speeds from 10 mm/min to 1200 mm/min. The constant time at which the break should occur and the sample length were taken as 500 mm according to the GOST 6611.2-73 (ISO 2062-72, ISO 6939-88) standard. [4] The obtained results were analyzed and presented in the form of a diagram (Fig.1)

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Currently, methods for determining the tensile strength of textile materials differ in the type of materials under study, the shape and dimensions of the samples, the nature and parameters of the tests, and the instrumental support of the measurement method.

Tensile strength indicators (as a property) are determined from the force-elongation diagram obtained when determining the strength properties of textile materials. The tests are carried out on tensile testing machines of various designs equipped with an automated device for recording the diagrams.

The modulus of elasticity can also be described by the slope of the slope α and $\alpha_2$, a straight-line section on the stress-strain diagram: [5]

$$A_1 = \tan a$$

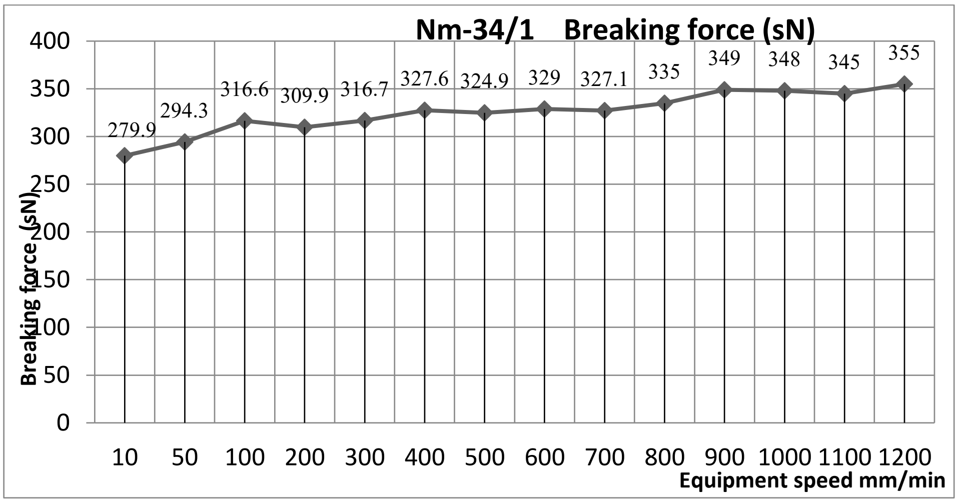


**Figure 1. Diagram of the breaking force of the rope in the example versus its speed**

It can be seen from the diagram that as the breaking speed increased, the breaking force also increased. This practically justifies the above points.

From this diagram, we can determine the percentage change in the breaking force of the yarn with a thickness of Nm-34/1 spun from 100% cotton fiber in the sample from a speed of 10 mm/min to a speed of 1200 mm/min using the following formula:

$$G = \frac{P_{max}}{P_{min}} * 100\% = \frac{355-279.9}{355} * 100\% = 21.154\%$$

Here: $P_{max} - The\ maximum\ breaking\ strength\ of\ the\ yarn\ in\ the\ sample$,sN;
$P_{min} - Minimum\ breaking\ strength\ value\ of\ the\ yarn\ in\ the\ sample$ ,sN.

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The results show that the percentage change in breaking strength from a speed of 10 mm/min to a speed of 1200 mm/min is 21.154%. This is because initially, when the sample yarn is pulled at a speed of 10 mm/min, the fibers resist, and as the pulling force increases, the fibers pull each other and become parallel, resulting in a high resistance at the breaking point of the yarn. At high speeds, many fiber bundles do not have time to become parallel and break, resulting in increased cracks or elastic and plastic deformations. [6]

This not only increases the tension of the yarn, but also increases the breaking strength of the yarn, which also affects the quality and appearance of the fabric.

Also, based on the determined values, the elasticity of the yarn was determined by dividing the breaking strength of the yarn in the sample P (sN) by its elongation at break Elg (mm). Table 1 shows the physical and mechanical properties of the yarn determined by breaking in a semi-periodic manner on a YG026T measuring machine.

**Table 1.**

| Equipment speed (mm/sek) | Breaking strength (sN) | Elongation at break (mm) | Elasticity (sN/mm) | Relative breaking strength (sN/teks) | Break work (sN*mm) | Time (sek) |
|---|---|---|---|---|---|---|
| 10 | 279,9 | 22,75 | 12.3 | 9,52 | 36,07 | 136,5 |
| 50 | 294,3 | 24,17 | 12.17 | 10,01 | 41,02 | 29 |
| 100 | 316,6 | 26,35 | 12.01 | 10,77 | 46,62 | 15,81 |
| 200 | 309,9 | 26,89 | 11.52 | 10,54 | 47,08 | 8,07 |
| 300 | 316,7 | 26,98 | 11.73 | 10,77 | 47,78 | 5,4 |
| 400 | 327,6 | 26,42 | 12.39 | 11,14 | 48,29 | 3,97 |
| 500 | 324,9 | 26,26 | 12.37 | 11,05 | 47,5 | 3,15 |
| 600 | 329 | 27,41 | 12 | 11 | 31 | 2,74 |
| 700 | 327,1 | 27,32 | 11.97 | 11,13 | 47,96 | 2,34 |
| 800 | 335 | 27,4 | 12.22 | 10,43 | 43,06 | 2,06 |
| 900 | 349 | 28,57 | 12,21 | 11,87 | 52,11 | 1,91 |
| 1000 | 348 | 29,33 | 11.86 | 11,9 | 33,2 | 1,76 |
| 1100 | 345 | 29,49 | 11.69 | 11,38 | 49,94 | 1,61 |
| 1200 | 355 | 28,96 | 12.25 | 12 | 45,27 | 1,45 |

Formula for determining elasticity: $K = \frac{P_{sN/teks}}{Elg_{mm}}$;

Here: P - is the relative breaking strength of the yarn in the sample

Elg - is the elongation at break of the yarn in the sampleMasalan:

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V=10 mm/min - $K = \frac{P_{sN}}{Elg_{mm}} = \frac{279.9}{22.75} = 12.3\ sN/mm$

V=50 mm/min - $K = \frac{P_{sN}}{Elg_{mm}} = \frac{294.3}{24.17} = 12.17\ sN/mm$

V=1200 mm/min - $K = \frac{P_{sN}}{Elg_{mm}} = \frac{355}{28.96} = 12.25\ sN/mm$

## Conclusion

The stretching speed of yarns spun from cotton depends on their physical and mechanical properties. Each factor, including tensile strength, moisture, temperature, and the structural composition of the yarn, plays a significant role in the stretching process. Analyzing these factors is essential for improving the mechanical strength of the yarn and the processing techniques.

In the experiment, the optimal operational speeds for the looms during the weaving process were determined for a specific assortment of yarns. In other words, it was proven that the faster the loom operates, the higher the tensile strength of the yarn.

Viscosity is also one of the physical-mechanical properties of yarn. The viscosity of textile yarns determines its elastic properties, specifically how much it can stretch under tension and how the tensile strength is affected. The viscosity of the yarn is a crucial factor in determining its quality, strength, and the process of producing products from it. Yarns with higher viscosity tend to be more elastic, durable, and capable of long-term use. However, when the viscosity is too high, the yarn's stretchability decreases, which can lead to an increased risk of breakage during the weaving process.

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