# METHODS FOR DETERMINING THE DEFORMATION PROPERTIES OF SPUN YARN

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## Abstract
This study investigates the mechanical properties of spun yarns and textile products in the textile and light industry. Through theoretical analysis, it explores semi-cycle, one-cycle, and multi-cycle characteristics under various mechanical stresses. Emphasizing tensile strength and tear resistance, the research highlights the significance of parameters like breaking load and breaking elongation in assessing fabric strength. This analysis offers valuable insights for enhancing material design and product performance within the textile and light industry sectors.

**Keywords:** Spun yarn, single cycle strain, half cycle strain, multi-cycle strain fabric, tensile strength, elongation at break.

## Introduction
Mechanical properties determine the ratio of textile products, under the influence of various forces applied to them, leading to tensile, compressive, bending deformation and related phenomena. The characteristics of the mechanical properties of textile materials are divided into half-cycle (tensile strength, tear resistance), single-cycle and multi-cycle according to the test method. Textile materials are often subjected to tensile deformation. If we talk about the strength of fabrics, we usually have to see their ability to withstand certain loads or deformation. Various indicators are used to describe the strength, the most common of which are the breaking load and breaking elongation.

**Materials and methods**

The mechanical properties of fabrics refer to the properties that describe the reaction of finished fabrics to various external influences.

The mechanical properties of spun yarns and fibres depend on their structure and constituents, but these modes manifest themselves only when certain external forces act on them. External forces can be applied in different directions, causing tensile deformation in fibres and yarns, bending, twisting and compression. The most common type for textile materials and spun yarns is definitely stretching.

Depending on the methods, the application of forces to the material for each type of deformation and the implementation of the test cycle for the return of the material to its original state after such a process takes three groups of mechanical properties: half-cycle, one-cycle and multi-cycle.

The characteristics of the half-cycle determine the ratio of materials to a single load and indicate the maximum mechanical capabilities of materials.

Single-cycle characteristics are obtained under long-term loading conditions and subsequent rest. This feature clearly reveals the effect of the time factor, the characteristics of the deformation of the material, and its ability to store.

Multi-cycle characteristics indicate the stability of mechanical properties under repeated force. With the repeated impact of small forces, the structure of bodies is destroyed, intermolecular bonds are weakened, and even molecules are destroyed. Thus, multi-period characteristics evaluate the stability of the structure.

Semi-periodic tensile properties of textile materials allow us to evaluate their ultimate mechanical capabilities. An example of the semi-periodic characteristic of braided yarns is the tensile strength.

Tensile strength is the greatest strength that represents the ability of a material to withstand the force applied to it. This indicator plays a very important role for textile semi-finished products and finished products.

Relative breaking load $P_0$, cN/tex

$$P_0 = P_a / T \qquad (1)$$

Breaking stress $P_a$ related to breaking area S, $mm^2$ - breaking load $R_r$

$$\Omega = P_p / S \qquad (2)$$

Absolute elongation at break I, mm, - length growth at the time of cracking material samples:

$$L_r = L_1 - L_0 \qquad (3)$$

Here $L_1$ is the length of the sample at the breaking moment, mm; $L_0$ is - the initial (compression) length of samples, mm.

Relative elongation at break, % - the ratio of the absolute elongation at break to the initial length of the sample:

The relative elongation at break $\varepsilon_r$, % is the ratio of the absolute elongation at break to the initial length of the sample:

$$\varepsilon_r = l_p / L_0 \quad (4)$$

The breaking work can be defined as the area bounded by the curve on the tensile diagram on the "breaking load - absolute elongation" axes

**Single-cycle properties of threads.** Under the influence of external forces, fibres and yarns are deformed, and the nature and degree of deformation depends on the nature and magnitude of the applied stress, the speed and duration of application. About load movement, environmental parameters, as well as specific properties of the material. The deformation of textile fibres and threads, like all polymeric materials, consists of three parts:

1) The resulting return elastic deformation- $E_y$ disappears immediately when an external force is applied;

2) Reversible elastic deformation that develops under the influence of load and disappears after some time;

3) Irreversible plastic deformation $E_p$ does not disappear after removing the load.

Reversible elastic deformation occurs under the influence of an external force due to small changes in average distances between the particles of polymers that make up textile fibres, as well as between atoms in neighbouring units and macromolecules. At the same time, intermolecular and interatomic bonds remain, and bond angles increase slightly. The elastic deformation cannot be large: when the particles are removed to a considerable distance, the connection between them is broken, and cracks and distortions occur.

Reversible elastic deformation occurs due to external forces causing a change in the configuration of polymer macromolecules - their rearrangement. Under the influence of an external force, the polymer macromolecules become aligned and oriented in the direction of the forces, that is, they stretch along the fibre axis. The joints of the same molecule, due to its curvature, interact with each other, these movements are carried out only by small ones. Sections of polymer molecules and broken intermolecular interactions are replaced by new ones immediately. Such regrouping takes a long time. This is done as a relaxation process over time and leads to reaching a state of equilibrium. Elastic deformation develops over time at a small rate and strongly depends on the conditions affecting the intensity of intermolecular interaction. Irreversible plastic deformation is caused by the irreversible movement of macromolecule units over large distances under the influence of external forces. With this type of deformation in fibres, macromolecules have to overcome significant intermolecular bonds, so they develop more slowly than elastic ones.

In its pure form, the development of plastic deformation, which is the flow of the material, is stationary and continues for a long time - until the material fails. Plastic deformation is irreversible because there are no causes to eliminate it after the external force is removed.

Along with true plastic deformation, another type of irreversible deformation occurs in the thread, which is usually formally called plastic deformation. This irreversible deformation occurs due to the displacement of whole fibres or large sections in a poorly reinforced yarn. If an external force overcomes the frictional forces holding a certain part of a fibre attached between other fibres, it will move immediately, if the stretching is done quickly by applying a significant force. Irreversible displacements occur almost instantaneously at the same rate

Thus, the absolute total elongation (deformation) is defined as the sum of all its components:

$$L = L_y + l_e + l_p \quad (5)$$

Here $L_y$, $L_e$, $L_p$ are the elastic, elastic and plastic parts of deformation, respectively;

**Multiperiod properties of threads**. The gradual deterioration of the structure of materials with a regular long-term continuous or repeated interval is called material fatigue.

Distortion of the structure develops in small areas of the threads, where structural elements (fibres, elementary threads) are misaligned, there are thinning and they can easily move. As a result, the failure of the structure leads to destruction, that is, the cracking of the material

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