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THE DYNAMIC BEHAVIOR OF A FIBER IN A BUNDLE IN THE PRESENCE OF DRY FRICTION FORCES

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Introduction

As a result of the analysis of literature sources devoted to the study of mechanical properties, it was found that their indicators depend to a greater extent on the structure and conditions of yarn formation. Recently, research carried out in this direction is often found in periodicals [1, 2].
They consider yarn deformation taking into account the location (orientation) of the fibers in the yarn structure. In [3], the behavior of a fiber in a bundle was studied under a static application of an axial force, where the change in tension over time was not taken into account. In the process of yarn formation, the fibers are subjected to dynamic forces caused by the action of impulsive or periodic from time to time axial forces [3, 4, 5].

Analysis of the stress-strain state of yarn based on the theory of elasticity

To assess the indicators of the mechanical characteristics of the yarn, it is necessary to analyze the stress-strain state of the yarn, taking into account its structure.

To do this, consider a yarn in the form of a cylinder, which is symmetric along the axis and is an anisotropic body. The yarn is also uniform along the axis, the fibers are very thin compared to the diameter of the yarn, and the fiber is isotropic in cross section. So, the yarn is considered in the form of a cylinder, so that all calculations are carried out in the polar coordinates (r_p, θ_p , z_p) of the cylinder (fig. 1).

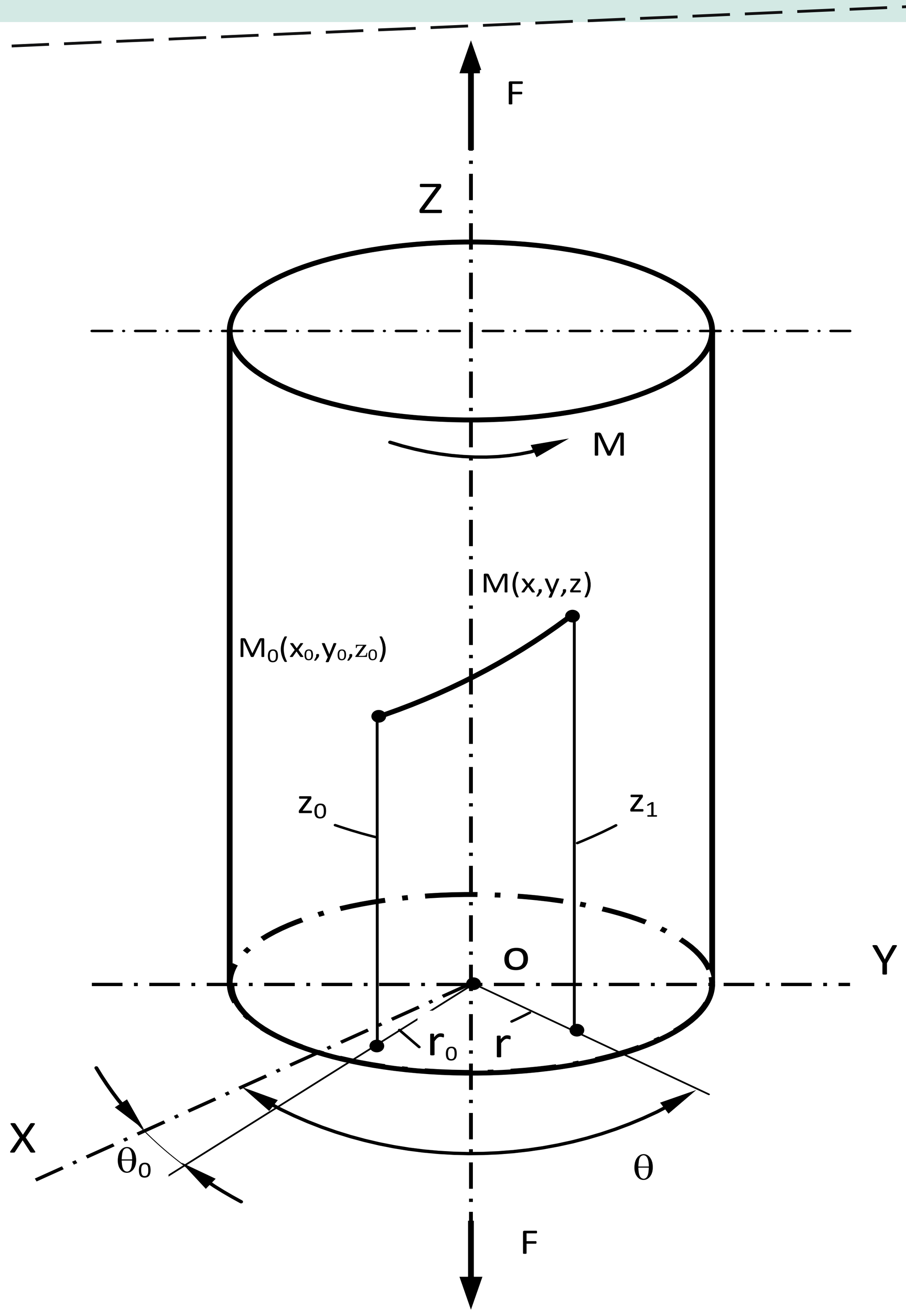
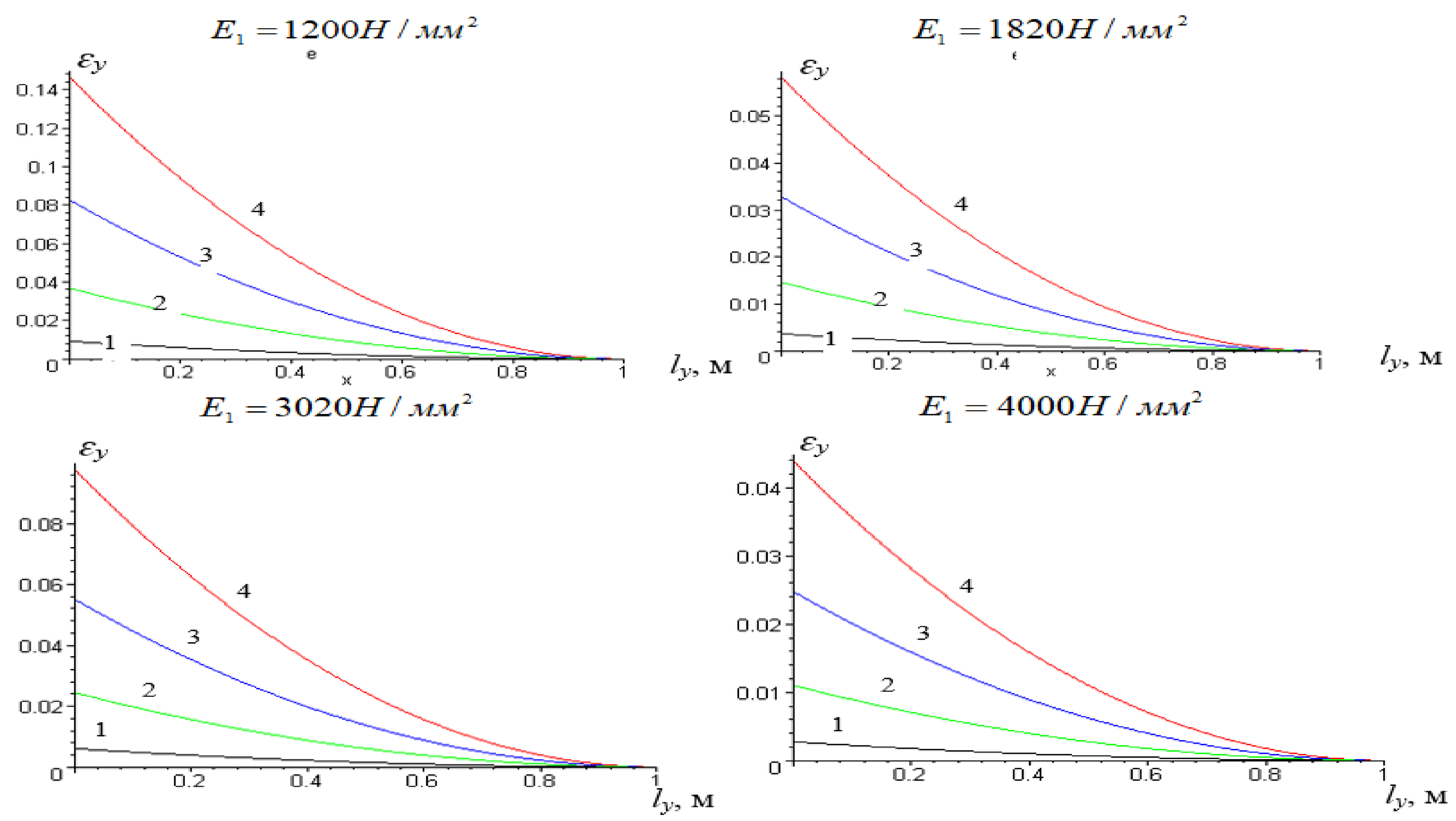


Figure 1. Yarn deformation diagram

Yarn deformations ε_y along its axis at different values of Young's modulus E_1 and orientation angle θ.

Shows changes in deformation ε_{zz} along the yarn axis for different values of Young's modulus E_1 and orientation angle θ. For the calculation, the following parameter values were taken: l_y =1 м, $E_2/E_1\approx 0$, $G=5\cdot 10^{-4}$ Н/мм^2, $\nu_{12} = \nu_{32} = 0,5$.

From the analysis of the graphs obtained, it was found that the tensile deformation of the yarn reaches a maximum at the attachment point, and at its other end, the deformation value is equal to ε_y. With an increase in Young's modulus, the deformation decreases proportionally, and with an increase in the orientation angle, the deformation of the yarn increases.



1- $\theta = 9^0$;   2- $\theta = 18^0$;   3- $\theta = 27^0$;   4- $\theta = 36^0$.

Material and method

A textile thread in the form of a yarn is a structural formation of systems of interconnected fibers of a certain length and thickness. The force of interaction is realized both through the friction of a separate fiber in the matrix (bundle), and through the elastic contact between the ends of the fibers (Fig. 2).

The yarn deformation process as a whole depends on the deformation of the individual fiber during loading and unloading. We assume that the pre-stretched fibers are stretched under loading, and under unloading, their length is reduced.

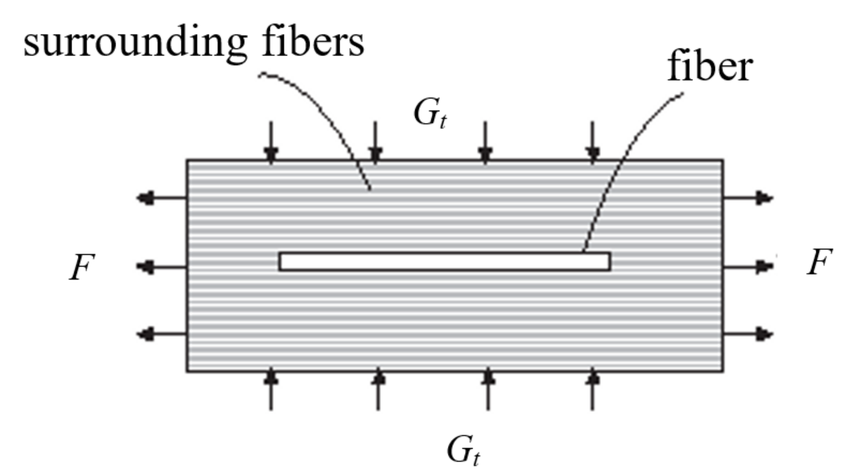


Fig. 2. Layout of the fiber in the spinning triangle

We set the origin at the center of the fiber, and taking into account the symmetry conditions, consider the right half of the fiber. The axis $0x$ is directed to the right from the center of the fiber. The frictional force is directed against the axis $0x$, and then the stress for the right side of the fiber in the presence of frictional forces and the action of an axial force satisfies the equation

$$\frac{d\sigma}{dx} = \frac{4\mu}{d} G_t \qquad (1)$$

Conclusions

As a result of the analysis of the obtained formulas, it follows that the presence of a friction force between the fiber and the beam leads to complex wave phenomena along the fiber, while fiber sections are formed where the fiber cross-sectional velocity vanish, and the stress can take maximum values. In this case, fiber breakage can occur, which leads to the destruction of the structure and ultimately to the breakage of the yarn itself.

References

1. X. Shao, Y. Qiu and Y. Wang, Theoretical modeling of the tensile behavior of low-twist staple yarns. Part I- Theoretical model, The Textile Institute, 2005; Volume 96(2), pp. 61-68.
2. X. Shao, Y. Qiu and Y. Wang. Theoretical modeling of the tensile behavior of low-twist staple yarns. Part II – Theoretical and experimental results, The Textile Institute, 2005; Volume 96(2), pp. 69-76.
3. Shukhratov, S., Milasius, R., Gafurov, J., Mardonov, B., Gafurov, K., & Repon, M. R. (2021). Investigation of Open End Yarn Tension Using an Elastic Yarn-Guide. FIBRES & TEXTILES IN EASTERN EUROPE, 29(4), 43-47.
4. Shukhratov, S., Milašius, R., Gafurov, K., & Gafurov, J. (2021). Investigation of Twist Waves Distribution along Structurally Nonuniform Yarn. Autex Research Journal.
5. Shukhratov, S., Yusupkhodjaeva, G., & Milašius, R. (2020, August). Research of methods to improve properties of blended fibres from waste of natural fibres. In Advanced materials and technologies: 22nd international conference-school (pp. 24-28).