ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 8 , August 2021

Method for Assessing the Influence of Reflection of Elastic-Plastic Waves from the Surface of the Working Body on Thread Tension

M. Ergashov, O.A. Akhunbabaev, Sh.Kh. Mukhamadrasulov

Doctor of technical sciences, prof., Head. Department, Tashkent Institute of Textile and Light Industry
Doctor of Technical Sciences, Senior Researcher, Director, Uzbek Research Institute of Natural Fibers
Doctor of Physics and Technology (PhD) Deputy Director, Uzbek Research Institute of Natural Fibers

ABSTRACT: The formulation and basic equations of the stationary motion of the filament are given, including the laws of conservation of mass, continuity of motion, kinematic and dynamic conditions that occur at the wave fronts and at the boundaries of the interaction of the filament with rigid bodies. The obtained analytical solutions can be used as an algorithm for calculating the tension and deformation of the regions of the thread imbibed by straight and reflected longitudinal waves. The proposed formulation and the constructed solution algorithm. as well as the obtained analytical solutions can be used in the design of new filament materials, assessment of the strength of the given materials, as well as for predicting the causes and measures to eliminate various defects arising in the technological processes of production and use of filaments.

KEY WORDS: thread tension. filament deformation, longitudinal wave, wave propagation speed, material deformation law, elastic material, elastoplastic material, Prandtl's scheme.

I.INTRODUCTION

The strength of the thread in technological processes and during operation is significantly influenced, first of all, by the law of deformation of the material, the methods of application and the intensity of the dynamic load. For example, the instantaneous transition of the deformation law from elastic to plastic mode can lead to large losses of strength, especially near the points of load application, reflection and interaction of waves.

Strength and technological properties, for example, of spiral ropes, various cables during the period of technical tests, and in the case of textile threads, change in technological processes. In spiral ropes subjected to high static and, especially, dynamic loads, plastic deformations appear rather large than, for example, in similar rods. Such deformations initially - during the period of technical testing - contribute to the hardening of the material of the spiral ropes. However, the hardening ceases when the wires of the helical rope have been sufficiently compacted. In the future, plastic deformations become the cause of an intense loss of strength and technological properties of spiral ropes and other flexible ties.

In most cases, breakage, for example, of textile threads, is preceded by plastic deformation. Therefore, predicting the causes of breaks, especially those that occur periodically in the same area of a technological machine, is associated with the study of the area of plastic deformations. Obviously, the identified causes of plastic deformations make it possible to establish measures for eliminating technical problems that lead to an increase in the thread tension. Elimination measures can be changes in the technological or physical and mechanical properties of the thread, the dimensions or coordinates of the location of the working or auxiliary organs, the technological mode of the machine, etc.

Below we consider the problems of sliding a thread over the surface of a stationary solid, taking into account wave processes that can cause the appearance of plastic stresses. It is assumed that the thread has an ideal plastic property and the law of deformation of the material is described by the Prandtl scheme. The main attention is paid to the interaction of two longitudinal waves on the surface of a stationary solid body (working body).

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 8 , August 2021

Consider the problem shown in Fig. 1. Suppose that at t≥0 at the ends of the thread located at points A and D, a longitudinal impact is made. As a result, longitudinal waves c_1 and C_6 appear in the thread, propagating towards the point of contact B. The problems of determining the parameters of motion in regions 1 and 6 of the thread can be found in [1-10].

We will consider the problem of determining the parameters of motion in the regions of the thread arising from the interaction of waves C_1 and C_6 at the point of contact (point B in Fig. 1). As a result of interaction and depending on the intensity of direct waves C_1 and C_6, various wave processes can arise in the filament.

For example, one of the possible cases is the wave diagram shown in Fig. 2 - reflected elastic M, N and elastic-plastic wave K appear in the filament. The case is possible when an elastic wave appears to the left of point B and behind it (with a lower propagation velocity) elastic-plastic wave. Below we consider the case when elastic and elastic-plastic waves appear simultaneously to the left and to the right of the interaction point. The last case is the most general from which, in particular, the two previous cases follow.

Note that the considered wave pattern will take place if the forward waves C have sufficient intensity for this.

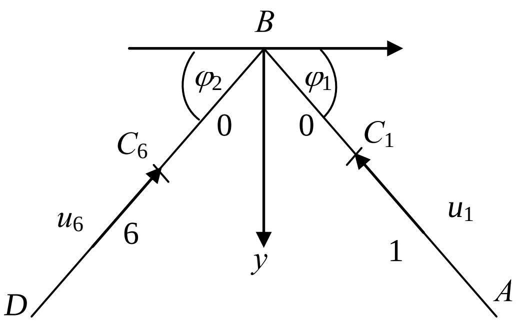
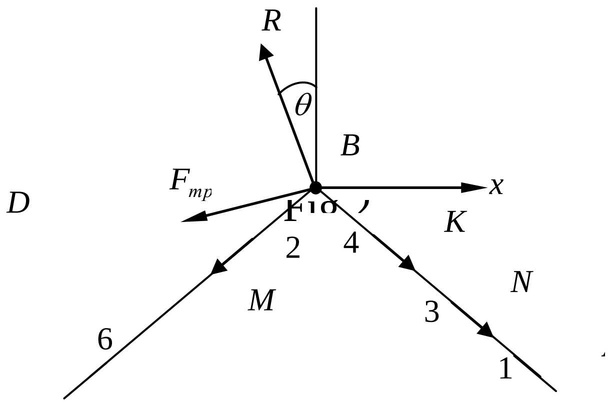


Fig.1.



Let the interaction of direct waves and (Fig. 1) occurs at a point and, as a result, four reflected waves appear in the flexible connection: two elastic N, and two plastic K, (Fig. 3). In this case, the direction of sliding of the flexible connection depends on the value of the tension and, bearing by straight waves and. If the tension is greater than the tension, then the flexible connection moves in the direction of the growth of the axis, if, then in the opposite direction, if, then there is no sliding.

We restrict ourselves to considering the case of sliding a flexible connection to the right side. Let the reflected waves carry deformations,, (), respectively, and the flexible connection moves in the direction of the growth of the axis. Here and in what follows, all designations coincide with designations pleasant in works [2-10].

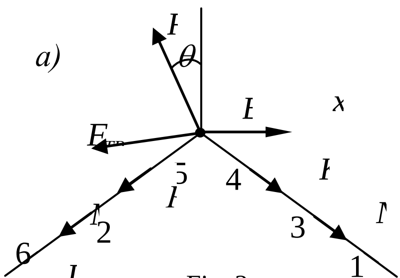


Fig. 3.

The statement and solution of the problem for areas 1 and 6 are given in the previous problems. We will investigate the parameters of movement of areas 2 - 5 of the thread

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 8, Issue 8 , August 2021

At the wave fronts N, K, M and we have, respectively:

$$\dot{x}_3 - \dot{x}_1 = a_0(\varepsilon_1 - \varepsilon_S)\cos\varphi_1, \quad \dot{y}_3 - \dot{y}_1 = a_0(\varepsilon_1 - \varepsilon_S)\sin\varphi_1; \tag{1}$$

$$\dot{x}_4 - \dot{x}_3 = a_1(\varepsilon_S - \varepsilon_4)\cos\varphi_1, \quad \dot{y}_4 - \dot{y}_3 = a_1(\varepsilon_S - \varepsilon_4)\sin\varphi_1; \tag{2}$$

$$\dot{x}_2 - \dot{x}_6 = a_0(\varepsilon_S - \varepsilon_6)\cos\varphi_2, \quad \dot{y}_2 - \dot{y}_6 = a_0(\varepsilon_6 - \varepsilon_S)\sin\varphi_2; \tag{3}$$

$$\dot{x}_5 - \dot{x}_2 = a_1(\varepsilon_5 - \varepsilon_S)\cos\varphi_2, \quad \dot{y}_5 - \dot{y}_2 = a_1(\varepsilon_S - \varepsilon_5)\sin\varphi_2. \tag{4}$$

From the condition of continuity of the displacement and the law of conservation of mass, we obtain:

$$ds_2 = \frac{|\dot{x}_2|dt}{\cos\varphi_2} = \frac{|\dot{y}_2|dt}{\sin\varphi_2}, \quad ds_3 = \frac{|\dot{x}_3|dt}{\cos\varphi_3} = \frac{|\dot{y}_3|dt}{\sin\varphi_3}, \quad ds_4 = \frac{|\dot{x}_4|dt}{\cos\varphi_4} = \frac{|\dot{y}_4|dt}{\sin\varphi_4}, \tag{5}$$

$$ds_5 = \frac{|\dot{x}_5|dt}{\cos\varphi_5} = \frac{|\dot{y}_5|dt}{\sin\varphi_5}, \quad \rho_0 F_0 = \rho_2 F_2(1+\varepsilon_2), \quad \rho_0 F_0 = \rho_3 F_3(1+\varepsilon_3), \tag{6}$$

$$\rho_0 F_0 = \rho_4 F_4(1+\varepsilon_4), \quad \rho_0 F_0 = \rho_5 F_5(1+\varepsilon_5), \quad \frac{ds_5}{1+\varepsilon_5} = \frac{ds_4}{1+\varepsilon_4}. \tag{7}$$

For tension T2, T3, T4 and we have, respectively:

$$T_2 = T_3 = \rho_0 F_0 a_0^2 \varepsilon_S, \quad T_4 = \rho_0 F_0 a_0^2 \varepsilon_S + \rho_0 F_0 a_1^2(\varepsilon_4 - \varepsilon_S), \tag{8}$$

$$T_5 = \rho_0 F_0 a_0^2 \varepsilon_S + \rho_0 F_0 a_1^2(\varepsilon_5 - \varepsilon_S). \tag{9}$$

Here and in what follows, we will assume that and.

The equations of the law of conservation of momentum, written in projections on the x and y axes, take the form:

$$\rho_4 F_4 ds_4(\dot{x}_4 - \dot{x}_5) = (T_4\cos\varphi_1 - T_5\cos\varphi_2 - R\sin\theta - fR\cos\theta)dt, \tag{10}$$

$$\rho_4 F_4 ds_4(\dot{y}_4 - \dot{y}_5) = (T_4\sin\varphi_1 + T_5\sin\varphi_2 - R\cos\theta + fR\sin\theta)dt. \tag{11}$$

If the proportionality limit of the material is known, then equations (1) - (11) form a closed system for determining all unknown parameters of the regions 2, 3, 4 and 5 of the flexible connection.

Equations (1) - (4) can be represented as:

$$\dot{x}_3 = a_0(2\varepsilon_1 - \varepsilon_S)\cos\varphi_1, \quad \dot{y}_3 = a_0(2\varepsilon_1 - \varepsilon_S)\sin\varphi_1, \tag{12}$$

$$\dot{x}_4 = a_0(2\varepsilon_1 - \varepsilon_S)\cos\varphi_1 + a_1(\varepsilon_S - \varepsilon_4)\cos\varphi_1, \tag{13}$$

$$\dot{y}_4 = a_0(2\varepsilon_1 - \varepsilon_S)\sin\varphi_1 + a_1(\varepsilon_S - \varepsilon_4)\sin\varphi_1, \tag{14}$$

$$\dot{x}_2 = a_0(\varepsilon_S - 2\varepsilon_6)\cos\varphi_2, \quad \dot{y}_2 = a_0(2\varepsilon_6 - \varepsilon_S)\sin\varphi_2, \tag{15}$$

$$\dot{x}_5 = a_0(\varepsilon_S - 2\varepsilon_6)\cos\varphi_2 + a_1(\varepsilon_5 - \varepsilon_S)\cos\varphi_2, \tag{16}$$

$$\dot{y}_5 = a_0(2\varepsilon_6 - \varepsilon_S)\sin\varphi_2 + a_1(\varepsilon_S - \varepsilon_5)\sin\varphi_2. \tag{17}$$

From the condition, and, respectively, we obtain and. Hence it follows that when waves are reflected and from a point at the fronts of the reflected waves, deformations arise if the initial deformations satisfy the conditions and. The wave is a wave of discontinuity of the speed of movement - before the wave passes, the particles of the flexible bond move in the direction of decreasing axis, and after passing - in the opposite direction.

The lengths of the considered elements of the thread in regions 2-5 will be:

$$ds_2 = a_0(2\varepsilon_6 - \varepsilon_S)dt, \quad ds_3 = a_0(2\varepsilon_1 - \varepsilon_S)dt, \tag{18}$$

$$ds_4 = [a_0(2\varepsilon_1 - \varepsilon_S) + a_1(\varepsilon_S - \varepsilon_4)]dt,\ ds_5 = [a_0(2\varepsilon_6 - \varepsilon_S) + a_1(\varepsilon_S - \varepsilon_5)]dt. \tag{19}$$

By supplying expressions (69), equation (58) is reduced to the form:

$$\varepsilon_5 = m + n\varepsilon_4, \tag{20}$$

где

$$m = \frac{2(\varepsilon_6 - \varepsilon_1)}{2\varepsilon_1 - \varepsilon_S(1 - a_{10}) + a_{10}}, \qquad n = \frac{2\varepsilon_6 + \varepsilon_S(a_{10} - 1) + a_{10}}{2\varepsilon_1 - \varepsilon_S(1 - a_{10}) + a_{10}}.$$

Excluding $\rho_4 F_4$, ds_4, $x_4^{\bullet}$, $y_4^{\bullet}$, $x_5^{\bullet}$, $y_5^{\bullet}$, T_4 and T_5, equations (10) and (11) are reduced to the form:

$$(m_1 - a_{10}\varepsilon_4)(n_1 - a_{10}\varepsilon_4\cos\varphi_1 - a_{10}\varepsilon_5\cos\varphi_2) = (1+\varepsilon_4)(k_1 + a_{10}^2\varepsilon_4\cos\varphi_1 - a_{10}^2\varepsilon_5\cos\varphi_2) - \\ - R^*(1+\varepsilon_4)(\sin\theta + f\cos\theta),$$

$$(m_2 - a_{10}\varepsilon_4)(n_2 - a_{10}\varepsilon_4\sin\varphi_1 + a_{10}\varepsilon_5\sin\varphi_2) = (1+\varepsilon_4)(k_2 + a_{10}^2\varepsilon_4\sin\varphi_1 + a_{10}^2\varepsilon_5\sin\varphi_2) - \\ - R^*(1+\varepsilon_4)(\cos\theta - f\sin\theta),$$

где

$$m_1 = 2\varepsilon_1 - \varepsilon_S(1 - a_{10}),\ n_1 = [2\varepsilon_1 - \varepsilon_S(1 - a_{10})]\cos\varphi_1 + [\varepsilon_S(a_{10} - 1) + 2\varepsilon_6]\cos\varphi_2,\ m_2 = m_1,$$
$$n_2 = [2\varepsilon_1 - \varepsilon_S(1 - a_{10})]\sin\varphi_1 + [\varepsilon_S(1 - a_{10}) - 2\varepsilon_6]\sin\varphi_2,\ k_1 = \varepsilon_S(1 - a_{10}^2)(\cos\varphi_1 - \cos\varphi_2),$$
$$k_2 = \varepsilon_S(1 - a_{10}^2)(\sin\varphi_1 + \sin\varphi_2).$$

Substituting expressions (2071) into the last equations, we obtain:

$$(m_1 - a_{10}\varepsilon_4)(n_1 - a_{10}\varepsilon_4\cos\varphi_1 - a_{10}m\cos\varphi_2 - a_{10}n\varepsilon_4\cos\varphi_2) = (1+\varepsilon_4)(k_1 + a_{10}^2\varepsilon_4\cos\varphi_1 - \\ - a_{10}^2 m\cos\varphi_2 - a_{10}^2 n\varepsilon_4\cos\varphi_2) - R^*(1+\varepsilon_4)(\sin\theta + f\cos\theta), \tag{21}$$

$$(m_2 - a_{10}\varepsilon_4)(n_2 - a_{10}\varepsilon_4\sin\varphi_1 + a_{10}m\sin\varphi_2 + a_{10}n\varepsilon_4\sin\varphi_2) = (1+\varepsilon_4)(k_2 + a_{10}^2\varepsilon_4\sin\varphi_1 + \\ + a_{10}^2 m\sin\varphi_2 + a_{10}^2 n\varepsilon_4\sin\varphi_2) - R^*(1+\varepsilon_4)(\cos\theta - f\sin\theta). \tag{22}$$

We bring the last equations to the form:

$$m_{10} + m_{11}\varepsilon_4 + m_{12}\varepsilon_4^2 = n_{10} + n_{11}\varepsilon_4 + n_{12}\varepsilon_4^2 - R^*(1+\varepsilon_4)(\sin\theta + f\cos\theta), \tag{23}$$

$$m_{20} + m_{21}\varepsilon_4 + m_{22}\varepsilon_4^2 = n_{20} + n_{21}\varepsilon_4 + n_{22}\varepsilon_4^2 - R^*(1+\varepsilon_4)(\cos\theta - f\sin\theta), \tag{24}$$

$$m_{10} = m_1(n_1 - a_{10}m\cos\varphi_2),\quad m_{11} = a_{10}[(a_{10}m - nm_1)\cos\varphi_2 - m_1\cos\varphi_1 - n],$$
$$m_{12} = a_{10}^2(\cos\varphi_1 + n\cos\varphi_2),\quad n_{10} = k_1 - a_{10}^2 m\cos\varphi_2,\quad n_{20} = k_2 + a_{10}^2 m\sin\varphi_2,$$
$$n_{11} = a_{10}[\cos\varphi_1 - (n+m)\cos\varphi_2] + k_1,\ n_{12} = a_{10}^2(\cos\varphi_1 - n\cos\varphi_2),$$
$$m_{20} = m_2(n_2 + a_{10}m\sin\varphi_2),\quad m_{22} = a_{10}^2(\sin\varphi_1 - n\sin\varphi_2),$$
$$m_{21} = a_{10}[(nm_2 - a_{10}m)\sin\varphi_2 - m_2\sin\varphi_2 - n],$$
$$n_{22} = a_{10}^2(\sin\varphi_1 + \sin\varphi_2),\quad n_{21} = a_{10}^2[\sin\varphi_1 + (n+m)\sin\varphi_2] + k_2.$$

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 8 , August 2021

Thus, the problem of determining the unknown relative deformation is reduced to solving the algebraic equation (66). Deformation and reactive force are determined from formulas (20) and (21) or (22), respectively.

The solutions obtained make it possible to establish the dependences of the law of deformation distribution on the angles of the thread wrap around the surface of a solid, the properties of the material, the conditions of friction between the materials of the thread and the solid, as well as the velocity of the longitudinal impact on the end of the thread.

The constructed calculation algorithm makes it possible to extend the numerical-experimental studies of the dependence of the tension of the regions disturbed by direct and reflected waves on the condition of thread sliding over the surface of a solid and the law of material deformation.

REFERENCES

1. Ergashov M. Properties and interactions of waves in threads. Tashkent. Fan, 2001.
2. Saidova RA, Ergashov M. A wedge blow on a flexible thread.Izv.RAS.MTT.1998. No. 6.
3. Ergashov M. Issues of collision of a thread with rigid bodies. T: Fan, 2001.
4. Ergashov M. Investigation of deformations arising from transverse impact by a rectangular bar on a thread. Izv. AN. Russia. MTT.1987. No. 1.
5. Ergashov M. On the sliding of a thread on the surface of a horizontal shelf // International Journal of Applied Mechanics. NAS of Ukraine. T. 30. 1994. No. 2.
6. Ergashov M. Investigation of the processes of propagation of elastic waves in winding bonds with allowance for the effects of their rotation under tension. Izv.RAS.PMM. T. 56.1992. one.
7. Ergashov M. Theory of wave propagation in winding connections. Tashkent. Fan, 2001.
8. Ergashov M. Wave problems of collision of threads with rigid bodies. T: Fan, 2001.
9. Akhunbabaev OA, Ergashov M. Methods for calculating the tension of nonlinear warp threads interacting with the working bodies of the modernized silk-weaving machine. T .: Fan vatexnologiya. 2016.
10. Akhunbabaev O.A., Ergashov M '. Vapiev G, N Questions of dynamics of interaction of silk threads with working organs of textile machines. T .: Fapvatexnologiya. 2019.