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ANALYSIS STUDY OF THE DYNAMICS OF THE PROCESS OF YARN TWISTING IN PNEUMO-MECHANICAL SPINNING

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Abstract: *The paper presents the results of a study of the dynamics of the process of torsion of yarn of pneumo-mechanical spinning in the presence of a stationary false twist reel, dynamic mathematical models of the process of twisting of yarn of pneumo-mechanical spinning in the presence of a stationary false twist reel, in unsteady modes of starting and stopping the forming-twisting device are constructed.*

Key words: *Pneumatic spinning; forming and twisting devices; yarn; twist; nominal twist; twist direction; twisting process; fixed reel of false torsion; unsteady mode; start; stop; analytical dependence.*

Introduction. For the modern textile industry, one of the characteristic trends is the desire to increase the productivity of technological machines by increasing the speed, which causes not only an increase in workloads, but also a sharp increase in energy costs and a decrease in efficiency. This situation is especially characteristic of the pneumo-mechanical method of spinning, which occupies a significant share in our country.

This provision sets the task of reducing the cost of electricity in rotor spinning, the successful solution of which requires the use of non-traditional approaches to its solution [1, 2].

In connection with the foregoing, the problem of systematizing the accumulated information on new methods of forming yarn and designs of forming and twisting devices arises, clarifying a number of issues of theory and technology, as well as classifying methods for forming yarn. The main direction in the development of new methods of forming yarn remains the increase in the speed modes of the working bodies and, first of all, the forming and twisting devices, in connection with which a number of important problems arise, both technological and constructive. One of the important problems is a sharp increase in the power consumed by the PKU with an increase in the rotational speed. As shown by scientific research, the relationship between power consumption and forming and twisting devices rotational speed is exponential. Since the share of power consumed by forming and twisting devices in pneumo-mechanical spinning machines is currently 70 percent or more, under the conditions of the modern requirement for all-round saving of all resources, and first of all, fuel and energy, the urgency of this problem is increasing. Another important problem is a sharp decrease in the service life of ball-bearing bearings of the forming and twisting devices with an increase in rotational speeds [3, 4].

Main part. A well-known feature of rotor-spun yarn, which consists in high twist coefficients compared to ring-spinning yarn, due to the peculiarity of the structure of rotor-spinning yarn and the conditions for its formation, greatly exacerbates the problem of increasing the power consumption of the forming and twisting devices. This, in turn, makes the actual problem of reducing the twist coefficient of rotor spinning yarn, the solution of which would provide an additional opportunity to achieve an increase in the speed of yarn formation in rotor spinning machines without increasing the rotational speed of the FCU with a corresponding reduction in power consumption [5].

An increase in operating speeds also makes it relevant to study the dynamics of the forming and twisting devices during yarn torsion in new methods for producing yarn, in particular in rotor spinning in an unsteady mode during start-up and stop.

There are studies that indicate the prospects for the use of false torsion finches in pneumomechanical spinning. In this regard, we study the operation of a fixed false torsion reel in an unsteady mode [4]. Consider an elementary technological scheme shown in Fig.1. In the established mode of operation for a rotating reel (n=const , v=const) the twist of the first section will be equal to

$$K_b = \frac{n}{v} \tag{1}$$

and for an immobile reel will be determined by the formula [6]:

$$K_H = \eta\chi_0 \left[1 - e^{\frac{T_0 \Gamma_H^2}{GJ_p}\left(1 - e^{-\mu\varphi}\right)} \right] \tag{2}$$

Where

χ_0 -is the natural torsion of the thread axis at the entry point to the surface of a fixed reel, rpm;

η - correction factor;

T_0 - axial yarn tension force, N;

r_H - thread radius, m;

G - Modulus of elasticity of the yarn in torsion, N/m2;

J - Polar moment of inertia of the cross-sectional area of the yarn, m4;

μ - coefficient of friction between the materials of the reel and yarn;

φ - the angle of wrapping the reel with a thread, rad

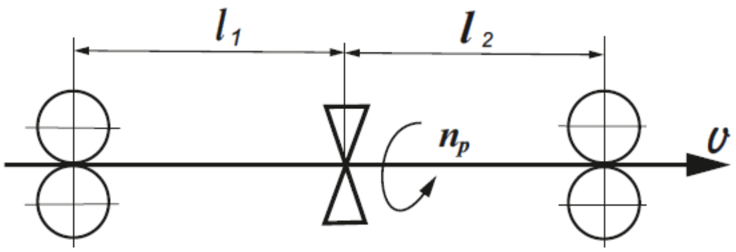

Fig.1. Calculation scheme of a fixed reel.

Keeping in mind that under certain conditions $K_н = const$ and equating the right side of (1) with the left side of (2) we get:

$$n = K_H v, \qquad (3)$$

that is, a fixed reel has the same effect as a rotating reel with a rotation frequency determined by (3).

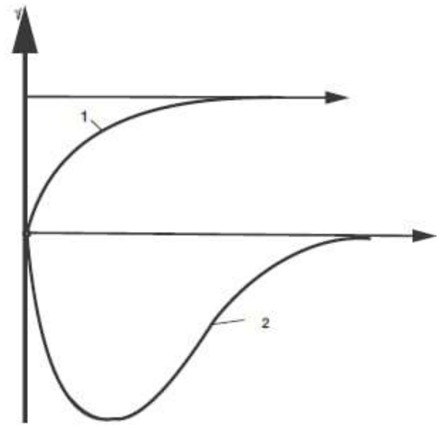

Fig.2. Dependence of twist on time at start-up.

Let us designate this quantity $n_P = K_H v$ and call it the reduced rotation frequency of the motionless reel. Then, at start-up for 1 section of yarn, we can write the equation

$$dk_1 = \frac{n_{np} - K_1 v}{l_1} dt \qquad (4)$$

Where

dK_1 -is the increment of yarn twist in the first section during the time dt;

l_1 -is the length of this section;

v -is the speed of the yarn.

Under initial conditions: at $t=0$ $K_1=K_H$, the equation has a solution:

:

$$K_1 = \frac{n_{np}}{v}\left[1-\left(1+\frac{K_H v}{n_{np}}\right)e^{-\frac{vt}{l_1}}\right] \qquad (5)$$

For $K_H = 0$ (5) takes the form:

$$K_1 = \frac{n_{np}}{v}\left(1-e^{-\frac{vt}{l_1}}\right) \qquad (6)$$

Analysis of (5) and (6) shows that the twist of the first section changes exponentially and in the steady state reaches the value $\frac{n_{np}}{v}$. The change in twist K_1 is shown in Fig.2 by line I (for the case of K_H=0).

Similarly, we can write an equation for the second section:

$$dk_2 = \frac{K_1 v - n_{np}}{v} dt \qquad (7)$$

Its solution under the initial conditions: $t=0$ $K_2=K_H$ has the form:

$$K_2 = K_H e - ^{\frac{vt}{l_2}} - \frac{n_{np}}{v}\frac{l_1}{l_1-l_2}\left(1+\frac{K_H v}{n_{np}}\right)\left(e^{-\frac{vt}{l_1}} - e^{-\frac{vt}{l_2}}\right) \qquad (8)$$

With K_H=0 (8) takes the form:

$$K_2 = -\frac{n_{np}}{v}\frac{l_1}{l_1-l_2}\left(e^{-\frac{vt}{l_1}} - e^{-\frac{vt}{l_2}}\right) \qquad (9)$$

Conclusion. Their analysis shows that, in contrast to the steady state operation $(t \to \infty)$ in the starting mode (at a finite t), the value of K_2 is nonzero. Curve 2 in Fig.2. shows the change in twist K_2 over time (for the case of K_H= 0).

Equating to zero the derivative of equation (9), i.e., $K_2^1 = 0$ we determine the maximum value of the twist K_{2m} and the time when it occurs, $t_{m=0}$.

$$K_{2m} = -\frac{n_{np}}{v} \frac{l_1}{l_1 - l_2} \left(e^{-\frac{vt_m}{l_1}} - e^{-\frac{vt_m}{l_2}} \right) \quad (10)$$

$$t_m = \frac{l_1 l_2}{v(l_1 - l_2)} \ln \frac{l_2}{l_1} \quad (11)$$

i.e., with constant l_1 and l_2, t_m depends only on the speed v, and the absolute value of K_{2m} is determined by the ratio of l_1 and l_2.

For При $l_1 = l_2 = l$:

$$K_{2m} = \frac{n_{np}}{v} \frac{v}{l} t e^{-\frac{vt}{e}} \qquad t_m = \frac{l}{v}$$

A practical solution to the problem of forming pneumomechanical yarn with a reduced twist coefficient is possible on the basis of studying the theory of pneumomechanical spinning and studying the dynamics of forming and twisting devices during yarn torsion and developing an appropriate design solution based on them.

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