APPLICATION OF DRIVE MECHANISMS ON MACHINES FOR TEXTILE PROCESSING
OF MAN-MADE FIBRES

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Drive mechanisms (DM) have begun to be widely used on machines for the production and processing of man-made fibres in recent years. Most often they have been installed on twisting and rewinding machines after unwinding the yarn from the input package, and serve to level out fluctuations in tension, thereby preventing the incidence of yarn with nonuniform internal stretching stresses over their length either into the zone for winding up the output package or onto other devices where definite technological operations are carried out. This is one of the necessary conditions for forming high-quality packages and obtaining yarn with uniform characteristics along its length.

These DM were first installed on foreign specimens of twisting and rewinding machines. Domestic equipment is also being equipped with such mechanisms, for example the BP-340-0 bobbin-rewinding machines, which are intended for rewinding textile grade texturized polyamide yarns.

Adequate studies on optimization of their operation have not preceded the wide introduction of DM. Thus, in the special literature there is only a description of the construction of the DM for the BP-340-0 machine [1], plus studies devoted to individual aspects of their operation [2-5]; a constructive diversity of mechanisms have been revealed in patent sources, for example [6-10].

Moreover, analysis of trends in the modernization of DM in plants of the man-made fibre sub-branch shows that ways for improving them have not always been chosen in the optimum way. Besides, sometimes because of lack of understanding of the essence of DM functioning, it has been excluded from the technological scheme of the machine and is not accepted as one of its necessary elements. This leads to a considerable lowering in package quality and yarn quality, and of finished articles prepared from them.

In this connection it is advisable to examine the principle of action and experience in operating a DM in the case of the BP-340-0 machine, a simplified technological scheme of which is shown in Fig. 1. The yarn \( \text{1} \) after unwinding from the input package \( \text{2} \) passes through the yarn guide \( \text{3} \) and goes to the DM, which consists of the rotating rolls \( \text{4} \) and the immobile yarn-guide set \( \text{5} \). The circumferential velocity of rotation of the rolls should exceed the linear velocity of yarn movement. A definite law for change in winding tension \( P_{\text{win}} \) is ensured by the comb-like yarn tensioner \( \text{6} \), whose mobile combs are connected, via a system of leaves, with the rolling shaft \( \text{7} \). After passing through the immobile yarn-guiding set \( \text{8}-\text{10} \), the yarn is wound up on the output package \( \text{11} \). A back and forth motion is communicated to the yarn by the yarn guide \( \text{12} \). By \( P_{\text{un}}, P_{\text{in}}, P_{\text{out}}, P_{\text{in}}, P_{\text{out}}, \) and \( P_{\text{win}} \), in Fig. 1, we have denoted the yarn tension in unwinding, on yarn entry and yarn exit from the DM and comb-like yarn tensioner, and also the tension in winding the yarn onto the package. \( \text{A} \) and \( \text{D} \) are the points of unwinding and winding up; \( \text{B} \) and \( \text{C} \) are the points of entry and exit of the yarn from the DM.

A distinctive feature of both the rewinding machine and also of any machine for textile processing is the inconstancy of tension in unwinding the yarn from the input packages (\( P_{\text{un}} \)) in view of differences in form, structure, amount of lubricant applied, presence of winding defects, and so on. Herein the quantity \( P_{\text{un}} \) has an indeterminate value with time. Therefore, if a DM is not used, the character of change in tension \( P_{\text{in}} \) may be spasmodic (line 2 in Fig. 2). The winding up tension will also vary in similar fashion (line 4). In this case, control of the parameter \( P_{\text{win}} \) and obtaining high quality packages is impossible. To form a wound body with assigned parameters and preserve the physicomechanical properties obtained in preceding technological stages, the tension \( P_{\text{win}} \) should vary by a strictly defined law (line 3), which is realized with the aid of a yarn tensioner. To ensure this law, the tension...
An important condition for normal performance of the technological process is a maximum enlargement of the regulation range of the wind-up tension, which is determined by the ratio $P_{\text{win}}/P_{\text{in}}$. In the general case, this quantity depends on such basic factors as the allowable package density, the product of the frictional coefficient by the total angle of contact of the immobile elements of the yarn guiding equipment of the machine by the yarn, and the degree of reduction in tension by the DM. In the case of a yarn assortment assigned in advance and a known machine for processing it, the first two factors remain unchanged. Then possibilities of regulating the wind-up tension will depend only on how much the tension has been reduced in the DM.

Thus, the basic requirement on a DM is to ensure a constant mean level of output tension ($P_{\text{out}}$), regardless of the magnitude and fluctuations in input tension ($P_{\text{in}}$) or in change of other technological factors (amount of lubricant applied, climatic conditions, and so on). Among the other necessary requirements to which a DM should conform must be listed the possibility of starting and stopping a working position without changing the technological scheme of machine adjustment without contact of the operator with the yarn, convenience in yarn adjustment, safety in servicing, and reliability of mechanism operation.

For a more complete representation of the operation of a DM and its effect on machine functioning as a whole, one should make use of the relationship of $\{\text{i}\}$, which, in the general case, determines the connection between the input ($P_{\text{in}}$) and output ($P_{\text{out}}$) yarn tensions in a DM if it consists of $n$ immobile directing rods and $n$ rotating rolls:

$$P_{\text{out}} = P_{\text{in}} \exp \left( \sum_{i=1}^{n} f_i \alpha_i - \sum_{i=1}^{n} f_i \beta_i \right) - T \Delta v \exp \left( \sum_{i=1}^{n} f_i \alpha_i - \sum_{i=1}^{n} f_i \beta_i \right) \right) - aRy$$

where $n$ is a real number; $i$ is the instantaneous value of $h$; $T$ is the linear density of the yarn; $a$ is the lengthwise acceleration of the yarn; $R$ is the radius of the rotating roll; $f_i$ and $f_j$ are the coefficients of fraction of the yarn on the rolls and rods, respectively; $\alpha_i$ and $\beta_i$ are the contact angles of the yarn on the rolls and rods, respectively; and $v_r$ and $v_y$ are the circumferential velocity of the rotating rolls and the linear velocity of yarn movement, respectively.

The basic technological parameters of a DM is the contact angle of the yarn on the rotating rolls. If we assume that $a = 0$, then from Eq. (1) one can determine the optimum contact angle of the yarn on the rolls ($\alpha_{\text{op}}$), which ensures an assigned output yarn tension:

$$\alpha_{\text{op}} = \frac{1}{f} \ln \frac{\sigma_{\text{in}} - b \Delta v^2 \alpha_i}{\sigma_{\text{out}} - b \Delta v^2 \alpha_i} \cdot \frac{f}{f} \sum_{i=1}^{n} \alpha_i'$$