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THE MANUFACTURING PROCESS FOR PRODUCTION OF COMBINED CONDUCTING FIBRES

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The equations reported here can be used for calculating the physicomechanical parameters of combined conducting fibres. The breaking load of combined conducting fibres is basically a function of the strength of the core — the complex chemical fibre.

A method for making combined conducting fibres with hollow spindles on a spinning-twisting machine that ensures a relatively high level of coverage of the core of the conducting microwire has been developed in the Department of Spinning of Natural and Chemical Fibres at Vitebsk Technological University. At the same time, the conducting element itself is almost not deformed.

The structure and properties of the combined fibres are a function of the type of equipment used, the type and properties of the covering components, the direction and degree of twisting, the thickness of the microwire and core fibre, and the thickness of the cover of the microwire by the complex fibre.

Fibres processed on machines with hollow spindles have a good state of equilibrium due to winding of the core component with overlapping turns. However, all of the deformation properties of the initial materials must be taken into consideration for giving the fibres the optimum twist [1].

Fibres of any type can be used for making conducting articles of the required external appearance. The deformation characteristics, particularly the elongation at break, and the breaking load at a given deformation is predetermined by the strong core, including its thickness and wrapping in twisting. Possibilities thus appear for planning and regulating the deformation properties of fibres for articles of different types and applications.

The combined conducting fibre is made as follows. The complex chemical fibre is twisted with a microwire in the Z direction (left) and then wound with the complex chemical fibre in the S direction (right direction). The two strands are twisted in the opposite direction with the same device operating on the rotating scroll tube principle.

If the spindle is rotating clockwise, then the first strand in the section above the spindle is given a twist of the correct direction. The final twist of the combined fibre has the opposite direction. The number of twists of the first strand is approximately equal to the number of twists of the finished combined fibre, since the same rotating device — the hollow spindle with the bobbin — makes the twist in this and the other section. The manufacturing scheme of production of the combined conducting fibre is shown in Fig. 1.

The essence of the manufacturing process consists of the following. Pack 2 with the conducting element (first strand) is installed in modernized frame 1 (diagram a) of the machine. Bobbin 8 with the complex chemical fibre (second strand) is placed on hollow spindle 7. When the bobbin with the fibre rotates, ballooning fibre 9 descending from it is twisted with the conducting element (first strand) in rotating and is removed by discharge cylinders 11 and 12 through the eyes of thread guide 5 into central channel 6 of spindle 7, causing the bobbin to rotate in the modernized feeding frame. The two strands are joined at the top of the spindle. In the path from the top of spindle 7 to discharge pair 11, 12, the conducting element and complex chemical fibre rotated by the same spindle are twisted and acquire a twist with direction Z. The twisted fibre 10 in two forms is wound in cylindrical cartridge 13 by winding cylinder 14.

Twisted fibre 10 must be twisted with complex chemical fibre 15 (b) in direction S to stabilize the structure of the combined conducting fibre. The chemical fibre must not completely cover the previously twisted fibre.

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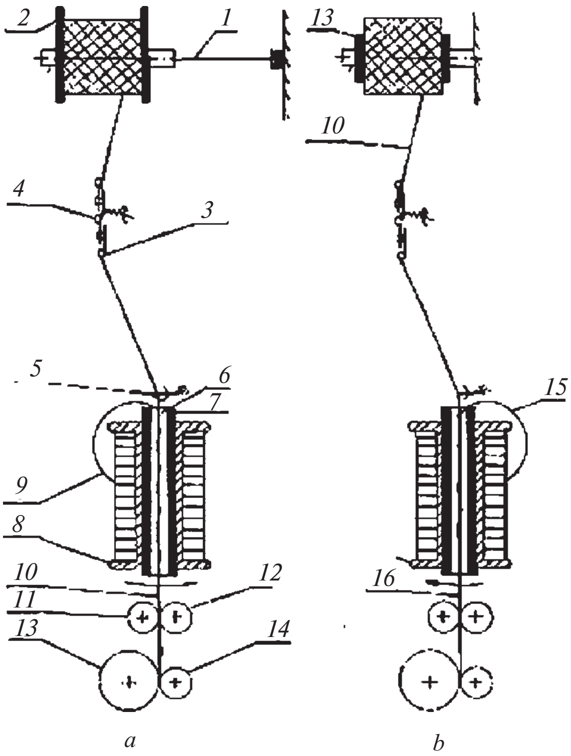

Fig. 1. Manufacturing scheme for production of combined conducting fibres: a) direction of twist Z; b) direction of twist S.

TABLE 1. Comparative Analysis of the Theoretical and Experimentally Determined Physicomechanical Parameters of the Combined Conducting Fibre

Characteristics	Numerical values	
	obtained by calculation	experimentally obtained
Linear density, tex	50	50.2
Relative tenacity, cN/tex		
first-twist fibre	35.2	34.7
second-twist fibre	36.4	36.1
Diameter, mm	0.28	0.3

The main advantages of the method are the high output of the spinning-twisting machine and the high weight of the output pack. This allows obtaining a sufficient length of the knotless fibre. The structure, which determines the physicomechanical, electrophysical, and performance properties, is one of the features of the combined conducting fibre made on machines with hollow spindles.

The linear density of the combined conducting fibre ($T_{\text{comb.f}}$) is determined with the equation

$$T_{\text{comb.f}} = T_{\text{cor}} K_{\text{p.cor}} + T_{\text{micro.w}} K_{\text{micro.w}} + T_{\text{w}} K_{\text{w}}, \tag{1}$$

where T_{cor} is the linear density of the core, tex; $T_{\text{micro.w}}$ is the linear density of the microwire, tex; T_{w} is the linear density of the winding component, tex.; $K_{\text{p.core}}$ is the core pileup coefficient; $K_{\text{micro.w.p.}}$ is the microwire pileup coefficient; $K_{\text{wi.p}}$ is the winding component pileup coefficient.

The tenacity of the combined conducting fibre, which is basically a function of the strength of the core (complex chemical fibre) and metal microwire, is the sum of three constituents: the tenacity of the core and metal microwire and the tenacity of the winding component.

The relative tenacity of the first-twist fibre ($P_{\mathrm{fir.tw}}$, cN/tex) is determined with the equation

$$P_{\mathrm{fir.tw}} = P_{\mathrm{micro.w}} + P_{\mathrm{cor}}\left(\frac{100 - X_1}{100}\right)\frac{\varepsilon_1}{\varepsilon_2}, \tag{2}$$

where $P_{\mathrm{mic}}{}^{\mathrm{r.w}}$ is the tenacity of the microwire, cN/tex; P_{cor} is the tenacity of the core (complex chemical fibre), cN/tex; X_1 is the per-unit embedding of the binding component (microwire), %; ε_1, ε_2 are the elongation at break of the less and more extensible component, %.

The relative tenacity of the combined second-twist conducting fibre ($P_{\mathrm{com}}{}^{\mathrm{b.f}}$, cN/tex) is determined with the equation

$$P_{\mathrm{comb.f}} = P_{\mathrm{wi}} + P_{\mathrm{fir.tw}}\left(\frac{100 - X_1}{100}\right)\frac{\varepsilon_1}{\varepsilon_2}, \tag{3}$$

where P_{wi} is the tenacity of the winding component, cN/tex; $P_{\mathrm{fir}}{}^{\mathrm{.tw}}$ is the tenacity of the first-twist fibre, cN/tex; X_1 is the per-unit embedding of the first-twist fibre, %; ε_1, ε_2 are the elongation at break of the less and more extensible component, %.

The core pileup coefficient of the combined conducting fibre ($K_{\mathrm{p.c}}{}^{\mathrm{or}}$) is determined wiht the equation

$$K_{\mathrm{p.cor}} = \frac{l_0 + (l_1 - l_0)}{l_0}, \tag{4}$$

where l_0, l_1 is the length of the core before and after twisting, mm.

The diameter of the combined conducting fibre ($D_{\mathrm{comb.f}}$, mm) is determined with Eq. (5),* where T_{cor} is the linear density of the core, tex; $T_{\mathrm{micro.w}}$ is the linear density of the microwire, tex; T_{wi} is the linear density of the winding component, tex; γ_{cor} is average density of the core, g/cm^3; $\gamma_{\mathrm{mic}}{}^{\mathrm{ro.w}}$ is the average density of the microwire, g/cm^3; γ_{wi} is the average density of the winding component, g/cm^3.

$$D_{\mathrm{comb.f}} = 0.0357\sqrt{\frac{T_{\mathrm{cor}}}{\gamma_{\mathrm{cor}}}K_{\mathrm{p.cor}} + \frac{T_{\mathrm{micro.w}}}{\gamma_{\mathrm{micro.w}}}K_{\mathrm{p.micro.w}} + \frac{T_{\mathrm{wi}}}{\gamma_{\mathrm{wi}}}K_{\mathrm{p.wi}}}, \tag{5}$$

The values of the physicomechanical parameters of the combined conducting fibre calculated with Eqs. (1)-(5) and verified in practice are reported in Table 1. The error between the theoretical and practical indexes is insignificant. As a consequence, these equations can be used for calculating the physicomechanical parameters of the combined conducting fibre.

The combined conducting fibres containing a complex chemical fibre and a microwire are thus characterized by high strength and compactness. They can be used as weft or warp fibres in fabrics and knits for special applications [2].

REFERENCES

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2. E. G. Zamostotskii and A. G. Kogan, *Cherzvych. Situatsii: Preuprezhd. Likvid.*, No. 2 (20), 71-75 (2006).