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DEVELOPMENT OF RATIONAL TECHNOLOGY FOR MANUFACTURE OF ARSELON SEWING THREAD

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The effect of the twist value on the basic physicomechanical indexes of Arselon sewing thread of 29 tex × 4 structure was examined. Polynomial models that adequately reflect the dependence of the optimization criteria on the twist were obtained. The analysis of these models allowed establishing the optimum twisting parameters for Arselon sewing thread.

On the threshold of Russia's entry into the World Trade Organization, having its own comparatively cheap products manufactured from domestic stock is becoming increasingly important with respect to economic security. Arselon fibre, developed in our country and manufactured from Russian stock in the Union Republic of Belarus' and processed into finished articles in large volumes in Russia, is a product that meets these requirements in the thermostable chemical fibre and thread sector.

On many physicomechanical indexes, Arselon is better than the analogs manufactured in Russia and CIS countries (Togilen, Tverlan, Fenilon), including the limiting temperature of use, strength, and shrinkage in boiling water and in air. In addition, fibre made of poly-*p*-phenyloxadiazole, i.e., Arselon, withstands thermal shock up to a temperature of 400-425°C. The low cost of the industrial monomers themselves — terephthalic acid and hydrazine sulfate — is also an important advantage over other thermostable fibres and thread [1].

The following are the basic qualities of Arselon: high glass transition temperature (up to 370°C), working temperature in ambient air of 300°C for 100 h with 75-95% loss of strength, elasticity after prolonged use in air at high and low temperatures, does not melt, oxygen index of 32% (i.e., it burns in air only in an open flame), high resistance to chemical reagents (does not swell and does not dissolve in organic solvents and acids), high equilibrium moisture content (12% at 65% relative humidity), total of 1% shrinkage in boiling water, and under 2.5% shrinkage in air at 300°C. The valuable properties of Arselon combined with the low production cost make it one of the most promising kinds of thermostable fibres [2].

The strength, thermostability, and hygroscopicity of Arselon fibre, manufactured with uncomplicated technology and a readily available raw material base, open up broad possibilities for using it in different branches of industry for manufacturing thermostable fabrics for filtration of high-temperature gases in ferrous and nonferrous metallurgy and in the carbon black and cement industries; protective clothing and gloves for metallurgists, welders, and those working in extreme conditions. Developing sewing thread made from Arselon fibre for sewing these items is an urgent problem.

The Chemical Fibre Processing Department at MSTU is conducting comprehensive studies on creating technology for manufacturing spun items with Arselon yarn. Studies were initially conducted on determining the optimum twist value in processing Arselon yarn [3, 4]. A twist range from 400 to 800 tw./m was selected. The values of the breaking load, elongation at break, linear density, and real twist were found for each twist level. The results obtained were processed with mathematical methods of experiment design. It was found that the maximum value of the absolute breaking load for twisted Arselon yarn is attained at a first twist of 600 tw./m.

The effect of a second twist on the properties of Arselon sewing thread with a linear density of 29 tex in 4 threads was then investigated. The samples were processed on a TKM-12 doubler-twister. The results of determining their physicomechanical properties were processed with Statistika software and the average values were processed with mathematical methods of experiment design using Microsoft Excel. Graphs were plotted with the results (Table 1).

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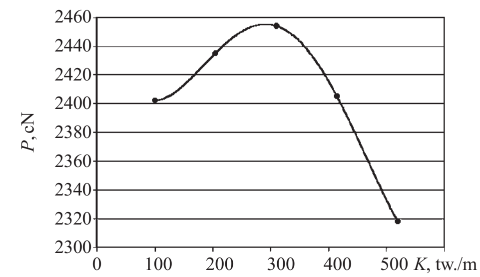
TABLE 1. Indexes of the Physicomechanical Properties of 29 tex × 4 Arselon Sewing Thread

Twisting, tw./m	*P*, cN	ε, %	*T*, tex	P_u, cN/tex	*K*, tw./m	N, loops/m	S, arb. units
100	2402	19.605	113.64	20.65	108.1	2.10	24.51
205	2435	21.83	111.4	21.35	213.5	2.14	20.66
310	2454	23.47	114.8	21.05	326.2	5.615	19.91
415	2405	25.05	116.7	20.05	436.7	29.97	23.48
520	2318	26.40	117.15	19.30	543.1	32.22	25.33

Notation: *P* — absolute breaking load; ε — elongation at break; *T* — linear density; P_u — unit breaking load; *K* — twisting; N — nonequilibrium; S — stiffness.



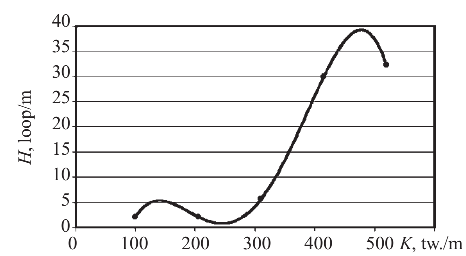


Fig.1 Fig.2

Fig. 1. Breaking load of sewing thread (*P*) vs. twist (*K*).

Fig. 2. Nonequilibrium (N) of sewing thread vs. twist (*K*).

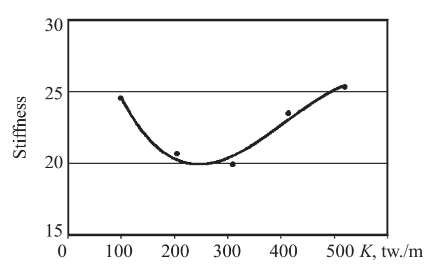


Fig. 3. Stiffness of sewing thread vs. twist (*K*).

The dependences of the basic physicomechanical properties of Arselon sewing thread on the second twist were determined. The experimental values of the parameters are designated by the points in the figures and the calculated values obtained as a result of optimization are designated by the solid line.

The highest breaking load of sewing thread of 29 text × 4 structure was attained in twisting of 310 tw./m (Fig. 1). The breaking load increased from 100 to 310 tw./m due to compacting of the structure and an increase in the friction forces between fibres and strands. The decrease in the breaking load in twisting after the critical twist is due to breaking of individual fibres by external stresses. The mathematical regression model (fourth-degree polynomial series)

$$y_P = 3\cdot 10^{-8}x^4 - 4\cdot 10^{-5}x^3 + 0.0148x^2 \quad 1.9443x + 2482.9$$

accurately describes the indicated function, since the degree of confidence of the approximation is equal to 1.

The dependence of nonequilibrium of the sewing thread on the twist is shown in Fig. 2. When the twist increases to 310 tw./m, the nonequilibrium increases insignificantly — from 2.1 to 5.615% — due to compensation of stress from the first twist. After 310 tw./m, the nonequilibrium increases sharply, to 32.22%. The mathematical regression model (fourth-degree polynomial series) is described by the equation

$$y_H = -2\cdot 10^{-8}x^4 + 2\cdot 10^{-5}x^3 - 0.0091x^2 + 1.362x - 65.338.$$

The effect of the twist on the stiffness in twisting is illustrated in Fig. 3. When the second twist of 29 tex × 4 Arselon sewing thread is increased to 310 tw./m, the strands untwist, which insignificantly decreases the stiffness, and with a further increase in the second twist, the compactness of the thread and its stiffness in twisting increase. The mathematical regression model is described by the equation (third-degree polynomial series)

$$y_S = -3\cdot 10^{7}x^3 + 0.0004x^2 - 0.1459x + 35.308.$$

The critical twist for 29 tex × 4 Arselon sewing thread was determined at 310 tw./m for 23.47% elongation at break. The optimum twist value also ensures minimal stiffness in twisting. The nonequilibrium at this twist is 5.5%, but as a result of heat treatment at a temperature above 250°C in hot air, it decreases significantly.

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