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Optimization of Tribotechnical Properties of Fibrous Carding Tape in the Production of Artificial Fur

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Abstract—The study is devoted to the optimization of tribotechnical properties of fibrous carding tape for the production of artificial fur. The influence of the amount of IS-2 emulsifier applied to the fibers of the carding tape on the quality indicators of artificial fur, such as the surface density of the pile cover, the mass of loosely fixed fibers, the specific surface electrical resistance, resistance to pile dumping and the strength of the tape, has been studied. The mechanisms of the influence of the oiler on the dynamic coefficient of friction and the coefficient of tangential resistance of the fibrous carding tape were established and the consumption of the emulsifier applied to the fibers was optimized to achieve maximum quality indicators of artificial fur (2–3 g of emulsifier per 1 kg of fiber). The results of the conducted studies have shown that the oiling of fibers in the production of artificial fur with fat-free emulsifier IS-2 at an optimal concentration of 2–3 g of emulsifier per 1 kg of fiber, depending on the type of fur, leads to an increase in the mass of the pile cover from 5.4 to 19% (fur density increases), to a significant decrease from 77.8 to 81.3% of the mass of loosely fixed fibers in the pile, reducing the specific surface electrical resistance from 22.6 to 45.4%. It has been established that the resistance of the pile to dumping does not depend on the concentration of the emulsifier on the fiber surface. Also, at an optimal concentration the greatest strength and the minimum coefficient of variation are achieved, i.e., the best uniformity of strength along the tape.

Keywords: fibers, carding tape, artificial fur, dynamic coefficient of friction, coefficient of tangential resistance, electrophysical properties of fibers, surface density of pile cover, mass of loosely fixed fibers, tape strength, oiling agent, resistance to pile piling

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INTRODUCTION

Artificial fur in its structure resembles natural fur and consists of ground and pile [1]. The ground is the base of the fur in which the fibers of the pile are fixed. Pile is a fibrous cover, which, depending on the method of manufacturing, type of fibers, and used threads, the purpose of the fur, can be uniform and heterogeneous in length and thickness of the fibers, according to the density of their arrangement; height from a few millimeters to several centimeters. Fur on a knitted basis is obtained on circular knitting machines by knitting bundles of fibers from a combed tape into soil loops. The technology for the production of artificial fur includes the process of manufacturing a fibrous carding sliver. The carding sliver is produced according to the following scheme: primary loosening and mixing of fibers, layer-by-layer mixing and loosening of fibers, emulsification of fibers, carding of fibers, and formation. The most important stage, which significantly affects the quality of the produced material, is carding the fibers. Depending on the purpose of the artificial fur, the tape can be carded twice (first carding, second carding). The main task of the carding process is to obtain a carding sliver of high evenness with a minimum amount of trash, good straightening and parallelization of the fibers.

One of the problems of textile enterprises is the determination and justification of the required consumption of the emulsion for applying of the carding sliver to the fibers in the production of artificial fur.

Objective—To establish the effect of the amount of emulsol IS-2 applied to the fibers of the carding sliver on the quality indicators of artificial fur and to optimize its consumption in terms of the quality of artificial fur.

FORMULATION OF THE PROBLEM

In [2, 3], the general laws of friction of fibrous materials were considered, and the influence of the concentration and properties of textile auxiliary substances on the friction properties of fibers and threads was shown. The nature of the change in the dynamic coefficient of friction depending on the concentration

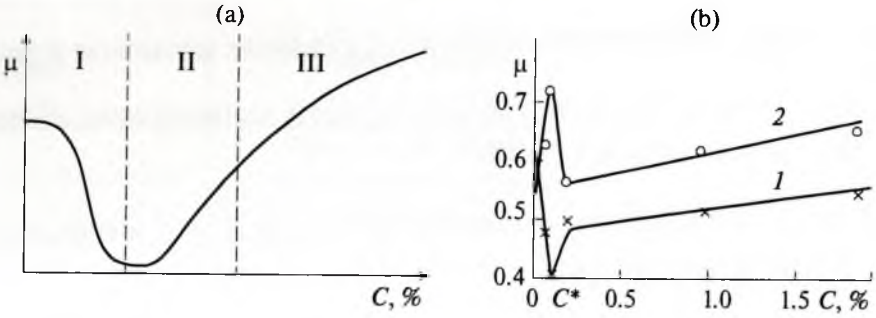

Fig. 1. (a) The general dependence of the dynamic coefficient of friction μ on the concentration *C*, % of the surfactant on the fiber surface; (b) *1*—change in the dynamic coefficient of friction; *2*—change in the coefficient of tangential resistance; *C**—concentration corresponding to the formation of a monomolecular layer.

of the preparation on the surface of the fiber is shown in Fig. 1a [4].

If there is a monomolecular layer of a textile auxiliary preparation on the surface of a moving body, boundary friction is observed (zone I, Fig. 1a), in the presence of many layers, an intermediate friction mode (zone II) or hydrodynamic friction mode (zone III) is observed. Shown in Fig. 1a, the dependence of the dynamic coefficient of friction μ of a fiber on metal is an analog of the Gersey–Striebeck diagram [5]. The Gersey–Striebeck diagram was presented to the scientific community in 1902, but for some reason in the literature on the processing of chemical fibers [2, 3], it is believed that the same relationship for fibers and threads was first obtained by Howell [2] in the 1950s. Note that the physical meaning of the friction mechanism in both dependences is the same.

Even a rough theoretical estimate of the amount of the preparation associated with the fiber in the form of a monomolecular layer is a rather difficult task. This is due to the fact that the applied emulsion of emulsol IS-2 has a complex structure in the form of micelles, in contrast to homogeneous mixtures of vivifying preparations. The process of interaction of micelles with the fiber surface and the properties of the monomolecular layer in this case are poorly understood. According to the dependences shown in Fig. 1b, there is an optimal amount of surfactant on the fiber surface at which friction coefficients μ have extremes: the dynamic friction coefficient when the fiber moves along the metal has a minimum, and the tangential resistance coefficient when the fiber moves along the fiber is maximum [3]. The task of determining this extremum and taking it into account in the technological process is important for the formation of a high-quality carding sliver. Let us assume that in our case, there is such a concentration of emulsol IS-2 at which the positive properties of the tape will be maximum.

The quality indicators of artificial fur, which can be affected by oiling the fibers of the tape are as follows: the surface density of the pile cover, the weight of loosely fixed fibers, the specific surface electrical resistance, resistance to stalling pile, the strength of the tape, and the best uniformity of strength along the tape itself [6].

Indicators of physicomechanical and physicochemical properties of artificial fur, necessary to control its quality, as well as the sampling procedure, are regulated by GOST 26666.0–85 [7]. The quality indicators of knitted artificial fur are determined by GOST 4.80–82 [8]. The values of normative quality indicators depend on the purpose of artificial fur and are regulated in accordance with GOST 28367–94 [9]. The method for determining the surface density of the pile cover is regulated by GOST 3815.1–93 [10].

RESULTS AND DISCUSSION

The following samples of artificial knitted fur were selected:

— N-32 (composition—modified polyacrylonitrile fibers kanekaron with a linear density of 0.33 tex—30% and 1.2 tex—70%)—artificial fur for outerwear, plain dyed.

— I-59 (composition—PAN + P/E with a linear density of 0.33 tex)—artificial fur for toys, short pile.

— I-81-1VU9D19 (composition—PAN 100% with a linear density of 0.33 tex)—artificial fur for toys, short pile, with a pile effect.

The quality indicators of artificial fur were tested when the fibers of the carding sliver were oiled with IS-2 developed at the Vitebsk State University of Technology [11]. The results of tests to determine the surface density of the pile cover are summarized in Table 1. The consumption of emulsol IS-2 in Table 1 is indicated in grams per 1 kg of the tested fiber.

Analyzing the indicator of the surface density of the pile cover, one should be guided by the indicated norm of this indicator in GOST 28367–94 [9]. The actual result must be equal to or greater than the specified norm. Table 1 shows the values of the mass of the pile cover at the optimal consumption of emulsol IS-2 for

Table 1. Surface density of the pile cover

Type of fur	Emulsion composition and its consumption	Weight of pile cover, g/m^2	
		norm (at least)	fact
N-32 faux fur for outerwear, smooth-dyed	First comb: IS-2 (2 g/kg) Second comb: IS-2 (2 g/kg)	290	312 (+7.6%)
I-59 faux fur for toys, short-pile	IS-2 (2 g/kg)	130	137 (+5.4%)
	IS-2 (4 g/kg)	130	133 (+2.3%)
I-81-1VU9D19 faux fur for toys, short-pile, with pile laying effect	IS-2 (3 g/kg)	200	238 (+19%)

Table 2. Weight of loosely anchored fibers

Type of fur	Emulsion composition and its consumption	Weight of weakly attached fibers, g/m^2	
		norm	fact
N-32	1—comb: IS-2 (2 g/kg) 2—comb: IS-2 (2 g/kg)	8.0	1.5 (−81.3%)
I-59	IS-2 (2 g/kg)	4.5	1.0 (−77.8%)
I-81-1VU9D19	IS-2 (3 g/kg)	8.0	1.5 (−81.3%)

different types of artificial fur. The results of the studies show that the use of fiber oiling with IS-2 fat-free emulsol in the production of artificial fur leads to an increase in the weight of the pile cover, and the actual index of the surface density of the pile cover is higher than the norm from 5.4 to 19%, depending on the type of fur.

For I-59 artificial fur for toys, short pile, the results of comparing the effect of emulsol of different costs (2 g/kg and 4 g/kg) are given. The studies have shown that the use of emulsol with a non-optimal consumption worsens the surface density of the pile cover by 3.1%.

The quality of textile materials is evaluated by performance indicators. The performance characteristics of artificial fur include the mass of loosely fixed fibers and resistance to stalling. Determination of the mass of weakly fixed fibers in the pile of artificial knitted fur is regulated by GOST 26666.3–85 [12]. The results of tests to determine the mass of weakly fixed fibers in the pile of selected samples are summarized in Table 2.

Analyzing the mass index of weakly fixed fibers, it is required to focus on the specified norm of this indicator in GOST 26666.3–85 [12]. The actual result should not exceed the norm. In this case, when using oil agent IS-2 with optimal consumption, the mass index of weakly fixed fibers is below the norm from 77.8 to 81.3%, depending on the type of fur.

To assess the quality of the produced fur, hygienic indicators are used. For artificial fur, such an indicator is the indicator of the specific surface electrical resistance, which is regulated by GOST 29104.20–91 [13]. This indicator characterizes the ability of artificial fur to dissipate electrical charges.

The essence of the method for determining the indicator of the specific surface electrical resistance is to determine the electrical resistance of an elementary sample of artificial fur, located between two electrodes, to which voltage is applied.

The results of tests to determine the specific surface electrical resistance of selected samples of artificial fur are summarized in Table 3.

The actual result should not exceed the norm according to GOST 29104.20–91 [13]. In this case, the specific surface electrical resistance is below the norm from 24.6 to 45.4%, depending on the type of fur. Tests have also shown that the deviation from the optimal consumption of emulsol IS-2 worsens the indicator of specific surface electrical resistance.

Determination of the resistance of fur to pile stalling is regulated by GOST 21516–76 [14]. As the research results showed, the composition and concentration of IS-2 emulsion do not affect the resistance of the pile to stalling [6].

The strength of the carding sliver for I-59, an artificial fur for toys, short-pile, has been studied as the most frequently destroyed when moving to the sealing funnel under the action of its own weight as a result of the low adhesion of the fibers. The results of testing the strength of the fibrous card sliver using various emulsion rates are presented in Table 4.

Table 3. Specific surface electrical resistance of artificial fur

Type of fur	Emulsion composition and its consumption	Specific surface electrical resistance, Ω	
		norm (no more)	fact
N-32	1—comb: IS-2 (2 g/kg) 2—comb: IS-2 (2 g/kg)	5×10^{10}	2.73×10^{10} (−45.4%)
I-59	IS-2 (2 g/kg)	5×10^{10}	3.77×10^{10} (−24.6%)
	IS-2 (4 g/kg)	5×10^{10}	3.87×10^{10} (−22.6%)
I-81-1VU9D19	IS-2 (3 g/kg)	5×10^{10}	2.87×10^{10} (−42.6%)

Table 4. Strength of the carding tape

Type of fur	Emulsion composition and its consumption	Average strength of the carding tape, N	Coefficient of variation on the breaking load, %	Average linear density of carding tape, (kg/km) ctex
I-59	IS-2 (4 g/kg)	1.14	9.5	13.8
	IS-2 (2 g/kg)	1.20	4.7	15.1

Let us note that the best result has been obtained using the IS-2 emulsion at a concentration of 2 g/kg. At the same time, the average strength of the card sliver was 1.2 N with the lowest coefficient of variation of 4.7%, that is the best uniformity of strength along the length of the I-59 fur tape.

It should be noted that all studies were carried out on the same production line at JSC BELFA (Zhlobin, Republic of Belarus) at the same operating parameters of the machines, which excludes the influence of other factors on the quality of artificial fur, except for the influence of emulsols applied to the fibrous carding sliver.

CONCLUSIONS

It has been experimentally confirmed that both the dynamic coefficient of friction and the coefficient of tangential resistance of the fibers can vary significantly depending on the concentration of textile auxiliary substances on the surface of the fibrous materials of the carding sliver. When processing fibers with IS-2 fat-free emulsol, various friction zones appear due to different modes of interaction of two rubbing surfaces.

The influence of the amount of emulsol applied to the fibers of a carding sliver on the quality indicators of artificial fur, such as the surface density of the pile cover, the mass of weakly fixed fibers, the specific surface electrical resistance, the resistance to pile stalling, and the strength of the carding sliver, has been experimentally studied.

The consumption of the applied emulsol was optimized (the concentration of emulsol is 2 g per 1 kg of fiber for N-32 and I-59 fur, and for I-81 fur, 3 g per 1 kg of fiber) per fiber in terms of the quality indicators of artificial fur. The results of the studies showed that the use of oiling the fibers in the optimal concentration (2–3 g/kg depending on the fur) with fat-free emulsol IS-2 in the production of artificial fur leads to an increase in the mass of the pile cover (tape compactness) from 5.4 to 19%, to a significant reduction from 77.8 to 81.3% of the mass of loosely fixed fibers in the pile, a decrease in the specific surface electrical resistance from 22.6 to 45.4%, depending on the type of fur. The concentration of emulsol IS-2 does not affect the resistance of the pile to stalling. In addition, at the optimal emulsol concentration, the greatest strength is achieved with a minimum coefficient of variation, that is, the best uniformity of strength along the length of the tape, which is explained by the maximum coefficient of tangential resistance (curve *2* in Fig. 1b).

It should be noted that the process of carding the fibers and the formation of a carding sliver of high evenness with a minimum amount of trash, good straightening and parallelization of the fibers, which is carried out after oiling, also strongly depends on both the dynamic coefficient of friction and the coefficient of tangential resistance of the fibers. Carding is carried out with a metal comb and with a minimum dynamic coefficient of friction, mainly weed impurities are combed out, and the fibers themselves are slightly shifted relative to each other due to the high coefficient of their tangential resistance, that is, strong sticking together. In such a situation, when carding, the fibers straighten and parallelize, which contributes to the distribution of strength uniformity along the length of the fibrous tape.

REFERENCES

1. *GOST* (State Standard) *25562–82: Artificial knitted fur. Terms and definitions*, 1982.

2. Howell, H., Meiszis, H., and Tabor, D., *Friction in Textiles,* London: Butterworth, 1959.
3. Pakshver, A.B., Melnikov, B.N., Usenko, V.A., Kukin, G.N., and Soloviev, A.N., *Svoistva i osobennosti pererabotki khimicheskikh volokon* (Properties and Features of Chemical Fiber Processing), Moscow: Khimiya, 1975.
4. Stepanova, T.Y., *Emul'sirovanie kak sposob modifikatsii svoistv poverkhnosti tekstil'nykh volokon* (Emulsification as a Method of Modifying the Properties of the Surface of Textile Fibers), Ivanovo: Ivanovo Gos. Univ. Khim. Tekhnol., 2011.
5. Stribeck, R., The main characteristics of plain bearings and roller, *J. Assoc. German Eng.,* 1902, vol. 46, pp. 1341–1348; *J. Assoc. German Eng.,* 1902, vol. 46, pp. 1432–1438; *J. Assoc. German Eng.,* 1902, vol. 46, pp. 1463–1470.
6. Sakevich, V.N. and Poskannaya, E.S., The effect of greasing fibers with fat-free emulsifier on the quality indicators of artificial fur, *Vestn. Viteb. Tekhnol. Univ.,* 2016, no. 1 (30), pp. 99–104.
7. *GOST* (State Standard) *26666.0–85: Artificial knitted fur. Acceptance rules and sampling method,* 1987.
8. *GOST* (State Standard) *4.80–82: A system of product quality indicators. Artificial knitted fur. Nomenclature of indicators,* 1984.
9. *GOST* (State Standard) *28367–94: Artificial knitted fur. General technical conditions,* 2004.
10. *GOST* (State Standard) *3815.1–93: Pile materials. Method for determining the surface density of the pile cover,* 1993.
11. Tolkach, A.P., Sakevich, V.N., and Poskannay, E.S., Lubricant IS-2, TU BY 100006975.024-2016, 2017.
12. *GOST* (State Standard) *26666.3–85: Artificial knitted fur. Method for determining the mass of loosely bonded fibers,* 1987.
13. *GOST* (State Standard) *29104.20–91: Technical fabrics. Method for determining the specific surface electrical resistance,* 1991.
14. *GOST* (State Standard) *21516–76: Artificial fur made of chemical fibers. A method for modeling wear and assessing wear resistance,* 1978.

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SPELL: 1. emulsol