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INFLUENCE OF POLYSULFONAMIDE TANLON FIBER ON RESISTANCE INDICATOR OF POLYTHETRAFLUORETHYLENE

The article considers the effect of Tanlon T700 polysulfonamide fiber on the wear resistance of polytetrafluoroethylene under conditions of friction without lubrication. It is established that the introduction of the filler leads to an intensive reduction in wear of the original polymer (486-1215 times), reaching a minimum at a fiber content of 15 mass.%. These results are due to the fact that in the process of friction of the developed polymer composite materials a transfer film is formed on the counterbody: the wear products are fixed in the micro-irregularities of the counterbody; as a result its roughness is reduced. With regard to the coefficient of friction, it was found that the introduction of polysulfonamide fiber reduces this idicator by 15%, reaching minimum values at a filler content of 5-15 mass.%. Further increase in the fiber content (up to 35 mass.%) leads to a sharp increase in the coefficient of friction, due to the high frictional characteristics of the filler. It is determined that the effective content of filler in the polymer matrix is 15 mass.%. Consequently, this composite was recommended for the manufacture of plain bearings of friction units as a coating for rollers of the roller conveyor of the extrusion line of aluminum profile.

Key words*: polytetrafluoroethylene, polysulfonamide fiber, intensity of linear wear, organoplastic, coefficient of friction, without lubrication*

Introduction. Today it is impossible to imagine the development of society without the use of agricultural, textile and automotive machinery. Reliability, durability and efficiency of it directly depends on the operation of tribological units [1]. The maintenance of the machinery equipped with serial metal parts, in turn, requires significant economic resources connected with their insufficient resistance to fatigue, erosion and corrosion, aging. The use of polymer materials of tribotechnical purpose allows to solve this problem. Thus, the use of polymer materials allows to obtain parts (plain bearings, gears, etc.) with such high technical characteristics like environmental friendliness in operation, chemical and thermal resistance, lightness, low coefficient of friction and thermal linear expansion, corrosion resistance and resistance to many aggressive environments or influence of various loadings, stability of work at the increased indicators of humidity and temperatures [2].

Problem statement. One of the promising thermoplastic polymers is polytetrafluoroethylene (PTFE) due to its low coefficient of friction, wide range of operating temperatures (from 73 to 523 K), chemical inertness and the ability to work stably without of lubricants. However, its use in heavily loaded tribological units is constrained by low wear resistance and fluidity. The use of fibers (basalt, carbon and organic) is a promising way to improve the wear resistance of PTFE. In view of the above, currently a significant part of materials scientists are researching the development of new compositions of polymer composite materials (PCM) based on polytetrafluoroethylene in order to improve its performance characteristics [3, 4].

Purpose of the work: the study of tribological properties of polymer composite materials based on polytetrafluoroethylene reinforced with Tanlon T700 discrete organic fiber.

Objects and methods of research. Polytetrafluoroethylene (GOST 10007-80) was chosen for polymer composite materials. It is white powder with a bulk density of 0,2-0,3 g/cm^3 that is intended for the manufacture of products by direct pressing or sintering. Polysulfonamide fiber Tanlon T700 (manufactured by «Shanghai Tanlon Fiber Co.» China) was used as a filler. This fiber is characterized by such high technical properties as modulus of elasticity (7450 MPa), elongation at break (20-25%), long-term operating temperature (523 K). The samples with different ratios of components (5-35 mass.%) were prepared by compression molding to determine the effective content of the filler [5].

Before the start of tribological studies each sample was tested in working mode until full contact with the counterbody. The study of the tribological properties of the developed composites was carried out in the friction mode without lubrication on a reciprocating machine at a load of 1,91 MPa, a sliding speed of 0,5 m/s. The friction path and the experiment time were 1000 m and 3600 s, respectively. Samples of the compositions were made of cylindrical shape Ø = 10, h = 15 mm, steel 38H2MYUA (45-48 HRC, R_a = 0,16-0,32 μm) was used as a counterbody [6].

One of the common counterbodies in the friction units is cast iron, so, taking into account the above, PTFE and composite with an effective filler content (15 mass.%) were tested in the mode of friction without lubrication on reciprocating motion machine. SCH20 cast iron (R_a = 0,35-0.60 μm) was used as a counterbody. The sample was under the load of 0,64 MPa, the sliding speed was 0,98 m/s. The friction path and the experiment time were 1767 m and 1800 s, respectively.

The wear of the samples was determined by the weight method on VLR-200 analytical scales (GOST 24104-80) with an accuracy of 0,0001 g. The intensity of linear wear I_h was taken as the main engineering characteristic of the wear process:

$$I_h = \frac{\lambda}{\rho_T} \cdot \frac{dG}{A_a \cdot dL_T},$$

where G is the value of mass wear; ρ_T is experimental (hydrostatic) density of the wear material; A_a is nominal contact area; L_T is friction path.

The obtained results were processed using the methods of mathematical statistics.

The surface roughness of the rod «before» and «after» the experiments was determined using 252 profilograph-profilometer. The study of the friction surface of the developed organoplastics was performed on «Hitachi SU1510» scanning electron microscope.

Discussion of the results. Analyzing the results of tribological researches (see Fig. 1), we can see that the reinforcement of PTFE with polysulfonamide fiber in the amount of 5-15 mass.% leads to a sharp decrease in linear wear by 486-1215 times reaching minimum values at a filler content of 15 mass.%.

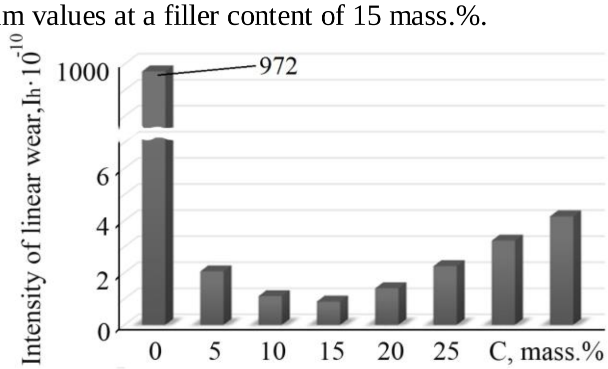
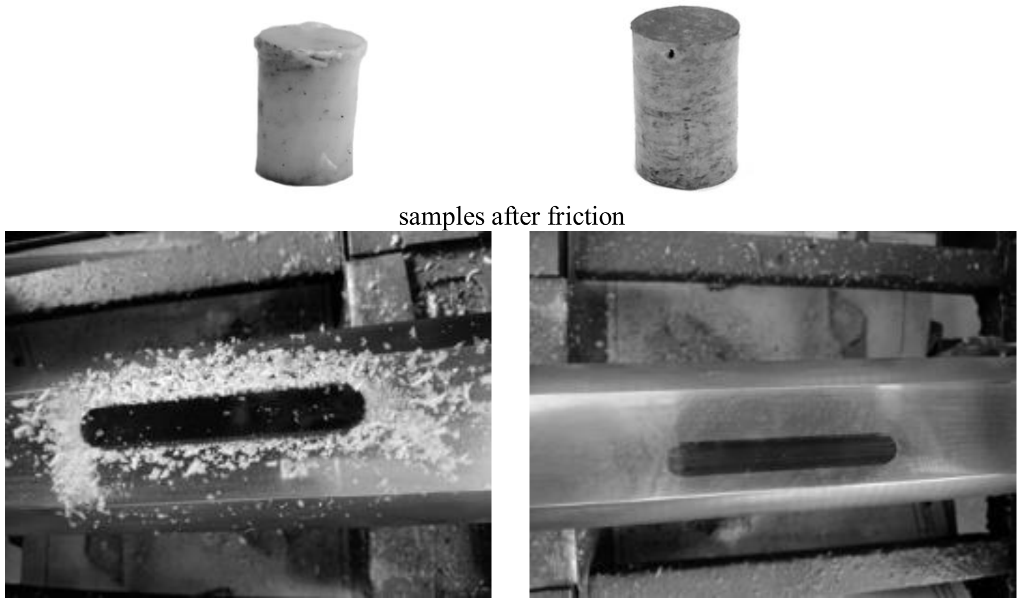


Fig. 1. The effect of Tanlon T700 organic fiber on the intensity of linear wear of polytetrafluoroethylene

Fig. 2 shows the wear products of the samples.



a *b*

Fig. 2. Wear products of pure polytetrafluoroethylene (*a*) and organoplastics (*b*) containing 15 mass.% of Tanlon T700 fiber

The obtained results indicate the ability of the developed PCM to resist the load in the process of interaction (see Fig. 2) with the steel counterbody (the composite sample is less deformed in the comparison to the base polymer). On the other hand, the increase in wear resistance of the initial polymer is due to the formation of a friction transfer film [7]: wear products formed by friction are fixed in the microroughnesses of the steel counterbody and reduce its roughness, and also block the share of the surface occupied by adhesive-active metal in relation to PCM [8]. A further increase in the filler content up to 35 mass.% leads to an increase in wear intensity that is connected with the weakening of the surface layer of the material that is probably due to the spread of cracks at the «binder-fiber» border, and as a result, subsequent pulling out the fiber from the polymer matrix [6].

With regard to the coefficient of friction (recorded at the time of failure), it was found that the introduction of Tanlon organic fiber in the amount of 5-15 mass.% reduces this indicator by 15% (see Fig. 3). Increasing the amount of filler in the binder up to 35 mass.% leads to its sharp growth due to the high coefficient of friction of the fiber [9].

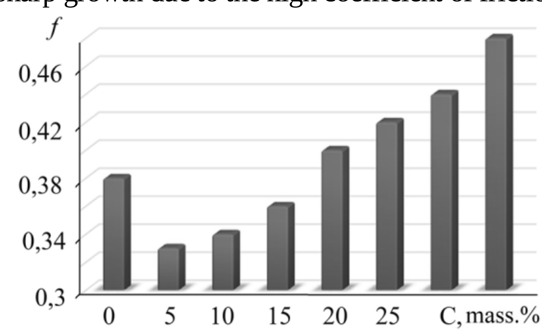


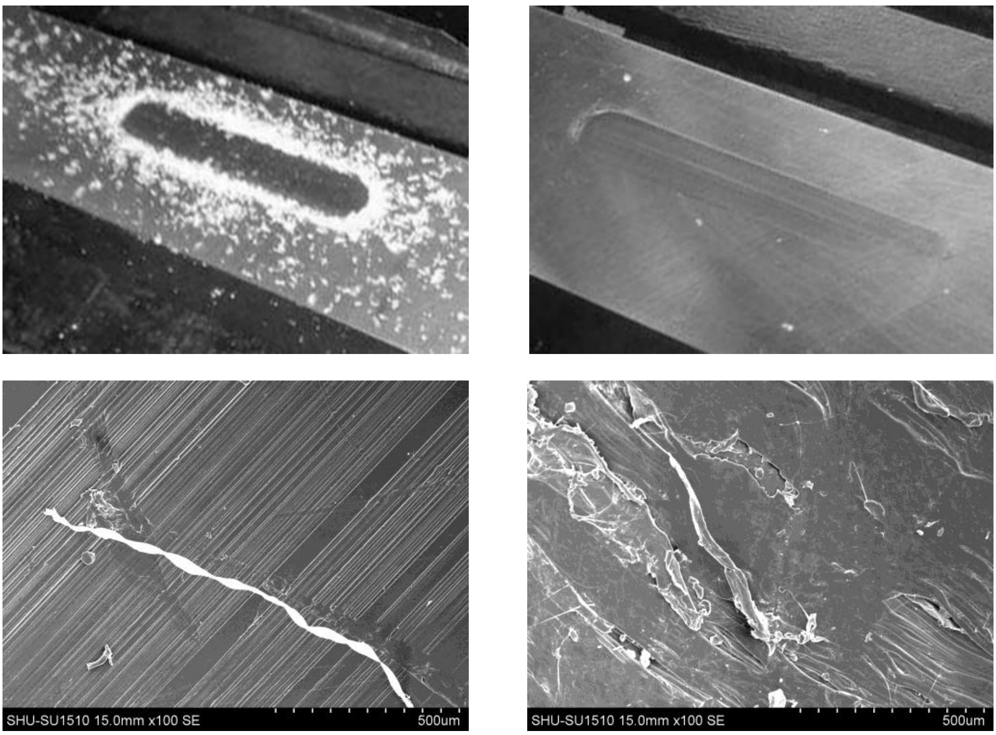
Fig. 3. Influence of Tanlon T700 organic fiber on the friction coefficient of polytetrafluoroethylene

It can be seen (table 1) from the data given in table 1that the introduction of organic fiber Tanlon T700 leads to a decrease in the coefficient of friction and the intensity of linear wear of PTFE by 1,13 and 73 times, respectively. As in the case of the steel counterbody, a transfer film is also formed; that reduces the roughness of the rod by 0,048 μm (Fig. 4).

Table 1

Tribotechnical characteristics of polytetrafluoroethylene and composite

Indicator	Fiber content, mass.%	
	0	15
Coefficient of friction, *f*	0,83	0,73
Intensity of linear wear $I_h \times 10^{-9}$, m/m	659,0	8,96
Roughness of a rod «before» work, R_a, μm	0,516	0,406
Roughness of a rod «after» work, R_a, μm,	0,482	0,358



a *b*

Fig. 4. The surface of the counterbody and the sample after friction of polytetrafluoroethylene (*a*) and composite (*b*) based on it, containing 15 mass.% of the fiber

Conclusion. Analysis of the results of tribological researches of the developed PCM showed that the use of polysulfonamide fiber Tanlon T700 as a filler for polytetrafluoroethylene is a promising way to improve its performance, because of the increase in wear resistance by 1215 times. Organoplastic with an effective filler content (15 mass.%) was recommended for the manufacture of plain friction bearings as a coating for rollers of the roller conveyor of the extrusion line of aluminum profile.

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ВПЛИВ ПОЛІСУЛЬФОНАМІДНОГО ВОЛОКНА ТАНЛОН НА ПОКАЗНИК ЗНОСОСТІЙКОСТІ ПОЛІТЕТРАФТОРЕТИЛЕНУ

Політетрафторетилен є одним із перспективних полімерів триботехнічного призначення завдяки низькому коефіцієнту тертя, широкому інтервалу температур експлуатації (від 73 до 523 К), хімічної інертності та здатності до стабільної роботи в умовах відсутності мастил. Проте його використання у важнонавантажених трибологічних з'єднаннях стримують низькі показники зносостійкості та плинності. Використання волокон дозволяє вирішити дану проблему. У статті розглянуто вплив полісульфонамідного волокна марки Танлон Т700 на показник зносостійкості політетрафторетилену в умовах тертя без змащення при зворотно-поступальному русі. Встановлено, що введення наповнювача призводить до інтенсивного зменшення зношування вихідного полімеру (в 486-1215 разів), сягає мінімуму при вмісті волокна 15 мас.%. Такі результати обумовлені тим, що у процесі тертя розроблених полімерних композиційних матеріалів на контртілі утворюється плівка переносу: продукти зношування закріплюються в мікронерівностях контртіла, внаслідок чого знижують його шорсткість. Щодо коефіцієнту тертя, то виявлено, що введення полісульфонамідного волокна зменшує даний показник на 15 %, сягаючи мінімальних значень при вмісті наповнювача 5-15 мас.%. Подальше збільшення волокна (до 35 мас.%) призводить до різкого зростання коефіцієнту тертя, що обумовлено високими фрикційними характеристиками наповнювача. Визначено, що ефективний вміст наповнювача в полімерній матриці складає 15 мас.%. З огляду на вищезазначене, даний композит був рекомендований для виготовлення підшипників ковзання вузлів тертя в якості покриття роликів рольгангу лінії екструзії алюмінієвого профілю.

Ключові слова: політетрафторетилен, полісульфонамідне волокно, інтенсивність лінійного зношування, органопластик, коефіцієнт тертя, без змащення

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