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MODERN SELF-LUBRICATING COMPOSITE MATERIALS BASED ON POLYTETRAFLUORETHYLIRENE

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The results of investigation of physical-mechanical and tribological properties of polytetrafluorethylene (PTFE), composites filled with small (5-10 wt %) amounts of nanoceramic and nano metallic powders are presented. BN, B_4C and Co were used as nanopowder fillers. At compression by 30 *MPa* pressure they are subjected to 10 mass % filled composites on the base of B_4C and Co is equal correspondingly to 3,20 and 2,46% that 6,5 and 8,5 times exceeds the index of unfilled polymer. The developed composites have 2...4 times better wear-resistance than that of the commercial "Superfluvis" on the base of PTFE.

***Keywords**:* self-lubricating composite materials, friction intensity, polytetrafluorethylene, nanopowder, polymer.

Introduction. Recently, in the context of the rapid progress of nanotechnology, the improvement of physical-mechanical and tribological properties of polymer composites by introduction of small amounts of various nanopowders into the compositions has attracted considerable attention. It is revealed that, for instance, by introducing 2…5 wt.% grains of nitrides/oxides of transition metals (grain size: 4…100 nm) into polytetrafluorethylene (PTFE), it is possible to produce such a polymer system that would have improved strength and tribological properties. It has turned out that nanoparticles are capable of forming cluster-type assembles in the material bulk, which affect the mechanism of polymer crystallization and eventually the improvement of wear resistance [1].

Basic part. Sample composites were made on the base of PTFE by introducing nanopowders by the technology described in [2]. Then, the physical-mechanical and tribological properties of these materials were studied. They were studied by the method of determination of frictional thermal stability by using the friction machine IM-58, where the overlap factor of friction faces of the frictional couple K was equal to one. Along with the developed composites, the subject of our investigation was the commercial material "superfluvis" developed on the basis of PTFE in Belarus as one of the best materials of the kind. It was used in the rubbing parts of the compressor designed in Georgia.

The results of the investigation of the physical-mechanical properties are listed in the table below.

Table

Physical-mechanical properties of the composites based on PTFE

Composite composition, %	Specific weight, *kg/m*^{3}	Compression deformation under 30 *MPa*, %	Brinell hardness, BH, *MPa*	Water absorption, %
1. Plain PTFE	2204	21.00	35	0.00
2. PTFE + 5 wt.% Co	2254	6.25	40	0.01
3. PTFE + 10 wt.% Co	2437	2.46	51	0.01
4. PTFE + 5 wt.% B_4C	2274	4.40	41	0.00
5. PTFE +10 wt.% B_4C	2392	3.20	50	0.00
6. PTFE + 5 wt.% BN	2237	5.4	39	0.00
7. "Superfluvis"	2038	2.80	60	0.05

From the Table above, it is evident that the composite filled with 10 wt.% Co has the highest specific weight. It is hard and strong. Under 30 *MPa* pressure, it underwent only 2.46% deformation, and its strength made up 51 *MPa*. The mechanical indices of the test samples of all developed composites were improved as compared with the plain polymer; in the composites filled with 5 wt.% fillers – 2…3 times, while in the composites filled with 10 wt.% fillers – 3…5 times.

When studying the tribological parameters of plain PTFE under constant load (P=0.7 *MPa*), it turned out that, in spite of a low friction factor (0.15…0.18), the friction intensity was rather high, and it was within $130…730 \cdot 10^{-9}$. The introduction of small amounts of nanoporous nanosized powders into PTFE significantly improved the properties of the latter (Fig. 1). Particularly, the friction resistance increased by two and even three orders of magnitude (100…1.000 times) which confirms the efficiency of application of these fillers while developing the self-lubricating composites based on PTFE. All sample composites showed high wear resistance at low friction speed. Over the friction speed range of 0.125…0.250 *m/s*, their friction intensity was equal to $2.0…16 \cdot 10^{-9}$. At high speed, the pattern was different. At the speed of 1.88 *m/s*, the composite filled with 5 wt.% boron nitride surpassed the one filled with 5 wt.% B_4C. At high friction speed, the wear resistance of the composite with boron nitride was 2.5 times as much as that of the one with boron carbide and 3 times as much as that of the composite with cobalt.

The investigation results of the friction and wear of "superfluvis" are of special interest. The most interesting is the fact that this material turned out to be less wear resistant at low temperature than the developed composites. For instance, at the speed of 0.624 *m/s*, its wear resistance was lower by the factor of 2…12 than that of the developed composites. However, at high speed, this material turned out to be the most wear resistant.

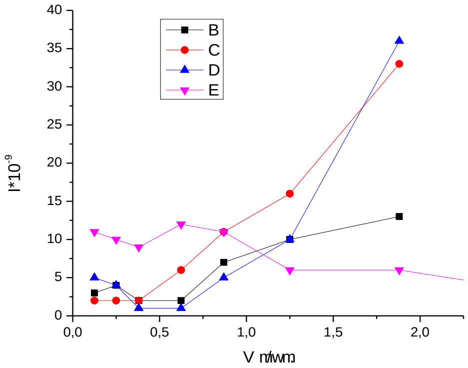

Fig. 1. Dependence of the composite friction intensity on the friction speed: B - 5 wt.% BN; C - 5 wt.% B_4C; D - 5 wt.% Co; E – "superfluvis"

Conclusions. Thus, we can infer that the developed composites have improved tribological properties as compared with plain PTFE. The introduction of small amounts of fillers increased their wear resistance 100…1.000 times. Their compression strength (developed deformation under 30 *MPa*) increased 3…8,5 times. This provides the basis for the production of high-temperature antifriction wear-resistant self-lubricating composites on the basis of the developed ones and for their prospective use in particular friction units of various devices, where the friction is dry and the lubrication of the rubbing parts is impossible or difficult.

Fig. 2. High-pressure water pump

Figure 2 shows a high-pressure water pump designed at Exergy, Ltd., Georgia. In the design of the gasket of its piston, the rings made of an antifriction self-lubricating composite based on PTFE developed by us was used.

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ԺԱՄԱՆԱԿԱԿԻՑ ԻՆՔՆԱՅՈՒՂՎՈՂ ԿՈՄՊՈԶԻՑԻՈՆ ՆՅՈՒԹԵՐ՝ ՊՈԼԻՏԵՏՐԱՖՏՈՐԷԹԻԼԵՆԻ ՀԻՄՔՈՎ

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Ներկայացված են պոլիտետրաֆտորէթիլենի (ՊՏՖԷ) հիմքով պատրաստված, փոքր քանակությամբ (5-10 զանգվածային %) նանոխեցե և նանոմետաղե փոշիներով լցոնված կոմպոզիտների ֆիզիկամեխանիկական և շփագիտական հատկությունների հետազոտությունների արդյունքները: Որպես լցանյութ օգտագործված են BN, B_4C, Co նյութերի նանոփոշիները: 30 *ՄՊա* ճնշումով սեղմելիս ամենափոքր դեֆորմացիան զարգանում է B_4C և Co-ի հիմքով պատրաստված 10 զանգվածային %-ով լցոնված կոմպոզիտներում, որը հավասար է համապատասխանաբար 3,20 և 2,46%, ինչը 6,5 և 8,5 անգամ գերազանցում է չլցոնված պոլիմերի ցուցանիշը: Մշակված կոմպոզիտներում փոքր արագությունների դեպքում ստացվել է 2...4 անգամ բարելավված մաշակայունություն՝ չոր շփման համեմատ, քան ՊՏՖԷ-ի հիմքով պատրաստված արդյունաբերական «սուպերֆլուվիսա» կոմպոզիտի դեպքում:

Առանցքային բառեր. ինքնայուղվող կոմպոզիցիոն նյութեր, մաշման ուժգնություն, պոլիտետրաֆտորէթիլեն, նանոփոշի, պոլիմեր:

СОВРЕМЕННЫЕ САМОСМАЗЫВАЮЩИЕСЯ КОМПОЗИЦИОННЫЕ МАТЕРИАЛЫ НА ОСНОВЕ ПОЛИТЕТРАФТОРЭТИЛЕНА

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Представлены результаты исследований физико-механических и трибологических свойств композитов на основе политетрафторэтилена (ПТФЭ), наполненных малым количеством (5…10 *мас. %*) нанокерамических и нанометаллических порошков. В качестве наполнителей были применены нанопорошки BN, B_4C, Co. При сжатии давлением 30 *МПа* наиболее малая деформация развивается у 10 *мас. %* наполненных композитов на основе B_4C и Co, которая равна соответственно 3,20 и 2,46%, что в 6,5 и 8,5 раза превосходит показатель ненаполненного полимера. У разработанных композитов в 2...4 раза улучшенная износостойкость относительно сухого трения на низких скоростях, чем у промышленного композита “Суперфлувиса” на основе ПТФЭ.

Ключевые слова: самосмазывающиеся композиционные материалы, интенсивность износа, политетрафторэтилен, нанопорошок, полимер.