Таблица 1

Оптимальные составы разработанных композиционных химических реагентов типа КХР-1

Ингредиенты		КХР-1-1	КХР-1-2	КХР-1-3	КХР-1-4	КХР-1-5
		Содержание ингредиентов, масс.ч.				
Состав КПГС	Госсиполовая смола (ГС)	65,24	63,99	62,54	61,16	59,74
	Каустическая сода(NaOH)	13,04	12,69	12,40	12,12	11,84
	Кальцинированная сода (Na_2CO_3)	13,04	12,69	12,40	12,12	11,84
	Алюмак	0,64	0,63	0,61	0,60	0,58
Общая сумма КПГС		92	90	88	86	84
КМЦ		8,0	10,0	12,0	14,0	16,0

Таблица 2

Оптимальные составы разработанных композиционных химических реагентов типа КХР-2

Ингредиенты		КХР-2-1	КХР-2-2	КХР-2-3	КХР-2-4	КХР-2-5
		Содержание ингредиентов, масс.ч.				
состав КХР-1	Госсиполовая смола (ГС)	65,24	63,99	62,59	61,16	59,74
	Каустическая сода (NaOH)	13,04	12,69	12,40	12,12	11,84
	Кальцинированная сода (Na_2CO_3)	13,04	12,64	12,40	12,12	11,84
	Алюмак	0,64	0,63	0,61	0,60	0,58
	КМЦ	8,0	10,0	12,0	14,0	16,0
Общая сумма (КХР-1)		100	100	100	100	100
Недопал ($CaCO^3$, Na_2O)		20,0	25,0	30,0	35,0	40,0

Полученный реагент испытан нами в качестве ингибирующего компонента при добавке его в обычно используемые промывочные агенты, применяемые для бурения скважин на нефтегазовых месторождениях Узбекистана при происхождении неустойчивых терригенных отложений представленных глинами и глинистыми породами.

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UDK 621.833; 669.056.9: 629.118.6

APPLICATION OF NANOSTRUCTURED MATERIALS IN PLAIN BEARINGS

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Sliding friction pairs are widely used in mechanical engineering, which makes it possible to increase the rigidity of friction parts, reduce their overall dimensions, improve heat dissipation and reduce noise and vibrations. At the same time, there is a possibility of situations in which there is jamming of friction surfaces. This is a critical factor when using plain bearings in precision equipment and mechatronic systems [1-3].

In some cases, high rigidity and operating properties can be achieved by using plain bearings with composite antifriction coatings, in particular, containing nanoparticles. Nanoparticles can be used either as a part of solid lubricants or in antifriction coatings [3].

The aim of the work is to develop a rational design and manufacturing technology for sliding friction pairs for precision friction units.

In sliding friction pairs based on modern, including nanostructured composite materials, the diameters of sliding bearings can be large enough, which allows achieving the required ultra-high precision of mechanical processing and nanometric roughness of the treated surface.

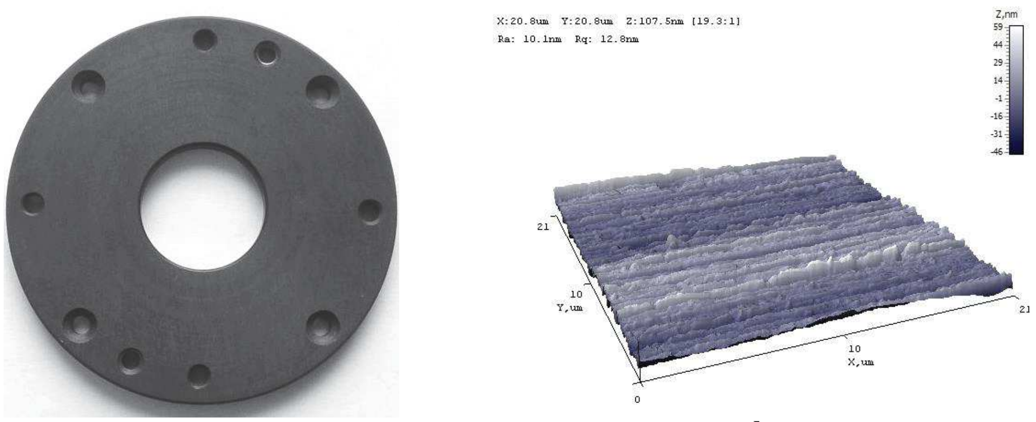
Our approach is based on the use of coatings made of composite antifriction materials modified with nanostructured materials. At the same time, the use of aluminum alloys in the manufacture of electric spindle shafts is of considerable interest from the standpoint of improving their dynamic properties, including increasing the own frequencies of mechanical vibrations to prevent resonances. In addition, heat exchange is improved when using forced cooling of the main components of the electric spindle. In this case, the working surfaces of the sliding bearings can be developed directly on the electric spindle shaft. Composite antifriction coatings containing nanoscale components can be formed on the shaft aiming the increase the wear resistance of the friction unit.

Different methods for forming antifriction coatings including vacuum spraying or sol-gel technology are known. In general, coating thickness is usually insignificant (does not exceed 0.01 of the thickness of the ceramic element) when implementing vacuum spraying resulting in the layer "pushing" at significant pressures [2].

For the research, a technological scheme was proposed in which a coating with a thickness of 90-110 microns was formed on samples made of an aluminum alloy disk by anode-cathode microarc oxidation (MAO), and which serves as a substrate. This thickness of the MAO-coating eliminates the "pushing" of the support surface and the occurrence of jamming when abrasive particles appear in the gap between friction surfaces.

Then the surface of the MAO-coating was prepared for subsequent processing, which included surface cladding of the coating with an antifriction material, for example, a nanostructured composite based on a copper alloy.

Studies of the implementation results of the above scheme have shown that even after mechanical superfine polishing of the MAO-coating surface (Fig. 1a), the topography of this surface remains sufficiently developed (Fig. 1b). Moreover, the analysis of microstructures indicates the presence of a significant number of pores and cracks.



a **b**

Fig. 1 – A sample with a mechanically polished of the MAO-coating surface (a) and the topography of this surface (b)

The analysis showed that the MAO-coating, which has a composition close to technical ceramics, is characterized by the presence of significantly greater macro - and microporosity, compared to traditional pressed ceramics. Moreover, this microporosity is unevenly distributed over the thickness of the MAO-coating. In the layer adjacent to the base boundary, there may also be significant macropores that contribute to the detachment of the MAO-coating from the base during stretching, compression, bending, and also, in some cases, due to internal stresses at the interface even in the absence of external loads.

On the other hand, the developed surface topography helps to increase the adhesion of the anti-friction cladded coating with substrate. However, the presence of cracks on the layers' boundary can have a significant impact on reducing the fatigue properties of parts during cyclic loading. Therefore, the MAO-coating was subjected to mechanical removal of a layer with a thickness of about 20 microns to remove the outer defective layer.

The structural-phase analysis shows the presence of the phases α-Al_2O_3 and γ-Al_2O_3 in the composition of the MAO-coating, which differ significantly in properties, as well as the aluminum alloy of the base, which can have a certain effect on the mechanical properties of the part and which should be taken into account when determining the technological parameters of processing.

To increase the antifriction properties of the ceramic coating (the main component of the coating is Al_2O_3 ceramics), it is advisable to introduce an additional antifriction material into the surface layer. Such materials can be nanostructured copper or its alloys.

We proposed to apply a nanostructured coating based on copper alloys by cladding with a flexible tool followed by exposure to a laser beam. Since copper and its alloys are characterized by high reflectivity, a layer of light-absorbing material containing nanoparticles was applied to the clad layer.

With the correct selection of the light-absorbing coating material, it is possible to ensure not only better absorption of the laser beam energy, but also to modify with nanoparticles the material of the antifriction cladding coating. During the experiments, the energy density of the laser beam has been changed, and the effect of laser treatment on the quality and composition of the coating are evaluated. During the implementation of proposed scheme, the determination of rational thicknesses of the MAO-coating and the cladding layer of the antifriction material, as well as the modes of laser treatment of the coating surface without melting the adjacent bulk material is crucial.

It is established from the carried-out research that the following technological scheme is one of the promising ways of forming antifriction coatings for precision friction units.

Initially, a coating with a thickness of 90-110 microns is formed on the working surfaces of sliding friction pairs by the method of anode-cathode microarc oxidation (MAO). This coating serves as a substrate and eliminates the "pushing" of the support surface. After the formation of the coating the defective layer (approximately 20 microns) is removed mechanically.

After that, the surface cladding of the MAO-coating is performed with an antifriction material (a nanostructured composite based on a copper alloy), which fills in the cavities, pores and cracks on its surface during the treatment. Finally, the coating structure is formed after laser treatment of the MAO-coating surface to ensure high adhesive properties of the antifriction coating.

Conclusions. The research results have shown that the use of combined technologies for the formation of sliding bearings on shafts made of aluminum alloys is promising. By selecting the modes of MAO processing, the compositions of the materials of the cladding and light-absorbing coating, the modification of the antifriction material, including nanoparticles, can be carried out. As a result, it becomes possible to create a precision friction unit with a qualitatively new set of service properties, including dynamic and characteristics, as well as meeting the requirements for rigidity.

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СТРУКТУРА ПОРИСТЫХ ПРОНИЦАЕМЫХ МАТЕРИАЛОВ ИЗ МЕТАЛЛИЧЕСКИХ ПОРОШКОВ

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Введение. Интенсивное развитие энергетики, промышленности и транспорта неизбежно вызывает рост потребления углеводородного топлива, что, в свою очередь, увеличивает количество продуктов его сгорания, выбрасываемых в атмосферу. Загрязнители воздуха представляют собой сложную смесь газообразных и твердых частиц. К основным газам, выбрасываемым с продуктами сжигания топлива, обычно относятся оксиды азота, угарный и углекислый газы, пары альдегидов, формальдегидов, бензапиренов и других ароматических соединений; в нефтеперерабатывающей промышленности – диоксид серы, метан, оксиды и производные минеральных включений. Токсичность выбрасываемых в окружающую воздушную среду газов зависит, главным образом, от качества, сорта и вида сжигаемого углеводородного топлива, условий организации процесса его сгорания, технического состояния тепловых двигателей и топливосжигающих установок. На сегодняшний день выделение диоксида углерода из топочных газов ТЭЦ зачастую проводится методом сорбции этанолом. Этот процесс является довольно дорогостоящим. Альтернативой сорбционным методам может быть метод мембранного газоразделения с использованием пористых проницаемых материалов (ППМ), обладающий повышенными экологическими и ресурсосберегающими характеристиками. Поэтому разработка новых фильтров на основе ППМ с улучшенными газоразделительными свойствами является актуальной задачей для вышеуказанного процесса [*D. DeMeisInterceram 2018 V. 67 P. 16–21*].

Пористые проницаемые материалы на металлической основе и/или из керамических материалов, получаемые методом порошковой металлургии с различными диапазонами пор, благодаря сформированным при получении материалов каналам используются в различных отраслях промышленности в качестве фильтрующих материалов как для жидкостей, так и для смесей газов. Одним