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HYDROGEN WEAR RESISTANCE UNDER THE METAL-POLYMER FRICTION PAIRS OPERATION

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Summary*. The results of studies of labyrinth seals made of composite materials on the basis of aromatic polyamide phenylon reinforced by copper-carbon fiber are presented. It is shown that in this case a selective transfer with friction is realized, the possibility of displacing the surface of the metal decreases, the wear resistance of the support joints and the ability to seal up are increased.*

Key words*: carbon fiber, copper carbon fiber, phenylon C-2, wear resistance, hydrogen deterioration, flooding of metal surface.*

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Introduction. Economic and efficient application of domestic machines, machines of chemical treatment in particular, depends greatly on the operation of sealing elements. Seals are the most wearable parts of the chemical treatment machines.

The main types of sealing devices in the chemical treatment machines are the labyrinth seals and glands according to GOST 8752-79. Reliable coupling tightness must be obtained thanks to the coupling of liquid in the labyrinth seal and because of the preliminary deformation (tension) of the gland seal being mounted on the shaft (further being supported by the band spring). But being affected by many factors, the intensive wearing of the labyrinth seals and the gland seal jaw takes place and ability to seal is lost. It results in the leakage of the aggressive liquids (perchlorine-ethyl, etc.), its contact with the parts of the bearing support, corrosion of the latter and the appearance of the solvent steam in the air of the working area. Besides, as the result of wearing the effective time of the machine operation is decreased, resulting in great expenditures for repair, recovering and replacement of wearable parts, contamination of the working area air, causing the disadvantageous effect on the human health.

Besides seals, the part coupled with them, the bearing shaft support is under wear as well. Great amount of moisture and other hydrogen mediums contribute to the state of hydrogen deterioration of the steel shaft.

Hydrogen deterioration is specified by high local concentration of hydrogen in the surface layer of the metal, caused by the high temperature and stress gradients, which results in the special nature of the micro cracks growth, contributing to the total fracture of the metal layer [1].

Critical amount of hydrogen, accumulated in the surface layers of the metal, causing their fracture, is specified not only by the «tribotechnical» hydrogen formed during friction, but by the hydrogen being in the parts material as well while their manufacturing, that is, «metallurgical» and «technological» hydrogen.

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The surfaces of the steel parts tend to accumulate hydrogen under mechanical, thermal and other types of treatment. Hydrogenation during the technological treatment results in different structural changes in the alloys. Thus, the investigations [3] have revealed the formation of pores in the metal structure during its thermal treatment, which can be caused by the process of the diffusion-movable hydrogen redistribution.

The process of hydrogen redistribution in the metal is highly influenced by its initial structure and chemical composition. Different available chemical elements change the structure of the crystal lattice of the basic metal: some being available (copper) make the hydrogen diffusion difficult, the others (nickel, manganese) contribute to the high hydrogen penetration.

Nowadays polymer composite materials are widely used in the machine friction units and technological equipment. In most cases they are used as the seal elements being connected with the shaft-bush. Analysis of the literature shows, that the metal, being in interrelation with the polymer, tends to hydrogen deterioration. As the result of different physical-chemical processes in the friction area a great amount of diffusion-movable hydrogen is formed. Its appearance is caused by the destruction of hydrogen compounds under friction interaction with metal. As it is known, all metals and alloys being used in mechanical engineering are not thermo-dynamically resistant to corrosion in the systems being able to transfer into the ionic state [2]. The stress and temperature gradients, caused by the friction, create the hydrophilic area on the metal surface, being able to adsorb hydrogen. The increase of hydrogen concentration in the surface layers results in the micro cracks initiation, which then, being caused by the effect of «pumping», becomes greater and the dramatic fracture of the metal takes place.

Because of that there is a need to prevent the metal hydration. There are some methods nowadays being the means of fighting with this phenomenon, they are: plating of the metal surface with the protective coatings possessing low hydrogen penetration, polarization displacement on the contact; introduction of strong carbide-forming elements into the steel composition, etc. Some investigations propose to use the polymers, containing copper additions as those, being able to realize the selective transfer regime.

The hydrogen deterioration is a complex process and for its investigation it is necessary to create special methods and investigation equipment. With this purpose the complex of devices, consisting of the multidimensional friction machine, gas analyzer, measuring and recording devices, have been developed.

Raising of wear resistance of the coupling shaft – gland seal and protection of the shaft from the hydrogen deterioration can be reached by the following ways: special thermal treatment of the shaft in the metal-plating mediums; finishing antifriction abrasive-free treatment of the shaft surface; application of the apilamine solutions for anti-friction coatings on the working surfaces of glands, etc.

Beside raising the wear resistance of the coupling gland seal-shaft, it is necessary to analyse and to increase, if possible, the wear resistance and sealing ability of the labyrinth seals.

For production of this seal the composite material «phenylon» of the aromatic polyamide class is used. The test investigations testified this material to be able to form a great amount of the diffusion-movable hydrogen during friction.

Investigated object and methods of investigation. The aromatic polyamide phenylon C-2 – based composites have been developed, the properties of which are presented on Table 1. They are reinforced by the copper-carbon fiber being in the dry state in the rotating electromagnetic field [5].

Table 1

Phenylon C-2 properties (ТУ6-05-226-72)

Appearance	*Bulk density, gr/cm²*	*Humidity %*	*Specific viscosity of 0,5 – solution*	*Glass-transition temperature, K*
Fine-dispersed white powder	0,33	0,40	1,2	553

As the investigations carried out earlier testify, taking advantage of the method of mixing the fiber and the polymer, using the non-equilibrium ferromagnetic particles (FP) in the rotating electro-magnetic field, homogenous uniform mixture is obtained, in which the carbon fibers are distributed in a random way, which provides obtaining the reinforced plastic materials with high and stable properties [6]. Besides, using the random mode of reinforcement by the discrete fiber makes possible to produce items of complex configuration almost without further mechanical working.

The FP from the produced mixtures were extracted, using the magnetic separation, and the mixtures were retreated into the finished products, using the method of compressor pressing at the temperature *598 K* and the pressure *50 MPa*.

For the obtained phenylon compositions with the copper-carbon fibre additions the estimation of their efficiency according to the hydrogen formation intensity parameters in the gas phase of the friction machine chamber was performed, as well as the wear intensity of the friction pair phenylon-steel 45 (surface rigidity being *0,32 mkm*, hardness *45 – 48 HRC*). The testings of composited materials, obtained by this method, were performed on the laboratory installation MTM – 2 (specific pressure – *2,5 MPa*, sliding rate – *2 m/sec*, testing time – *3600 sec*). With this purpose the jaws made of the composite material of such concentration of the copper-carbon fiber, were used: *0, 20, 30, 40, 50% mas*. The results of testings are presented in Fig. 1.

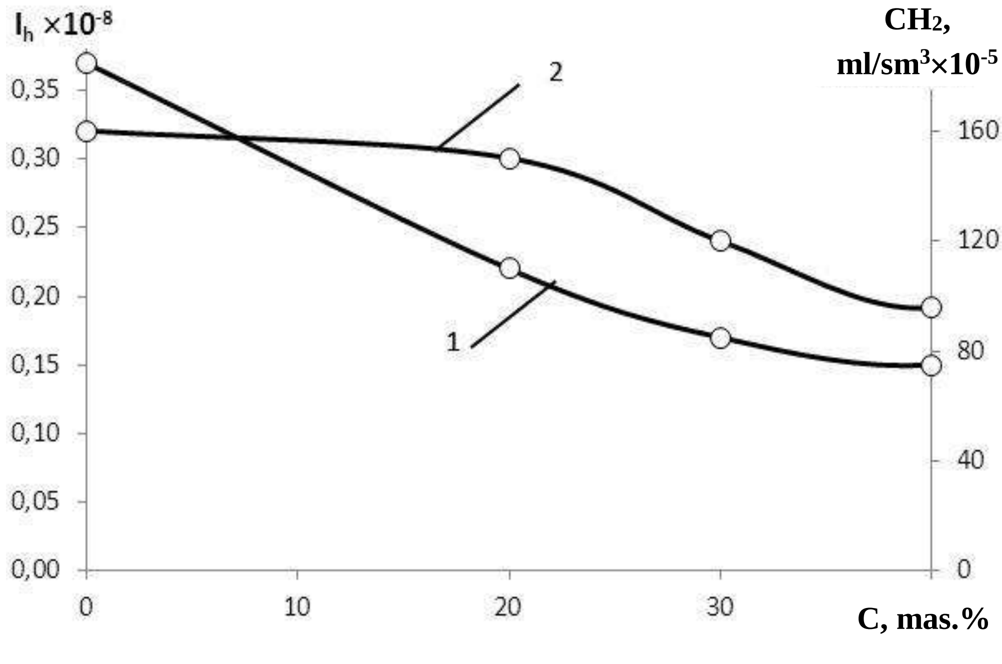

Figure 1. Results of the experiment for finding the maximum concentration of the copper – carbon fibre in the material «phenylon». 1 – graph of the hydrogen formation intensity in the gas phase of the friction machine chamber; 2 – graph of the wear intensity of the friction pair composite – steel 45

Results of the experiment and discussions. As it is seen from the testing results the greatest wear resistance is possessed by the composite of 40% content filler, it being the least capable to form free hydrogen in the friction area. For the BP containing *30 – 50% mas* Cu-BB the mode of selective transfer is realized in steel under their wearing. The metallography investigations of counter-specimens testified, that the copper film, providing the protection of the steel parts surfaces from the hydrogen surging, is formed on their surface. Such BP are the least capable to form diffusion – movable hydrogen in the friction area, that is, the greatest ability to calm the hydrogen surging, which is one of the factors specifying the durability of the movable joining parts. Thus, the composite polymer materials, reinforced by the copper – carbon fiber in joints, make possible to realize the selective transfer during friction, to decrease the possibility of flooding the metal surfaces, being in the friction interaction, and to increase the wear resistance of the friction joint. The friction coefficient was found to be decreased, which results in the decrease of power expenditures during operation of machines.

Conclusions. Stand testings of the complex measures for raising the wear resistance of the bearing joint support of the machine of chemical treatment testified the raise of the coupled pair wear resistance, decrease of the power expenditures and the raise of the sealing ability of the gland and the labyrinth seal, which resulted in the decrease of the diluent steam leakage into the working area air.

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ВОДНЕВЕ ЗНОШУВАННЯ І БОРОТЬБА З НИМ ПРИ ЕКСПЛУАТАЦІЇ МЕТАЛОПОЛІМЕРНИХ ПАР ТЕРТЯ

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Резюме. *Представлено результати досліджень лабіринтного ущільнення, виготовленого з композиційних матеріалів на основі ароматичного поліаміду фенілон, армованого мідьвмісним вуглецевим волокном за допомогою нерівноосних феромагнітних часток в обертальному електромагнітному полі. Проведено широкий комплекс досліджень із вивчення оптимальної концентрації армуючого наповнювача. Для цього використано колодки з композиційного матеріалу фенілон С-2, армованого мідьвмісним вуглецевим волокном: 0, 20, 30, 40, 50% мас та оцінено їх ефективність за параметрами інтенсивності утворення водню в газовій фазі камери машини тертя й інтенсивності зношування пари тертя фенілон-сталь 45. У результаті випробувань виявлено, що найбільшу зносостійкість має композиція з 40% вмістом наповнювача, вона ж має найменшу здатність до утворення в зоні тертя вільного водню. При зношуванні по сталі армованих вуглепластиків, які містять 30 – 50% мас Cu-ВВ, реалізується режим вибіркового перенесення. Металографічні дослідження контрзразків показали, що на їх поверхні утворюється мідна плівка, яка забезпечує захист поверхонь сталевих деталей від водневого зносу. Відзначено зниження коефіцієнта тертя, що призводить до зниження енергетичних втрат при роботі машини. Таким чином, стендові випробування показали вибіркове перенесення при терті, зменшення можливості наводнювання поверхні металу, підвищення зносостійкості супряженої пари, зниження енергетичних витрат і підвищення ущільнюючої здатності манжетного та лабіринтного ущільнень, що призводить до зниження витоку пари розчинників у повітря робочої зони.*

Ключові слова: *вуглепластик, мідьвмісне вуглецеве волокно, фенілон С-2, зносостійкість, водневе зношування, наводнювання поверхні металу.*

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