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UDC 622.75:629.7

APPLICATION OF ANTI-FRICTION COMPOSITE MATERIALS FOR INCREASING THE DURABILITY AND TRIBOTECHNICAL PROPERTIES OF HYDRAULIC EQUIPMENT UNITS

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In conditions of limited financial and material resources, the problem of technical rearmament of agricultural production cannot be solved only by increasing the supply of new equipment. A significant role in this process is assigned to the reasonable use of the available fleet of machines, maintenance of its technical level with the help of qualified maintenance. The power hydraulic cylinder occupies a special place here. The experience of operating hydraulic machines has shown that the share of hydraulic cylinders accounts for 17...30% of failures of the entire hydraulic system. Some agricultural enterprises are forced to carry out repairs on their own. At the same time, due to the lack of experience, technology and equipment, the resource of repaired units often does not exceed 30–60% of new resources. Therefore, the development and implementation of a new repair technology, based on the use of polymer parts made of antifriction composites based on supramolecular polyethylene, abbreviated SVMPE, in the tribo connections of power hydraulic cylinders, will allow to reduce the cost and repair time, which is of significant importance [1, 2].

Hydraulic cylinders and other samples of modern agricultural machinery cannot do without friction units, which require low friction force and high abrasion resistance. In addition to seals and guide elements of hydraulic cylinders, such nodes include all kinds of sliding and rolling bearings, liners, bushings, hinged joints, gears, mechanism guides and many others. Antifriction alloys based on lead or tin, such as bronze, babbitt, etc., were previously used for the manufacture of such nodes. But these materials are expensive and do not always meet all the necessary operational and technological requirements. Therefore, there is a need for a wider selection of antifriction materials [1, 3]. For this purpose, polymers are attractive for several reasons: - easy (technological) processing, - low specific gravity, - high corrosion resistance [1, 2]. Currently, polymeric antifriction materials are made mainly on the basis of polyamides and carbochain polymers, fluoroplastics. Polyamides are thermoplastic polymers, have fairly high mechanical and technological properties and are used as bushings that guide and seal rings. Fluoroplastic is of great interest in the creation of anti-friction parts. It is chemically inert, unable to collect moisture, has high plasticity, low modulus of elasticity, and a very low coefficient of friction, as well as heat-resistant and thermoplastic [3].

Attrition is a complex multi-level process. The main initiator of wear is deformation of the material of the contacting surfaces under the action of contact stresses and temperatures. Thermoplastics (polyamides, polyolefins, fluoroplastics, polyacetals, polyimides, polyphenyl sulfides, polysulfones, polyether ketones) are used unfilled and in the form of a matrix of antifriction composite materials. Thermosetting polymers (epoxy and phenol-formaldehyde) are used exclusively in the form of a matrix of composite materials. Composite materials have the most favorable combination of antifriction, strength and technological properties [1-3]. Finely dispersed fillers that reduce the coefficient of friction of polymers include powders of graphite, molybdenum disulfide, bronze, some selenides and metal iodides. All these materials are good dry lubricants. The low coefficient of friction of these compounds is due to their layered structure and low bond energy between the layers. Under the influence of the load, the layers move relative to each other and provide a low friction force [2]. For example, MoS2 consists of layers in which the Mo atom is surrounded by four sulfur atoms, and the layers are weakly connected to each other through sulfur atoms. The introduction of these powders very significantly reduces the coefficient of friction of many polymers (thermoplastics and reactive plastics), especially those characterized by a high coefficient of friction. Thus, the coefficient of friction of polyamide at the introduction of 30 wt. % MoS2 decreases from 0.4 to 0.05. This reduces the energy expended in overcoming the friction force and, as a result, reduces polymer wear and heat generation in the friction assembly. Polymers with such additives can be used without special liquid lubricants, since the fillers themselves are good lubricants. Under operational conditions, the performance of guide bushings, combined seals, protective rings and other structural products made of anti-friction compositions is primarily determined by the values of physical and mechanical characteristics. The strength of these parts also depends to a large extent on the manufacturability of the compositions and the correct selection of granulate processing parameters. Power hydraulic drives of agricultural machinery use hydraulic cylinders, the purpose of which is to transform the energy received by the working fluid from the pump into mechanical energy of reciprocating and reciprocating action for moving various mounted and trailed implements. The share of gradual failures associated with the wear of parts is more than 70% of the total repair fund of hydraulic cylinders. At the same time, the 80% gamma resource of new hydraulic cylinders is equal to 5440 hours of tractor operation, which is 1.5 times lower than the resource declared by the manufacturer. The dominant influence on the reliability of hydraulic cylinders is provided by operational factors, primarily the force interactions of tribojoint parts. For the production of polymer parts of hydraulic cylinders, a promising polymer from the high-tonnage class of polyolefins is ultra-high molecular weight polyethylene (HMPE). In order to improve the tribological properties, the compositions are introduced by the method of mechanochemical activation of the NVMPE mixture and finely dispersed and nano-sized fillers of the active type, such as shungite, nano-sized silicon dioxide, carbon nanotubes and other substances of a similar effect. The combination of metal and composite protects the node from possible blocking. At the same time, the following are implemented: favorable characteristics of wear friction, damping of mechanical vibrations, a good effect that cleans from adhering foreign particles, protection of seals from the "diesel effect", elimination of problems of hydrodynamic pressure in the supply system, ease of installation and changes of the polymer guide during repair, low costs for maintenance. The most widespread in the hydraulic drives of tractors produced in Ukraine are double-action piston hydraulic cylinders of the C series (C55/30, C75/30, C90/30, C100/40). A feature of the design of hydraulic cylinders of this series is lack of replaceable guide support rings in the rod and piston units. Hydraulic cylinders during operation are subject to a combination of sudden and gradual failures. Sudden failures include failures of hydraulic cylinders that occurred due to the formation of defects on the working surfaces of parts connected to the seal. Gradual failures include failures associated with wear of the working surfaces of parts. In the initial period of operation of the hydraulic cylinder, gradual failures prevail, and then, as the service life increases, the number of random failures increases. The impact on the hydraulic drive of heavy operating modes, aggressive environments, alternating loads leads to more intensive wear of hydraulic cylinder parts and a decrease in their durability [3]. All these factors contribute to increased wear of the seal units and guide elements of the hydraulic cylinder. Currently, there are several ways to restore the performance of hydraulic cylinders. They all have their advantages and disadvantages. In chapter 1 of the thesis, it was shown that the rod and piston sealing units are the main resources for hydraulic cylinders. Restoration of worn rods and sleeves. Internet sources present a method of repairing hydraulic cylinders by replacing worn rods and sleeves with new chrome rods and sleeves made of honed pipes of the required diameter and length [3]. Rods and pipes for repairing hydraulic cylinders are made of St35, St45, St40X materials. The surface of the rod is treated with hard chrome to a depth of 20 microns. Stems can also be supplied hardened to a depth of 2 mm. And for rods with a commercial length of 600...1700 mm, microwave hardening is carried out. Repair in this way ensures the inter-repair resource of hydraulic cylinders by 80% of the pre-repair resource. This method can be rationally applied to hydraulic cylinders with defects that are either impossible to restore or unprofitable: stem rupture; sleeve deformation; bending of the rod with deformation that cannot be eliminated by straightening; corrosion, risks and traces of setting, occupying more than 50% of the working surface area. The calculation of the cost of repairing hydraulic cylinders of the C100/40×400 and C75/30×400 brands, taking into account the costs of components, shows that the cost of repairing hydraulic cylinders with the replacement of parts with new ones is about 80% of the cost of a new hydraulic cylinder [2]. The technology of restoring the rod during repair very often copies the manufacturing technology, differing only in the introduction of operations to increase the diameter and finishing technological operations. There is a restoration technology, which consists in welding the threaded rod with flux-cored wires, followed by grinding and chrome plating [3]. The hardness of the coating is 50...58 units. The rods are restored to an increased diameter, while the holes of the front covers are bored and not restored. This technology has a number of disadvantages: high cost of surfacing equipment and materials; the use of galvanic operations is not excluded; when the dimensions of the connected parts are changed, the degree of compression of the rubber rings is disturbed, which leads to accelerated wear during operation. The automatic plasma sputtering restoration methods described in [3] have a number of advantages: reliable protection of the deposited layer from oxidation; the possibility of automating the surfacing process. However, scarce consumables, low quality and low wear resistance of the deposited layer, significant heating of the parts being restored to a temperature of 350-370ºC, and, as a result, a decrease in the fatigue strength of the part by 20-40% are the disadvantages of these methods, which does not allow them to be used in technologies of hydraulic cylinders.

The technological process of mechanochemical activation of dry-mixed NVMPE compositions and nano-sized modifiers to increase the spring-strength characteristics of NVMPE and uniform distribution of nanoparticles has been substantiated. The original composition of the composition based on NVMPE and carbon nanotubes (CNTs) is substantiated, the introduction of 0.1% of CNTs provides (relative to pure NVMPE) an increase in yield strength by 35%, strength by 28%, initial and final modulus of elasticity by 23% and 29%, respectively .

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