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Technology of recovery of precision parts of fuel pumps by composite chromium

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ABSTRACT: The deposition of dispersed particles together with the base metal makes it possible to dramatically change the physical and mechanical properties of the surface of the restored part. In particular, the wear resistance, micro-hardness and corrosion resistance of coatings are increasing.
Research and development of a method for the restoration and hardening of plunger pairs of high-pressure pumps by obtaining a composite galvanic coating based on chromium is the goal of this work.
The plunger pairs of the high-pressure fuel pump of diesel engines are one of the main parts of the fuel pump that provide uniform fuel supply to the engine at all operating modes.
Plunger pairs wear out during operation. The working conditions of the plunger pairs mainly determine the nature of their wear. In the conditions of Central Asia, it is characterized by a hot climate, high dust content, the service life of the plunger pairs is significantly reduced. The presence of abrasive particles in the fuel contributes to the formation of gaps on the working surface, which in turn leads to a sharp loss of dimensions and to galling of parts.
This paper presents the results of a study on obtaining a composite galvanic coating based on chromium, which makes it possible to increase the service life of the plunger pairs of diesel engines.

KEYWORDS: plunger pair, electroplated coating, chromium, dispersed powder of aluminum oxide (Al2O3), hydrodensity, micro-hardness.

I. INTRODUCTION

In modern conditions of intensive operation of machinery and equipment, no machine can do without repair and maintenance, which are integral stages of the process of operating a machine and must ensure the required level of reliability during the entire period of operation at the lowest cost of time and money.
Internal combustion engines are designed in such a way as to make the most of the energy of the fuel they burn. The fuel supply equipment directly implements the calculated fuel injection characteristic necessary for each particular engine. More than 60% of equipment engine failures are associated with the engine [1]. And the main reason for the failure of a diesel engine is problems with the power supply system, in particular, associated with fuel pumps. During the operation of high-pressure fuel pumps, plunger pairs, which are precision parts, wear out. Worn plunger pairs during pump operation reduce the cycle fuel supply by an unacceptable amount, since the cycle time increases, and with large gaps, the fuel from above the plunger space is pushed into the filling and cut-off bore of the sleeve. this leads to the fact that in the cylinders, into which little fuel enters, there are gaps of flashes, the engine begins to vibrate, the fuel consumption increases, it burns badly.
The main type of wear of plunger pairs is abrasive wear, due to the ingress of micron-sized abrasive particles into the fuel. Due to the high cost of plunger pairs and a large number of road and road equipment in Uzbekistan from different companies and countries of manufacture, spare parts of which differ in design and technological parameters, the development of a technological process for the restoration and hardening of plunger pairs is undoubtedly economically profitable and expedient.
The existing methods for the restoration and hardening of plunger pairs are based on the use of specialized equipment used at manufacturing plants and are quite expensive, in addition, the use of factory technologies is economically profitable, provided that a large number of similar plunger pairs are restored.
Currently, the most widely used are galvanic processes to restore the geometry of the plunger pair, of these processes, galvanic chromium plating is widely used. However, this process has a number of disadvantages; therefore, in recent years, new technological processes for obtaining electroplated composite coatings have been developed. The essence of these technologies lies in the fact that, together with the base metal, dispersed particles of various carbides, borides,

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oxides, etc. are deposited on the parts.

II. SYSTEM ANALYSIS

A universal electrolyte was chosen for the application of chrome coatings. it is used with medium concentrations of chromic anhydride and sulfuric acid and provides the widest operating range of temperatures and current densities for obtaining solid and shiny deposits [3].
Electrolyte, g / l:
-chromic anhydrite-250
-sulfuric acid-2.5
Mode:
- current density - varied from 20 to 100 A / dm^2
- electrolyte temperature -50 ° C

To apply a composite chromium coating, we used an ultrafine powder of aluminum oxide (Al_2O_3) with a particle size of 0.1-0.2 µm. Aluminum oxide powder has a high microhardness HV 25 GPa, high chemical resistance and good wettability in chromium electrolyte.
Composite electrolyte preparation was carried out in the following sequence. First, a universal chromium plating electrolyte was prepared. Then, in a special container, a suspension was prepared, consisting of an ultrafine powder and oleic acid diluted with an electrolyte. The resulting slurry was then poured into the chromium plating bath and mixed.
Lead was used as anodes in composite chromium plating. The oxidation process is provided on the surface of the lead Cr^{3+} in Cr^{6}. At the same time, there is a discharge on the anode surface OH^{-} and highlighting O_2. During electrolysis, a dark brown film is formed on the surface of the anodes PbO_2, which provides a more uniform surface condition of the anodes and improves their performance [3]
To determine the microhardness of the coating, cylindrical samples of steel were made 30ХГСА with a diameter of 20 mm and a height of 10 mm. The samples were subjected to composite chromium plating with a layer thickness of 100 µm. The microhardness was measured using the device ПМТ-3 by extruding a diamond pyramid according to ГОСТ 9450-76, under load 100 gr.
The reconditioned and assembled plunger pairs are checked for leaks. The tightness of the bushing-plunger pair is finally checked at a special stand. The test pair is installed in the nest of the stand, the plunger in the sleeve is lowered to the lower position until it stops, and the well of the nest is filled with diesel fuel. The load is set to its original position, a seal is placed on the end of the sleeve, and then a fixing sleeve is put on it. The seal is pressed against the end of the sleeve using a torque wrench with a tightening torque of 7 ± 0.5 kgm. Under the action of a weight of 3.13 kg, which is released by a latch, the plunger compresses the fuel under a pressure of 250 atmospheres. Moving, the plunger squeezes out the fuel through the gap of the test pair. The duration of the drop of the load in seconds to the stop characterizes the density of the pair. The viscosity of the fuel is 1.40-1.45 at a temperature of 20 ° C.

III. RESULTS

The technological process of composite chromium plating is carried out according to the following scheme: chemical degreasing; rinsing in warm water; rinsing in cold water; anodic treatment; composite chrome plating; rinsing in a hot water bath, rinsing with running cold water, drying, dehydration.
Chemical degreasing was carried out using Viennese lime. Finely ground Viennese lime was diluted with water to a mushy state and the plunger was wiped with a rag. The decapitation was carried out in a solution of hydrochloric acid 50 g / L at a temperature of 50 ° C for 5 min. After loading the plungers into the bath for 5 min, the parts were held without current to equalize the temperature of the plungers and the bath. Then, anodic activation was carried out at a current density of 25-40 A/dm^2. After anodic activation, the operating mode of the deposition of composite chromium was established.

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With continuous operation of the bath, the composition of the bath is depleted. Therefore, to maintain a constant concentration of the solution, the electrolyte was adjusted by loading the necessary components. The content of chromic anhydride and sulfuric acid was determined according to the method [3]. The content of dispersed particles of aluminum oxide was determined according to the method [4] by the formula:

$$C = \frac{S_1 (S_c + S_э) * 1000}{S_c * S_1} \quad (1)$$

Where : S_c- suspension density g/sm^3;

$S_э$ – electrolyte density g/sm^3;

S_1 – disperse density g/sm^3;

The process of electroplating was carried out in a lead bath, placed in a thermostat, in which the temperature was maintained at 50 ° C by heating the water with heating elements.

The main factor in the use of composite chromium coatings using dispersed particles is that, as a result, coatings with such a set of properties can be obtained that cannot be obtained using a coating of pure metals.

In the general case, a composite galvanic coating is obtained by deposition from an electrolyte with the addition of some dispersed powder. In the process of electrolysis, first, the base metal and the smallest particles of powder are deposited on the surface of the part or sample, which are gradually overgrown with the base metal. The mechanism of formation of the structure of the composite coating is as follows;

A) At the first stage, particles collide with the surface of the metal (cathode). Collision occurs both due to the Brownian motion of particles, and due to forced mixing of the solution [5].

B) The second stage is characterized by the retention of particles on the cathode surface. This process is the most difficult due to the fact that several processes occur simultaneously: adhesion, electrical interaction of particles with the main structure, the presence of defects in the main structure, etc. These processes, in turn, are influenced by the electrolysis modes: the distance between the cathode and the anode, the temperature of the electrolyte, and the cathode current density.

C) The third stage is the stage of overgrowing of the embedded particles into the main structure. It is the overgrowth stage that is responsible for the number of embedded particles and the strength of the resulting composite compound.

Taking into account all of the above, we carried out studies on the effect of the current density of the concentration of dispersed particles of aluminum oxide (Al_2O_3) on the microhardness of the composite layer (Fig. 1, 2). For the study, we used a standard chromium plating electrolyte at a temperature of 50 ° C.

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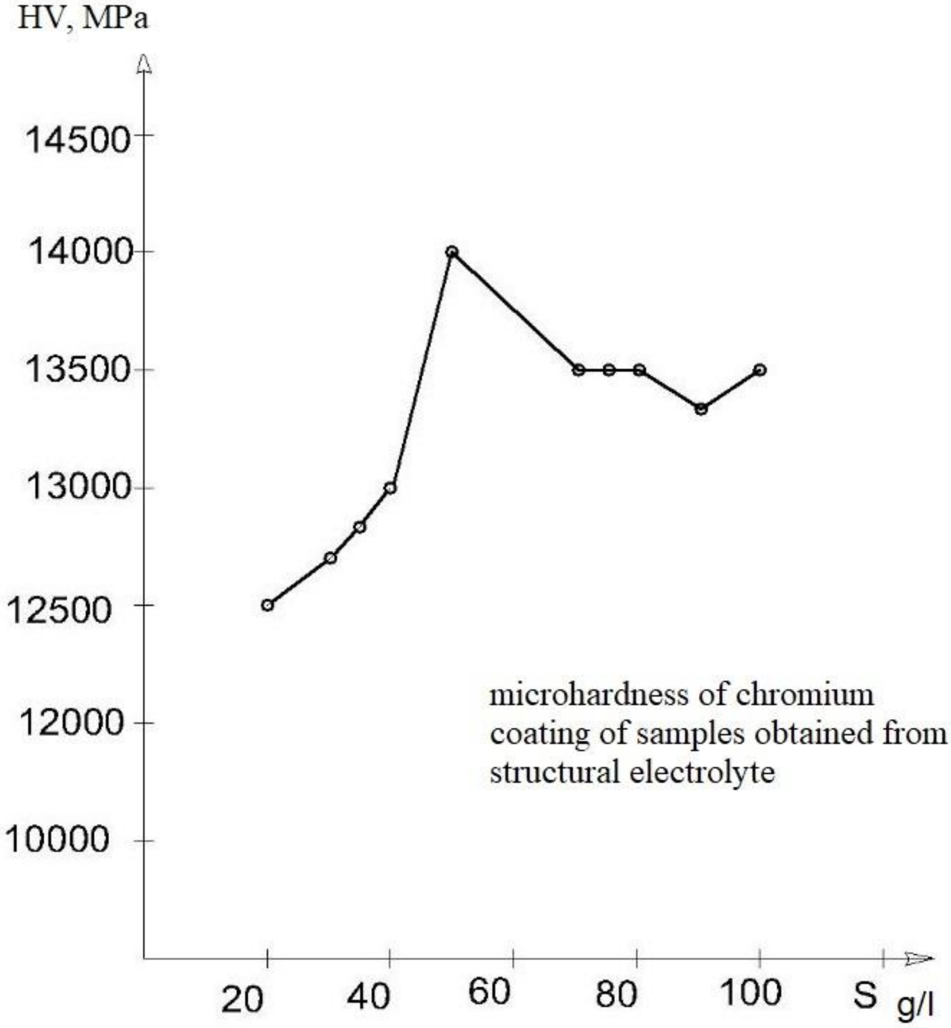

Fig. 1 Influence of the content of dispersed particles (Al_2O_3) on the microhardness of the composite chromium coating test temperature 50 ° C

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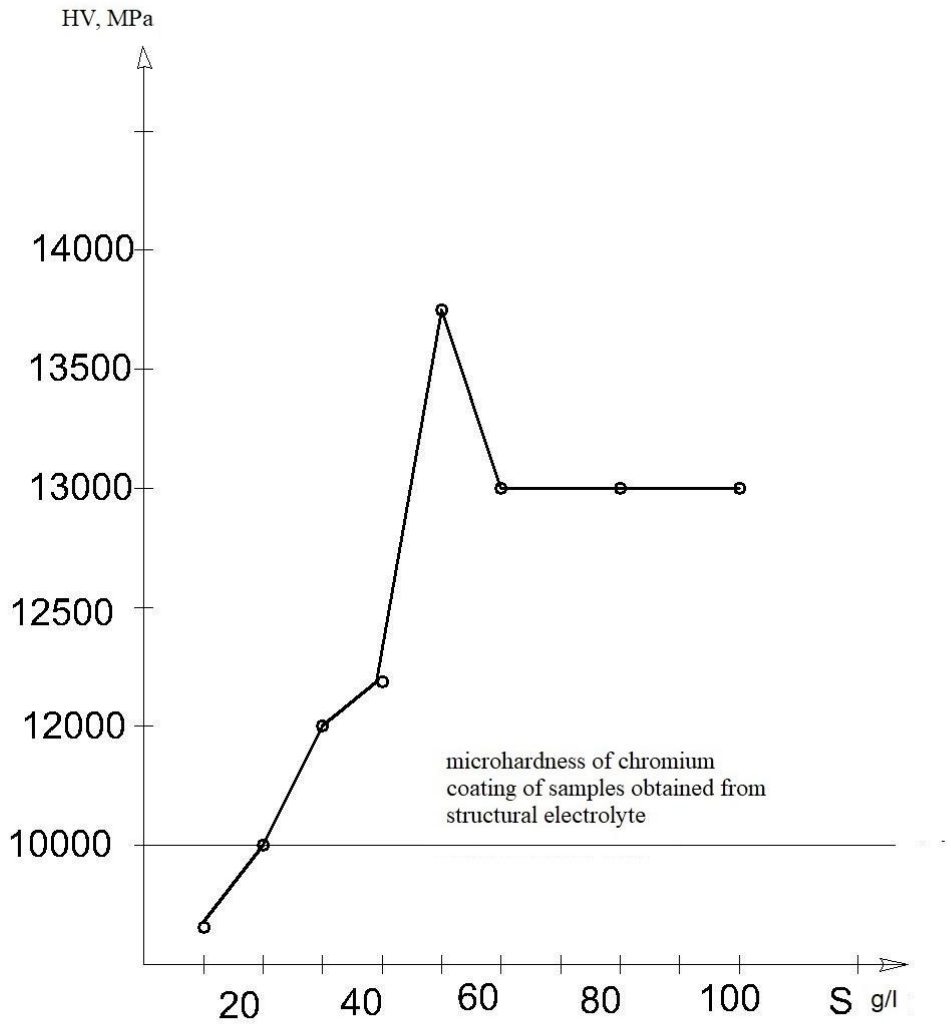

Fig. 2 Influence of current density on microhardness of composite chromium coating content of dispersed particles (Al_2O_3) g / L. Deposition temperature 50 ° C.

The essence of the process of restoration by composite chromium plating of the plunger pair is as follows. Plunger assemblies to be repaired at the beginning are dismantled. Then the bushings of the plungers are lapped, while the lap outside the hole should be provided for a length equal to ¼ of the lap length. The plunger is subjected to regrinding on centerless grinding machines to eliminate wear marks.

The regrind plungers are then electrolytically chromed to the size of the lapped bushing with the appropriate allowance for grinding.

After chrome plating, the plunger is subjected to dehydrogenation to eliminate brittleness, and then ground to fit the size of the lapped sleeve. The ground plungers are fine lapped and then mated to the sleeve. Paired plunger pairs are subjected to mutual lapping on the finishing headstock.

In our study, the plunger pairs of the KAMAZ vehicle were subjected to composite chromium plating. The reconditioned plunger assemblies were subjected to a leak test using a special stand. The test was carried out on 3 sets of remanufactured plungers, 8 pieces in each set. The test results are shown in Fig. 3 New factory-made plunger pairs of a KAMAZ vehicle have a hydraulic density of 50-60 sec.

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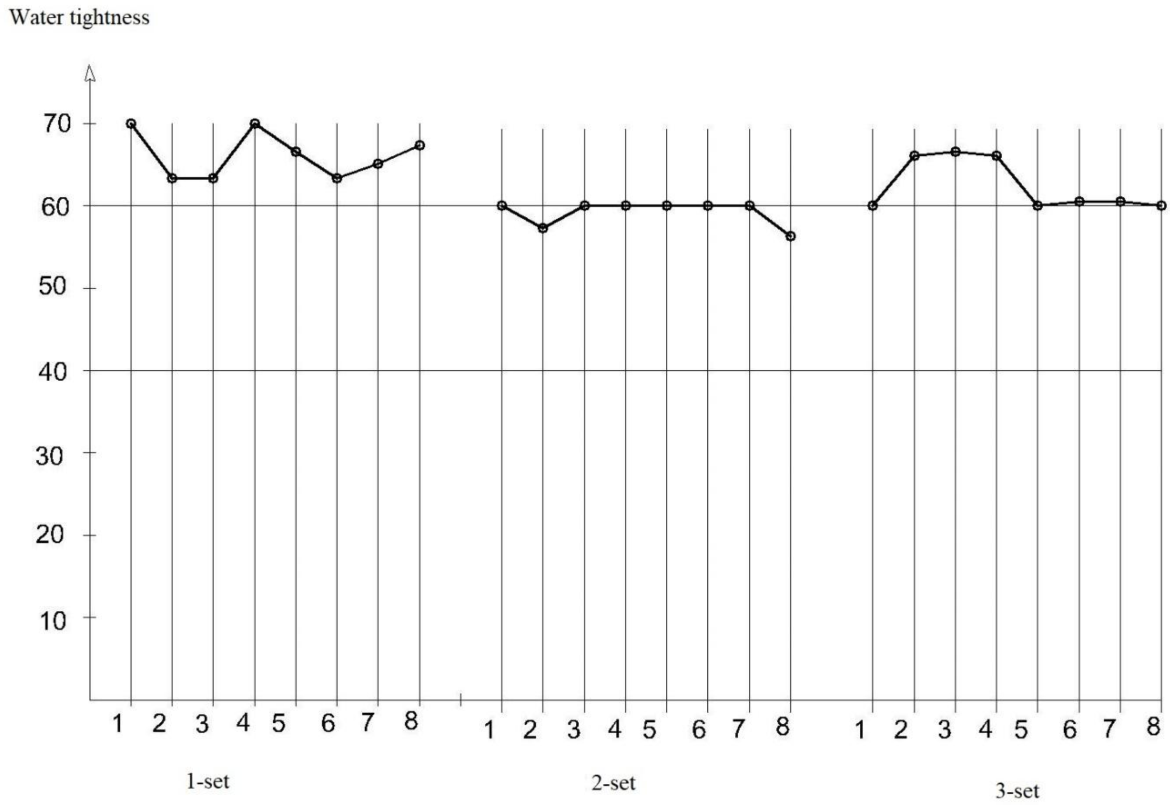

Fig. 3 Leakage of recovered plunger pairs by composite chromium plating

As can be seen from Fig. 3, the hydraulic tightness of all three remanufactured sets of plunger pairs corresponds in terms of the hydraulic tightness of new factory-made plunger pairs.

IV. DISCUSSION

Galvanic chromium plating is the most widespread method of plunger pair recovery due to the possibility of using this method both at manufacturing plants and in the conditions of repair plants and repair shops.

The electrolytic method of applying chromium plating is based on the method of producing a coating from an aqueous solution of chromic anhydride (CrO_3) under the influence of the electrolysis process. Most chromium plating electrolytes use sulfuric acid as an additive ($\mathrm{H_2SO_4}$) having the following advantages: availability, low cost, ease of analysis, stability in the electrolyte.

The most widespread is a universal electrolyte with medium concentrations of chromic anhydride and sulfuric acid, operating in wide ranges of temperatures and current densities. Composition of the universal electrolyte:

Chromic anhydride-250 g / l

Sulfuric acid - 2.5 g / l

Process temperature from 40 to 70 ° C

Chromium metal is deposited on parts that serve as a cathode during the electrolysis process. Lead plates are used as anodes. It was this electrolyte that was taken as the basis for the restoration of plunger pairs by composite chromium plating. The main factor in the use of composite coatings using dispersed particles is that as a result it is possible to obtain coatings with such a set of properties that cannot be obtained when using coatings from pure metals.

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Investigations of the effect of dispersed particles (Al_2O_3) introduced into the chromium electrolyte with a concentration of~0.3% in the chrome coating on the piston rings, carried out in [6], made it possible to increase their wear resistance up to 3 times. In our case, the introduction of dispersed particles (Al_2O_3) into the electrolyte made it possible to increase the microhardness from HV 1000 obtained in a standard electrolyte to HV 1400 in an electrolyte with dispersed Al_2O_3 particles.

V.CONCLUSION

The possibility of reconstructing the geometry of plungers by using composite chromium plating has been established.
The optimal content of dispersed particles of aluminum oxide in the Al_2O_3 electrolyte is established at which it is possible to obtain microhardness up to HV1400
The optimal modes of composite chromium plating have been established
- electrolyte temperature 50 ° C
- current density 50 A/dm^2.

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