IMPROVING THE RELIABILITY OF ENGINE TIMING PARTS WITH THE USE OF ADVANCED NICKEL-COPPER COATINGS

Serik Toigambaev[1], Otari Didmanidze[1], Erkin Bukanov[1], Alexander Bugaev[1], Shakizada Niyazbekova[2], Vagif Rustamov[3]

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[1]Russian State Agrarian University – Moscow Agricultural Academy named after K. A. Timiryazev, RGAU–MSHA, RUSSIA

[2]Moscow Witte University, RUSSIA

[3]Ganja State University, AZERBAIJAN

shakizada.niyazbekova@gmail.com

Abstract

Wear and deterioration of the technical condition of the gas distribution mechanism during operation leads to a malfunction of the diesel engine, a decrease in its power, an increase in specific fuel consumption, the formation of carbon deposits on pistons and parts of nozzle sprayers, accelerated wear of the crank mechanism. The need for restoration is dictated by the low post-repair resource of these parts. The currently existing methods for restoring guide bushings are complex and expensive. The chemical method of coating deposition is very promising and simple, since a relatively thin coating layer provides the necessary performance properties to the surfaces of the parts. This article presents one of the ways to restore the guide bushings, with the results of the conducted research.

Keywords: resource, restoration, timing mechanism, guide sleeve, wear, part

I. Introduction

One of the main components of which is the valve group: valve, seat and guide sleeve. The bushing is the main resource-determining link and when it is worn out, the entire gas distribution mechanism cannot work normally. Choosing the optimal way to restore the performance of worn-out machine parts is one of the main issues in the development of technological processes. When applied by chemical deposition on such coatings, there is no thermal effect on the part, leading to its warping, a change in the structure of the base metal and its physico-mechanical properties.

Ni-P-Cu coatings are more promising for restoring the operability of valve guide bushings. When using this method, the cost of expensive equipment is not required, since the equipment of electroplating workshops can be used when applying chemical coatings. In this regard, the urgent task of repair production is to develop a technology for restoring guide bushings using hard and wear-resistant coatings.

II. Results

The formation of the chemical coating was carried out in acidic solutions at a temperature of 90-95 ° C. These modes were chosen as ensuring the formation of high-quality coatings in a stable solution with sufficiently high deformation and strength properties, high adhesion strength and deposition rate. The deformation and strength properties of the coatings were studied according to the standard procedure (GOST 11262). The thickness of the coating on the samples varied from 10 to 300 microns. The samples for wear tests were rollers with a diameter of 50mm and a width of

12mm coated with Ni-P-Cu alloy and pads with a width of 10mm. When studying the deformation and strength properties of Ni-P-Cu chemical coatings, studies were carried out on samples with a copper content from 0 to 1.5% under various heat treatment modes. The microhardness of the coatings was determined on the PMT-3 device by indentation of a diamond pyramid according to GOST 9450-76. For this purpose, cylindrical samples with a diameter of 10mm and a height of 40mm were pre-made.

The coating was applied to a polished, polished, and then degreased surface. The tests were carried out at a load of 50 g. All samples coated with the Ni-P-Cu chemical alloy were subjected to heat treatment. The thermal treatment of the coatings was carried out in a muffle furnace for an hour. To measure the roughness of the surfaces of the semi-finished coatings, a profilograph profilometer mod. 2.01 of the Kalibr plant was used. The structure of the obtained Ni-P-Cu coatings was studied using a MIM-7 microscope.

The elemental composition of the coating and the presence of copper in it were determined using laser emission analysis. The research was carried out on a Carl Zeiss installation. Jena, consisting of an LMA-10 laser microanalyzer with a solid-state laser and a PGS-2 spectrograph.

III. Discussion

The wear resistance of the Ni-P-Cu coating was evaluated on the SMC-2 laboratory installation according to the roller-deck scheme. The pads were made of 40KHN steel. The hardness of the pad was 55...60HRC. Ni-P-Cu coating was applied to the rollers. The tests were carried out in the load range from 6.0 MPa to 12.0 MPa. The tests were carried out on M-10G2 engine oil. Operational comparative tests of engines with restored and serial guide bushings were carried out on MAZ vehicles with YAMZ 236 and YaMZ 238 engines. Before operational tests, experimental engines with restored and serial valve guide bushings were adjusted and run-in on the stand for 10 hours. During the operational tests, the following were monitored: engine operating time and performance indicators [1-15].

One of the main factors affecting the properties of the coating is the temperature of the solution, with a change in which the copper content in the coating changes (Fig. 1), which strongly affects the rate of deposition of the coating.

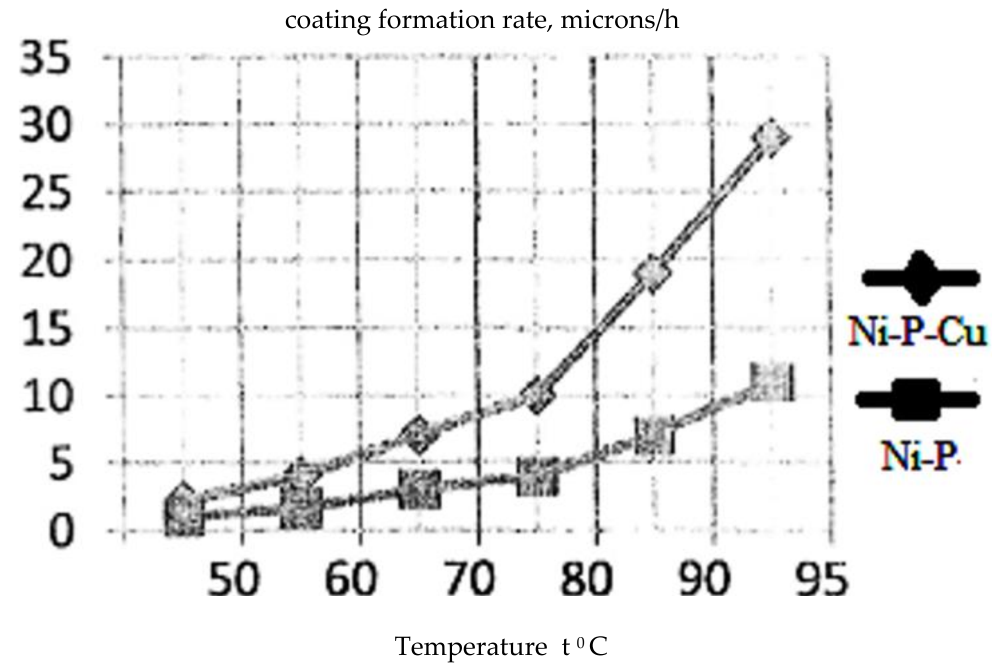


Figure 1: *Dependence of the coating formation rate on the solution temperature*

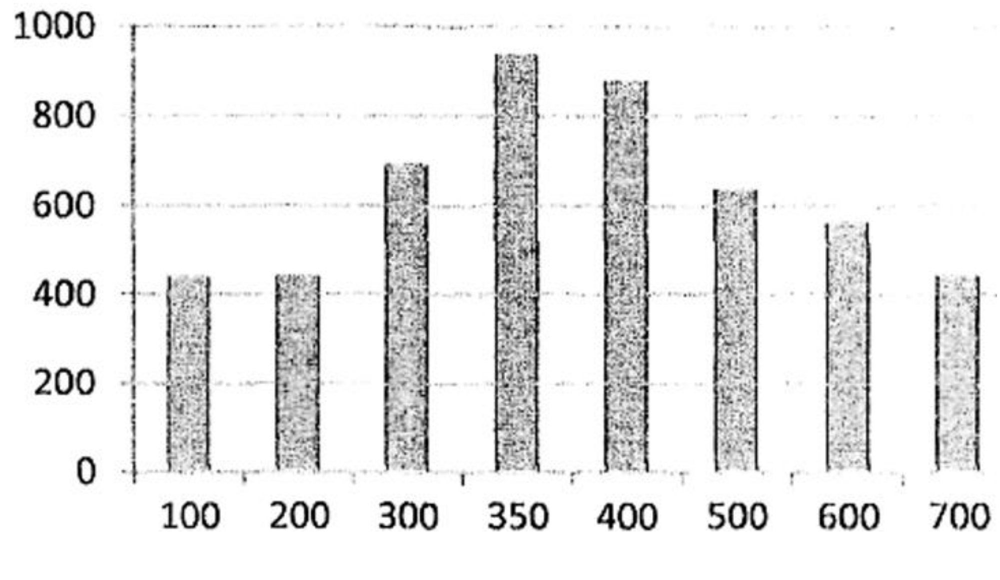
Comparison of Ni-P-Cu coatings before and after heat treatment shows that the presence of heat treatment eliminates layering in the coating and promotes the formation of a more finely crystalline uniform structure. After heating, the layering in the sediments disappears, and the size of the Ni3P particles is further enlarged. When the coatings are heated, phosphorus diffuses from them into the base metal, at the boundary of which a new phase is formed, probably iron phosphide Fe3P.

The precipitates of the chemically reduced coating immediately after their preparation, characterized by an amorphous structure with a random distribution of phosphorus in it, are metastable both in terms of "crystallinity" and in terms of "equilibrium" of the system of a mixture of a solid solution of phosphorus in nickel and a Ni3P compound. When chemically reduced nickel is heated, the amorphous precipitate turns into a crystalline one, which corresponds to two phases, namely the nickel phase (more precisely, the solid solution of phosphorus in nickel) and the intermetallic compound Ni3P. As the heating temperature increases, the amount of Ni3P phase increases due to the decomposition of the solid solution.

The conditions of formation of nickel-phosphorus-copper coatings and their structural features have a decisive influence on their performance characteristics. The heat treatment consists in heating the Ni-P-Cu coated part to a temperature of 400 ° C and keeping it at this temperature for at least 1 hour. The dependence of microhardness on the heat treatment temperature is shown in Figure 2. It should be noted that the disappearance of the amorphous component and the appearance of crystalline nickel and the Ni3P phase occurs after the first minute of annealing, but the maximum hardness is achieved much later. This can be caused by two successive processes: the transformation of a supercooled "liquid" solution into a supersaturated crystalline one and the precipitation of Ni3P from the latter.

In the case of heat treatment at 200 ° C, no changes in hardness occurred even with prolonged heating for 21 hours. As a result, it was found that the maximum microhardness of the Ni-P-Cu coating is 10 Gpa. The average value of the roughness parameter of the Ni-P-Cu chemical coating was 0.08microns.

microhardness, kg/mm^2



Temperature t ^{0}C

Figure 2: *Dependence of the microhardness of the coating on the heat treatment condition*

Comparative laboratory tests have shown that nickel-phosphorus-copper coatings have a wear resistance 1.5 times higher than 40KHN steel. The setting of samples made of 40KHN steel occurs after 0.83 h at a load of 1.25 kN, and samples with a chemical Ni-P-Cu coating after 1.41 h at a load of 2.12 kN. The increase in the setting load of Ni-P-Cu coated samples is explained by the characteristics of this alloy.

In addition, the absence of cracks also prevents the friction surfaces from setting, since the detached particles, falling into the gap of the friction surfaces, can cause them to jam. The high wear resistance of the Ni-P-Cu coating is due to the significant microhardness of such coatings, as well as structural features.

The corrosion tests carried out made it possible to establish that the Ni-P-Cu alloy after heat treatment at 400 °C has a corrosion resistance 1.2 times higher than 40KHN steel.

Since corrosion processes begin on exposed surfaces, a denser and finer grain structure prevents the spread of corrosion into the depth of the coating due to the absence of cracks and pores in it. Based on the conducted laboratory studies, a technology for restoring the guide bushings of the YaMZ-236 and YaMZ-238 engines was developed. According to the data obtained from operational tests, the resource of the guide bushings of YAMZ engine valves, restored using a chemical coating of nickel-phosphorus-copper, is 1.3-1.5 times higher than the resource of serial guide bushings installed by the manufacturer [16-19].

IV. Conclusion

1. When carrying out wear tests on the SMC-2 friction machine, the wear of samples coated with a nickel-phosphorus-copper chemical coating is 1.5 times less than samples made of 40KHN steel. The setting load of samples coated with Ni-P-Cu coating is 1.2 times higher than samples made of 40KHN steel.

2. The corrosion resistance of the studied samples coated with Ni-P-Cu chemical coating exceeds the corrosion resistance of 40KHN steel samples by 1.2 times.

3. The operational tests carried out showed that the service life of the valve guide bushings, restored using a chemical coating of nickel-phosphorus-copper, is 1.3-1.5 times higher than the serial ones.

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