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DETERMINATION OF THE INFLUENCE OF ELECTRO-SPARK ALLOYING ON THE STRENGTH INDICATORS OF MACHINE PARTS[5]

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Abstract. *Strengthening was carried out by electrosparking . The results of tests of parts strengthened by electrospark alloying show that the wear resistance of parts is increased by 1.3 times compared to the original state of parts . It has been established that strength indicators increase with increased fractal dimension.*

Key words: *electrospark alloying, sorbitol, microstructure, hydraulic hammer, fractal dimension, prediction.*

ВИЗНАЧЕННЯ ВПЛИВУ ЕЛЕКТРОІСКРОВОГО ЛЕГУВАННЯ НА ПОКАЗНИКИ МІЦНОСТІ ДЕТАЛЕЙ МАШИН

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Анотація. *Зміцнення проводилося шляхом електроіскрового легування. Результати випробувань деталей, зміцнених електроіскровим легуванням, свідчать, що досягається підвищення зносостійкості деталей в 1,3 рази в порівнянні з вихідним станом деталей. Встановлено, що показники міцності зростають при підвищені фрактальної розмірності.*

Ключові слова: *електроіскрове легування, сорбіт, мікроструктура, гідромолот, фрактальна розмірність, прогноз*

Introduction

In order to increase the wear resistance and fatigue strength of the material of hydraulic hammer parts, it is not always advisable to change the traditional technology of manufacturing the part and, in particular, the methods of its heat treatment. Different types of finishing are applied only specifically to the given product. In some cases, it is worth applying surface strengthening of the product [1-3] .

Analysis of publications

Currently, there are a number of surface strengthening technologies, each of which has its own advantages and disadvantages [4-6] . The most common are laser thermal hardening, electrospark alloying, galvanic chrome plating, ion-plasma hardening, gas detonation sputtering, vacuum-plasma hardening, surfacing of working surfaces.

Studying the influence of various methods of surface hardening on changes in the structure and properties of hydraulic hammer parts and choosing the most effective method of increasing their durability is an urgent task.

Chrome plating is one of the most common types of electroplating. In the technique of chrome plating of products, it is used to protect against corrosion, wear, sticking to the surface of contacting

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[5] Робота виконана під керівництвом проф. Глушкової Д.Б.

materials. Depending on the technology and methods of application, chrome coatings reach microhardness up to 950-1100 HV. High hardness and wear resistance, low coefficient of friction, high heat resistance and good chemical resistance provide chrome-plated parts with a high service life in any operating conditions [7, 8].

The purpose of the work

Establish a relationship between structural changes in the surface layers of parts after electrospark alloying and strength characteristics, as well as the fractal dimension of the structure with strength characteristics, which will allow them to be used as a non-destructive control of parts after electrospark alloying.

Research materials and methods

During chrome plating, anodes made of pure lead or a lead alloy with 4-6% antimony were used. Anodes are made from rods with a diameter of 10-15 mm or sheets. The ratio between the surface of anodes and cathodes should be between 1:2 and 2:3. Lead anodes in during the work process, they were covered with a layer of lead chromic acid, which makes work difficult. In the breaks between work, the anodes were removed from the bath and immersed in water.

Fig. 1. Installation for electrospark alloying

All parts were strengthened by electrospark alloying with tungsten. The power of the processing current was 1 kW. The peak, in addition to strengthening with tungsten, was additionally processed by electrospark alloying with chromium at a current of 1.5 kW. Surfaces processed by electrospark alloying were polished to obtain the roughness of the hardened surfaces of parts R and 04-08.

During the micro-examination of areas strengthened by electrospark alloying, which are outside the load zone during the test, it was established that the areas strengthened by electrospark alloying on the body and sleeve have a thickness of 10–40 μm and a hardness of H V 600–650. On the strikers, the initial thickness of the strengthened layer is 20 μm with a hardness of HV 600-650. The strengthened zones in the section have the appearance of arc-shaped, embedded surface layers of metal parts, phases. There are no structural changes under this zone in the main metal.

Tests and their discussion

The study of the wear resistance of parts strengthened by electrospark alloying was performed according to the standard method.

The tests were carried out before the formation of a wear pattern in the cavities of the body and sleeve, on the striker and at the peak, similar to that obtained on the parts manufactured without additional strengthening. The initial signs of wear of the device parts in the form of small burrs were detected at the peak in the "M" and "F" zones (see Fig. 2) after 300 load cycles, on the sleeve after 450 cycles, on the striker and the body, respectively, after 350 and 500 cycles

After 1300 load cycles, the nature and degree of damage to the parts corresponded to that obtained on the unreinforced assembly.

The specified diameter of the hull channels in the cut zone increased to 125.5 mm, the strikers in the "N" zone, fig. 3) worn by 0.35 mm, in zone "F" - by 0.55 mm. Peak wear leaves 0.35 and 1.15 mm, respectively.

The general type of damage to parts strengthened by electrospark processing during testing is shown in fig. 2 and fig. 3.

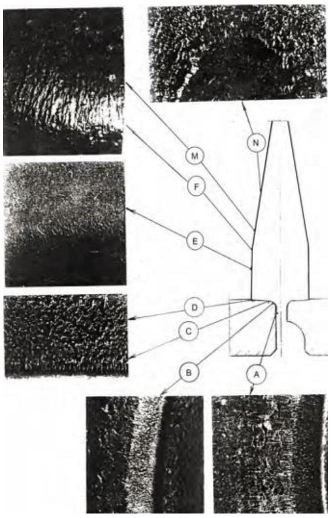


Fig. 2. Wear of the peak and sleeve, strengthened by 20 μm with a hardness of H V 600-650. Reinforced zones in the section have the form , ×3

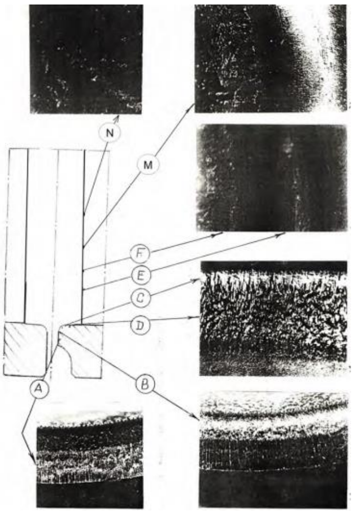


Fig. 3. Damage to the hull and striker, strengthened by detonation spraying , ×3

The damage zones of the housing and bushing coincide with the corresponding wear zones of the housing and bushing, which are not subjected to additional strengthening. The nature of the damage is also identical to that observed earlier, but the degree of damage (slander, cracking, plastic deformation of the metal, wear with the formation of grooves) is significantly greater.

It is noted that the grooves in the "B" zone on the body of the striker are less developed compared to the sleeve. In the "C" zones, intensive wear is observed with the formation of a relief surface, which is more developed on the body of the striker. Grinding of the original surface in the form of spots is visible in the "D" zones.

The "N" zone of skirmishes and spades has the appearance of a round spot with a diameter of about 14 mm, characterized by a smoothed and riveted surface, which passes into a fold-like relief with a general direction.

A well-developed relief formed by radial furrows characterizes the "M" zone. At the same time, at the peak, the degree of development of the relief is higher compared to the battle. Zones "F", covering about half of the surfaces, are characterized by slander, smoothing of the surfaces.

Some roughness and flaking of the surface layer of the metal is noted at the peak. Zone "E" shows signs of uniform wear and tear. The upper parts (body and striker) have darker colors of rust and soot.

On the working surfaces of the tested parts, wear of the surface volumes of metal strengthened by electrospark treatment is noted (Fig. 4, Fig. 5). Possible cracks; the metal along the walls of the cracks is smooth, covered with a dense layer of oxides. On the body and sleeve, cracks with a depth of 0.1–0.3 mm are concentrated in the "B" zones. On the face and peak, cracks of mesh orientation with a depth of 0.1–0.3 mm are noted in the "N", "M" and "F" zones. The greatest depth of cracks occurs in the "M" zones - 0.3 mm at the front and 0.1 mm at the peak.

On the working surfaces of all parts, the layer strengthened by electrospark alloying was preserved only in some areas. On the body and sleeve in zones "B" and "C". thickness from 5 μm to 0.01 mm. On the striker and peak, the remains of a layer with a thickness of 30 μm to 0.1 mm are observed only in places on the "F" surfaces. In the "N", "M" and "E" zones, the electrospark doping layer does not appear.

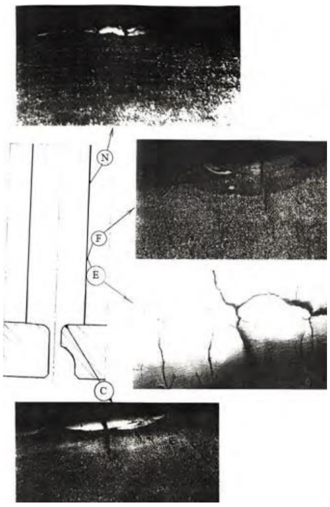


Fig. 4. Changing the structure of the material of the case and striker, strengthened by electrospark alloying , ×100

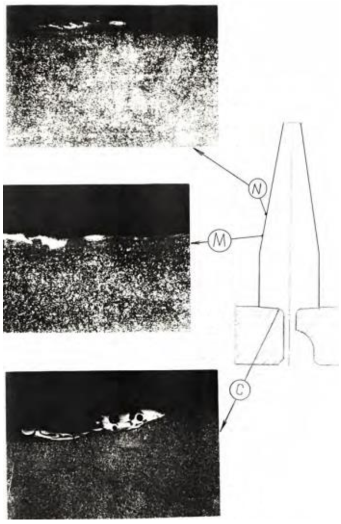


Fig. 5. Change in the structure of peak and sleeve materials strengthened by electrospark alloying , ×100

The main metal of all parts of the device directly near the working damaged surfaces underwent changes in structure and hardness. Peaks are observed in zones "B" and in zone "C" on the body and bushing of changes in structure to a depth of 0.1 mm (HV 400–500). There are no structural changes in zones "A" and "D".

At the peak and peak, there are no structural changes only in the "E" zones. In the "N", "M" and "F" zones, the depth of the zones of structural changes is 0.1–0.3 mm for the strike and 0.05–0.1 mm for the peak. The hardness of the material in these zones is HV 420-500, peaks HV 400-460. The structure of metal of troost-martensitic and troost-sorbite types.

The microstructure of the base metal consists of sorbitol. The mechanical properties of the material of the device parts were determined at a temperature of 20 °C on samples cut in the axial and tangential directions.

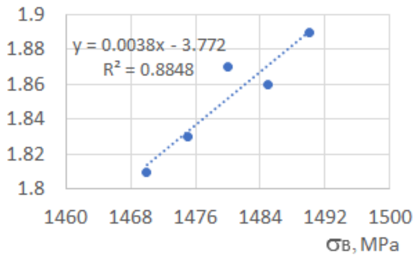
Since the obtained structure of sorbite was difficult to quantify by traditional methods of quantitative metallography, it was studied using the theory of fractals [9, 10].

To calculate the fractal dimension D of the hull structure, the striker at an increase of 100 was calculated according to the classical Hausdorff formula [11]:

$$D = \lim_{\delta \to 0} \frac{\ln N(\delta)}{\ln \delta}. \tag{1}$$

where δis the linear size of the cells covering the structure, $N(\delta)$- the number of cells.

The results of the fractal analysis of the structure of the striker body are shown in Fig. 6 - fig. 9.



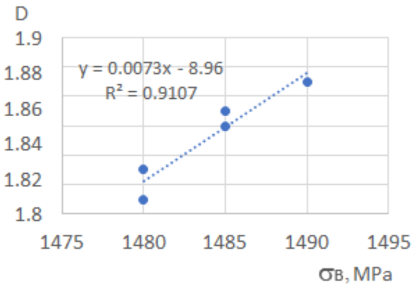
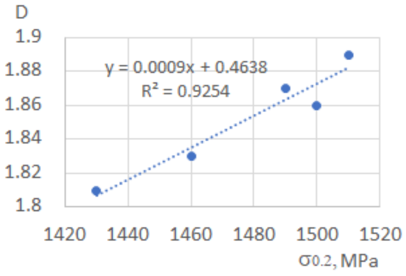


Fig. 6. Correlation between the fractal dimension of the sorbite structure of the striker body D and the strength limit σ_B for axial samples

Fig. 7 Correlation between the fractal dimension of the sorbite of the striker body structure D and the strength limit σ_B for radial samples



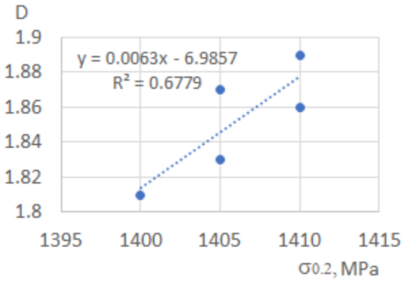


Fig. 8. Correlation between the fractal dimension of the sorbite of the structure of the striker body D and the yield strength of $\sigma_{0.2}$ for axial samples

Fig. 9. Correlation between the fractal dimension of the sorbite of the structure of the striker body D and the yield strength of $\sigma_{0.2}$ for radial samples

The obtained results make it possible to forecast the strength indicators of the body of the hydraulic hammer striker based on the fractal dimension of photographs of the microstructure at a magnification of 100.

Conclusions

1. Electrospark alloying with tungsten and chromium at a processing power of 1 - 1.5 kW provides local strengthening of the surface volume of the material of parts to a depth of 10 - 40 microns and a hardness of HV 600 - 650.

2. The results of tests of parts strengthened by electrospark alloying show that the wear resistance of parts is increased by 1.3 times compared to the original (not subjected to additional strengthening) version.

3. The locations of the damage zones and their nature on the parts strengthened by electrospark alloying are identical to those observed on the tested parts manufactured without additional strengthening and with the use of LTO.

4. The layer strengthened by electrospark alloying is characterized by a significantly greater degree of damage development compared to the non-reinforced version. On the body and bushing in the "A" (cut) and "D" (channel) zones, the strengthened layer is almost completely worn out, in the remaining zones, only the remains of the electrospark alloying layer with a thickness of 5 μm to 0.01 m have been preserved. On the strikers, the remains of the electrospark alloying layer of the same thickness are noted only in the "F" zone.

5. The structural changes that occur during the tests in the surface layers of the parts are characteristic of the phenomena of secondary hardening with a lower level of hardness than on the parts of the previous options.

6. The relationship between the fractal dimension of the sorbite structure and the strength characteristics was established, which allows us to use the obtained results as a non-destructive method of controlling the strength of parts after electrospark alloying.

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