OBTAINING A WEAR-RESISTANT COATING USING FLAME SPRAYING FOLLOWED BY MELTING

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Abstract: In this paper, details were restored by pouring and melting metal powders on the surface of the details with the help of a gas flame in order to increase the resistance to bending. The obtained scientific results show that the operational characteristics of the restored parts have increased several times compared to the gear shaft obtained by the traditional method.

Keywords: Flame spraying, reflow, wear resistance, intensive wear, coefficient of friction, carbon steel, high alloy steel, metal powder.

Ключевые слова: Газопламенное напыление, оплавление, износостойкость, интенсивный износ, коэффициент трения, углеродистый сталь, высоколегированный стал, металлические порошок

Аннотация: В работе предложен технология восстановления износостойкий деталей методом газопламенного напыления с одновременным оплавлением покрытия из высоколегированной сталей. В результате, эксплуатационных свойств покрытии увеличивается несколько раз по сравнении изготовленным деталей полученным традиционным методом.

Калит сўзлар: Газ алангаси ёрдамида қоплаш, эритиш, қаттиқлик, ейилишбардошлик, доимий ейилиш, ишқаланиш коэффициенти, углеродли пўлат, юқори легирланган пўлат, метал кукунлари.

Аннотация: Илмий мақолада ейилишга бардошлиликни ошириш максадида деталар юзасига газ алангаси ёрдамида метал кукунларини қуйиш ва эритиш усули билан бу деталлар қайта тикланган. Олинган илмий натижалар, яъни тикланган деталларни эксплуатацион хусусиятлари анъанавий усулда олинган вал-шестерняга нисбатан бир неча бор ошганлиги кўрсатилган.

Numerous studies have shown that up to 70...80% of failures of gearbox parts occur due to wear of friction units, and significant funds are spent annually on their repair, a huge number of spare parts are produced, and thousands of workers are occupied in the repair and maintenance of machines, a huge amount is spent amount of material resources.

Analysis of faults during the technical operation of the gearbox indicates that the main share of failures is the gear wheel or gear shaft.

Types of damage to gears that occur as a result of changes in the geometry of the working surfaces occur due to mechanical, abrasive, fatigue wear and seizure of mating surfaces, resulting in the development of abrasive wear, fatigue spalling, seizing, scuffing, chips, and cracks.

The most common causes of failure of gears or a gear shaft are chipping and mechanical wear of friction surfaces [1]. Mechanical wear is the abrasion of the working surfaces of the teeth as a result of scratching, cutting action and plastic deformation by solid particles of an abrasive nature [2].

Gear drives operating in dusty air cannot be completely isolated from the penetration of abrasive particles between the gear teeth, even with seals, air filters, etc. This is explained by the fact that small particles (quartz, for example, up to 30 microns in size) are able to remain in the air for a long time without settling, and therefore they penetrate through most filters. Gradually, the internal volume of the crankcases and the oil located there, especially with crankcase lubrication, become saturated with abrasive particles. These particles are spherical, round, angular, lamellar, rod-shaped, needle-shaped, spongy, dendritic, etc. Among them, the most dangerous are angular.

According to the results of some researchers [3, 4], abrasive impurities reduce the service life of gearbox parts for the following reasons:

- wear of the cemented layer of the working surfaces of gear teeth;
- sharp acceleration of chipping of the working surfaces of gear teeth;
- acceleration of the wear process of bearings;
- disruption of the engagement of gears operating on shafts with worn bearings, which leads to a decrease in load-bearing capacity due to misalignment of the shafts;
- loss of performance of rotating shaft seals due to wear of support bearings.

The main components of the dust are: silicon dioxide - quartz SiO_2, aluminum oxide - alumina $A1_2O_3$, iron oxide Fe_2O_3, and in much smaller quantities - compounds of Ca, Mg, Na and other elements. The most common in dust is quartz, the content of which is 65...95%, which has angular shapes and hardness is 2...3 times higher than the hardness of many steels [5].

The analysis of the state of the issue allows us to conclude that the main reason for this is abrasive wear of gears, which can contribute to the development of other types of wear, for example, chipping, plastic deformation and destruction under the influence of bending forces [6].

Gear wheels or gear shafts with tooth thickness wear of more than 25% of the tooth thickness, which corresponds to approximately 30% of the module size, are not repaired, but replaced with new ones. Worn gears, the repair of which is considered economically unfeasible, are preferably replaced in pairs, even if one of the gears in the pair being replaced has acceptable wear. If the newly manufactured gear meshes with the old one, the new gear becomes unusable. Currently, there are many ways to restore gears and gear shafts. Among them, the economical and simple method is thermal spraying. Gas flame spraying involves heating, melting, dispersing the melt and transferring molten particles of the acetylene-acid flame of the material to the metal surface of the part, where it forms a stable continuous coating.

The gas-flame spraying method is the oldest method, it has still not lost its popularity due to its simplicity. To ensure operation, there is no need to use expensive installations. Only a supply of a mixture of flammable gas and compressed air is required. Unlike other methods, it is mobile and has the highest productivity and coating thickness [7]. Gas thermal spraying belongs to the group of classical resource- and energy-saving technologies. Often the mass of the applied coating is only a fraction of a percent of the mass of the entire restored part. Since the layer is applied with minimal allowances for subsequent processing, the cost of machining is lower. The temperature of the part during the spraying process, as a rule, does not exceed

60...80°C, which completely eliminates warping and deformation inherent in surfacing methods [8].

Currently, manufacturers produce a wide range of equipment for applying protective coatings using the flame spraying method.

In Fig. 1., a surfacing torch of the MST-100 brand is presented. On powder burners, the sprayed powder enters the burner from above from the hopper through an opening, is accelerated by a flow of transport gas (a mixture of oxygen - combustible gas) and, at the exit of the nozzle, enters the flame, where it is heated. Powder particles entrained by a jet of hot gas fall onto a previously prepared sprayed surface [9].

Fig.1. Surfacing torch MST-100

In Fig. 2., the scheme for applying the coating using the flame spraying method is presented [10].

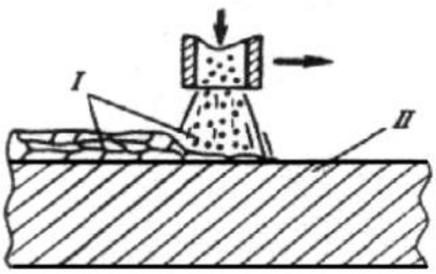

Fig. 2. Scheme for applying a flame coating. I - coating material, II - product.

Gas flame spraying is the process of heating metal, in powder form, to a liquid state, and transferring it with a jet of compressed air to the surface of the part. The sprayed material melts in the flame of a gas burner when burning flammable gas (usually acetylene or propane-oxygen mixture). The transfer of molten particles is carried out by a high-pressure air jet. When metal is transferred, impact collision and deformation occur. As a result, the transferred metal particles take the shape of the surface of the part and are connected to it [11].

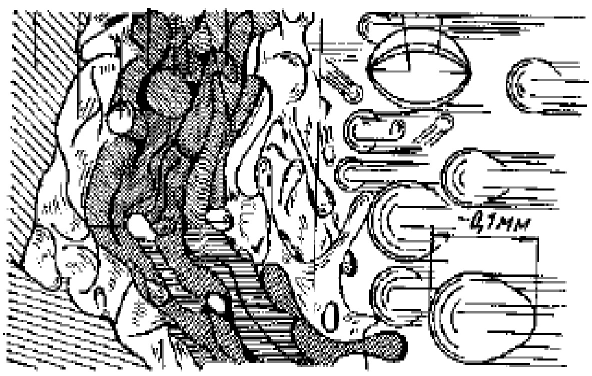

Fig.3. Flame spray coating process.

The main characteristics of the coating in flame spraying are following:

- Spray layer thickness 0.5 -10 mm;
- The porosity of the sawn coating is 5-12%;
- Adhesion strength of the coating to the base 2.5 -5.0 kg/mm² [12-15].

State Unitary Enterprise "Fan va Tarakkiyot" TSTU named after Islam Karimov has developed a technology for producing wear-resistant coatings using flame spraying followed by melting.

When using gas flame spraying followed by melting, the sprayed surface is initially heated in a SNOL-3.5 furnace to a temperature of t=200°C. Then the part is installed at the workplace, i.e. lathe by periodically pressing the burner lever, powder is supplied to the part. By moving the burner flame along the surface to be hardened at a speed of 2...3 mm/sec, powder of the PX18H9T brand is uniformly applied. Gas flame spraying is carried out in the following mode: oxygen pressure 0.4...0.45 MPa, acetylene 0.07...0.1 MPa, spraying distance 200 mm, angle of attack 900, productivity 1.5...2.5 kg /h, powder fraction 40...63 microns.

After spraying the powders, the coating is melted with the same burner using an oxygen-acetylene flame, but without supplying powder. The area covered with powder is heated until all the metal grains in the sawn layer are completely melted, resulting in a shiny surface. The coating is melted at a temperature of 1000^0C.

We determine the coefficient of friction of samples made of material Steel45X, gas-flame spraying without melting material from high-alloy steel grade PX18H9T, and gas-flame spraying with melting material from high-alloy steel grade PX18H9T.

In accordance with the requirements of GOST 28844-90 "Gas-thermal strengthening and restoring coatings. General requirements" metal powder was applied to samples consisting of a disk with outer diameter D=50mm and inner diameter D=15mm, thickness 12mm, followed by melting. The chemical composition of powder grade PX18H9T consists of Fe -72%, Cr-18%, Ni-9%, Ti-1% according to GOST 13084 – 88 [15-22]. To apply the powders, a surfacing torch MST-100 was used, which was equipped with an installation operating on an oxygen-acetylene flame. The recovery method used is described in a number of works [3-8]. Control samples of steel disks with a diameter of 50 mm had a hardness of 48-52 HRC.

The friction coefficient was calculated at certain time intervals according to the known dependence [7, 19, 22]:

$$f = \frac{M_{TP}}{N*R}, \qquad (1)$$

where, M_{TP}– friction moment, according to the readings of the registration device, N•m;

N – radial load, N; R – friction radius along the center line of the friction track on the counter body, m. Radial load is calculated using formula (2):

$$N=P*S \qquad (2)$$

Where, P – contact pressure, MPa; S – contact area of samples, m^2.

The test results show changes in the friction coefficient as a function of test time (test duration at load N=400 N) in Fig. 4.

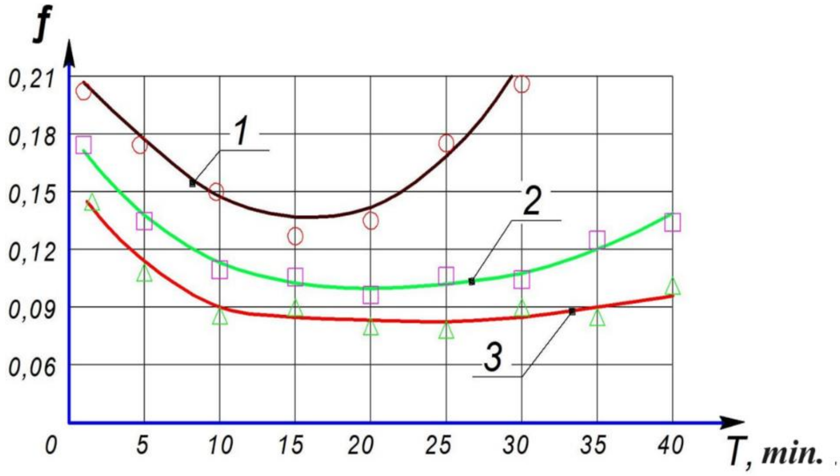

Fig.4. Changes in the friction coefficient depending on test time (test duration at load N=400 N)

1-o-line, machining of material Steel40X, 2-□- line, flame spraying without melting material made of high-alloy steel grade PX18H9T, 3- Δ-line, flame spraying with fusion material made of high-alloy steel grade PX18H9T.

From Fig.4., it can be seen that the nature of the change in the coefficient of friction over time showed that the sample 1-o-line from the beginning **ƒ** decreases and then sharply increases, and for samples with a coating without melting the 2-□- line during the test showed that from the beginning **ƒ** decreases subsequently increases significantly. 3-Δ-line, gas-flame spraying with melting of the material from high-alloy steel grade PX18H9T decrease in the coefficient during the running-in period, then it stabilizes and practically does not change in the future. Based on the results of the study, we can conclude that gas-flame spraying with melting of high-alloy steel grade PX18H9T reduces the coefficient during the running-in period, then it stabilizes and practically does not change in the future.

The reduction in the friction coefficient of samples obtained by gas-flame spraying with subsequent melting of high-alloy steel grade PX18H9T compared to Steel 45X is 1.5 and 2 times

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