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INCREASING THE STRENGTH OF THE SURFACE LAYERS OF WORN MACHINE PARTS IN EFFECTIVE WAYS

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ABSTRACT

In modern mechanical engineering, progress is determined by the ability of the material of machine parts to resist in the course of operation, which increases with the improvement of products of various types of loads. The main part of machine parts fail due to wear and tear, and repair costs are constantly increasing, solving the problem of strengthening and restoring the working surfaces of parts is given great importance. One of the promising ways to increase the service life of the most loaded parts can be the use of protective coatings for various purposes. This article contains materials on the choice and application of an effective method for restoring machine parts.

KEYWORDS: *detal, wear, recovery, thermal spraying, plasma method, detonation spraying.*

1. INTRODUCTION

The reliability and durability of machine parts and mechanisms is determined by the structural strength of the materials from which they are made. The performance characteristics of many products – wear resistance, corrosion resistance, reflectivity, heat resistance, and others-are determined by the properties of the surface. To obtain high structural strength characteristics of surface layers, various coating methods are often used to protect the base material from external influences, increase the service life of parts and reduce the cost of repairing worn equipment. Coatings are applied both to protect the surface from various types of impacts (high loads, temperatures, various aggressive environments) and for decorative purposes, and to restore the broken geometry of products [1].

Materials science of coatings is a large section of knowledge about a special class of functional materials. All coatings can be divided into two types according to the principle of interaction with the surface: 1) changing the chemical composition of the surface (chemical-thermal treatment); 2) applying a new material to the surface (spraying, deposition, surfacing, applying enamels and paints). If the formation of diffusion coatings during chemical-thermal treatment obeys General

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ideas about structural and phase transformations in metals and alloys, then the multi-factor nature of coating processes leads to a more complex picture of the structure and properties of the surface [2].

According to the method of coating application, they are classified into diffusion, thermomechanical, chemical, surfacing, gas-thermal, electroplating, contact, enamel, paint, combined and vacuum-plasma. Gas-thermal coatings are one of the most advanced and effective methods of protecting the surface of parts.

Characteristics of coatings obtained by deposition methods (gas-flame, plasma and detonation), in which the heated smallest particles are dispersed by the compressed gas coming out of the nozzle and sent to the coated surface, where they form a layer.

It is used to protect parts from corrosion, decorative finishing, restore worn-out rubbing surfaces, correct casting defects, increase electrical conductivity and wear resistance.

The essence of the processes of gas-thermal coating is the formation of a directed flow of dispersed particles of the sprayed material, which ensures their transfer to the surface of the processed product and the formation of a coating layer.

The coating is created due to the adhesion that occurs when particles collide on the surface of the base. The sprayed particles can be a powder or can be obtained by melting and gas crushing of the source material-wire, rods, plasticized mass, etc. various high-temperature gas media are used to disperse the particles. Heating of the sprayed material is carried out to increase the plasticity and adhesion ability of the particles.

Gas-thermal coatings, as well as surfacing, are applied to protect the surface from wear and high temperature, and are also widely used to restore the broken (during production or operation) geometry of the product.

There is no unified classification of methods of thermal gas deposition. According to the GOST 28076-89 standard, gas-thermal coatings are divided into classes according to their functional purpose and energy characteristics, since the fundamental difference between gas-thermal spraying technologies is determined by the type of energy source.

Most methods of thermal gas deposition are universal, as they allow you to apply a wide range of materials. Materials for spraying, in turn, can have different shapes (powders, wire, rods).

According to the form of the sprayed material, gas-thermal coating methods are divided into gas-flame, plasma-arc, electric-arc and detonation-gas methods.

2. MATERIALS AND METHODS

The gas-flame coating method uses heat generated by the combustion of flammable gases (acetylene, propanbutane, hydrogen, methane, natural gas, etc.) in a mixture with oxygen or compressed air (Fig. 1). the Temperature of the combustion products of combustible gases reaches 2000–3000 ° C. Acytilene-oxygen flame has the highest specific heat flow, so it is the most common. Depending on whether or not the combustible gas with the oxidizer was moved before being fed to the combustion zone, there is a distinction between a pre-moved and a diffusive flame.Gorenje.

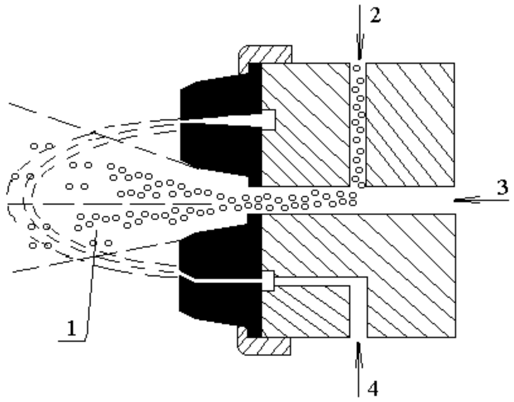

Fig. 1. Diagram of the gas-flame coating process from powder materials:
1-gas flame; 2-powder supply; 3-compressed air supply; 4-supply of a combustible gas mixture

When the gas flows out into an unlimited space filled with air or other gas, it forms a jet called a torch. The peripheral sections of the jet involve air or other gas from the environment. As the driving mass increases and its speed decreases, the cross section of the jet continuously increases and the entire jet takes the form of an expanding cone. The opening angle of the jet is approximately 25°.

The powder is fed, as a rule, along the axis of the flame torch, inside it. The temperature when using acetylene as a fuel gas reaches 3200 ° C, and the flow rate is 150-160 m/s. Getting into the jet, the powder particles melt or become highly plastic and acquire a speed of 20-80 m/s. The speed of flight of powder particles depends on the ratio of oxygen and combustible gas in the mixture, the flow rate of the blowing gas, the distance from the nozzle section, the flow rate of the powder introduced into the flame, its density, granulometric composition, and other factors.

If the sprayed material has the form of a rod or wire during the gas-flame process, it is fed by a special Electromechanical drive into the Central hole 3 (Fig. 1). In area 1, the formation of melt drops occurs, which are transferred by a jet of compressed air to the surface of the processed product.

The advantages of flame spraying coatings include:

1) The ability to obtain coatings from most materials that melt at temperatures up to 3000 °C without decomposition;

2) Sufficiently high process performance (up to 8-10 kg / h of self-fluxing alloy powders) with a high material utilization rate (more than 95 %);

3) Relatively low noise and light emissions, allowing the operator to work without additional protection;

4) Ease and ease of maintenance, low cost and mobility of equipment, which allows you to spray on the spot, without dismantling the products.

The plasma method is the most versatile and technological process of thermal gas deposition. Coating consists in forming a layer of particles on the surface of a part (product, structure) that have a certain amount of thermal and kinetic energy obtained as a result of interaction with a plasma jet. The temperature of the plasma jet reaches 5000-5500 ° C, and the flow rate is 1000-1500 m/s. In a plasma jet, particles acquire a speed of 50-200 m/s. The speed of particle flight depends on their size, material density, arc current, nature and flow rate of the plasma-forming gas [3-5].

Plasma jets are produced in special devices called plasma generators or plasmatrons (Fig. 2). the Plasmatron consists of a water-cooled cathode, an anode and an insulator separating them. Plasma-forming gas (argon, high-purity nitrogen, helium, hydrogen, etc.) is fed into an electric arc excited between the rod cathode and the annular anode (nozzle), heated and flows out of the nozzle as a plasma jet. The sprayed material is introduced into the plasma jet in the form of a powder or wire behind the anode spot; it is possible to enter the arc with a plasma-forming gas.

During plasma spraying, the powder is blown into the plasma jet by a transport gas directly through the special holes of the plasma torch (Fig. 2, a). Wire and bars can be fed in two ways (Fig. 2, b, c).

The advantages of this method are:

1) The ability to obtain coatings from most materials that melt without decomposition, without limiting the melting temperature;

2) The possibility of using various gases for the formation of an arc plasma jet: inert (argon, helium), reducing (hydrogen) and oxidizing (air, nitrogen), as well as ammonia, natural gas, water vapor, which in combination with the use of chambers with a protective medium (vacuum) or protective nozzles allows you to regulate the properties of the medium in which the powder particles are heated and move;

3) The possibility of flexible regulation of the electric and gas modes of operation of the plasma torch, including during the coating process, which allows you to control the energy characteristics of the sprayed particles and the conditions of coating formation;

4) Sufficiently high process performance: 3-20 kg / h for plasma torches with an electric power of 30-40 kW and 50-80 kg/h for plasma torches with a power of 150-200 kW;

5) a fairly high powder utilization rate (50...70%), depending mainly on the type of material being sprayed.

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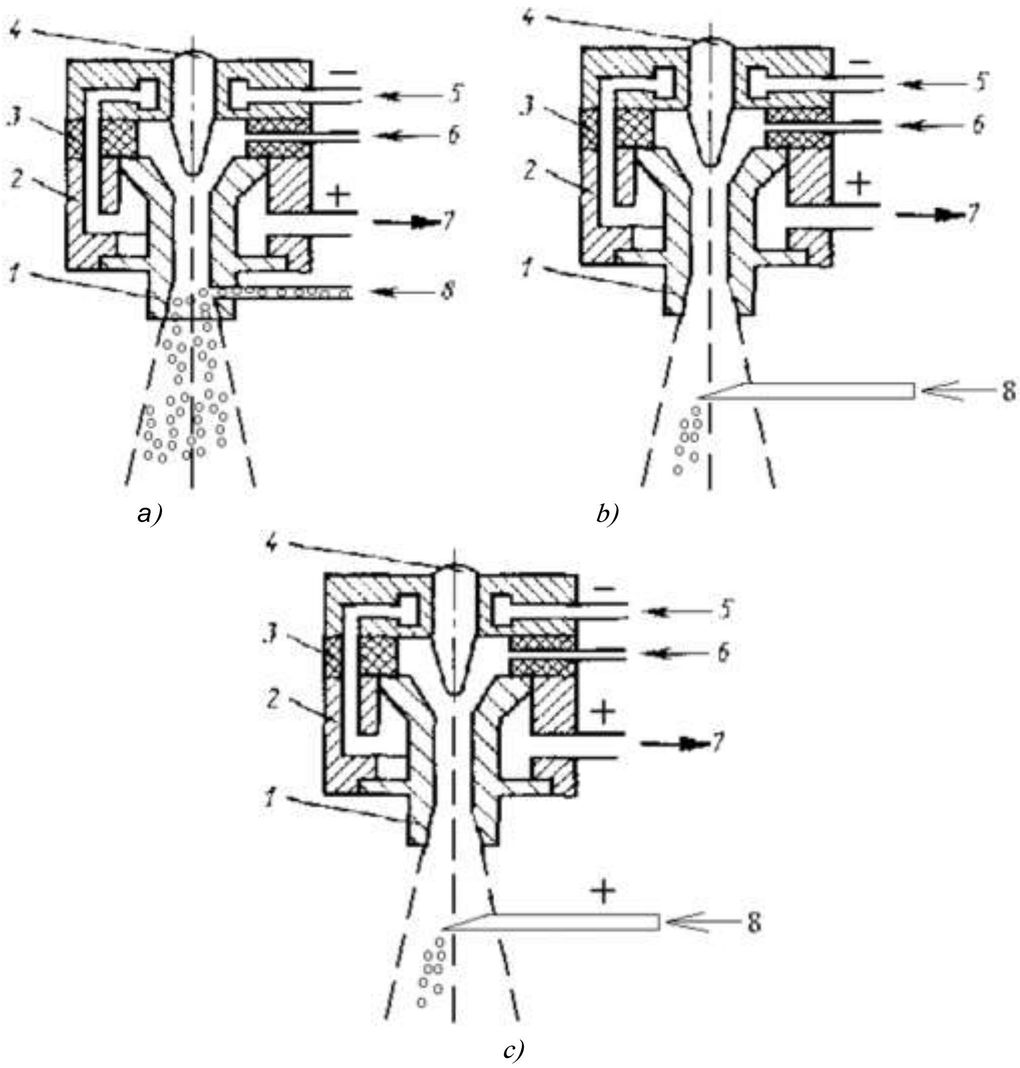

Fig. 2. Scheme of plasma deposition of powder materials (a); wire and bars (b, c):
1-water-cooled nozzle (anode); 2-housing; 3-insulator; 4-electrode (cathode); 5, 7-water supply and discharge; 6-plasma-forming gas supply; 8-atomized material supply

The essence of the electrometallization sputtering process consists in melting the wire with an electric arc and spraying the molten metal with compressed air.

During electric arc metallization (Fig. 3), a voltage is applied to the wires from the sputtered material 1 from a DC welding current source and an electric arc is excited. Compressed air is fed into the arc gap through the nozzle 2, which transfers the molten metal of the wire in the form of small drops to the surface of the processed product. The product is usually located at a distance of 10-20 cm from the metallizer nozzle. Instead of compressed air, an inert argon gas is sometimes used. This allows you to avoid significant oxidation of the sprayed material and improve the quality of the coating.

Arc metallization is a high-performance process that is several times superior to gas-flame spraying, allowing to obtain coatings with higher adhesion strength.

One of the main problems in the light industry is to increase the service life of machine parts and aggregates by using inexpensive and effective methods of strengthening the most worn working surfaces, as well as their recovery during repair. In this industry, there is a very acute problem of wear of equipment, many elements of which work at high sliding speeds in contact with polymer materials, significant inertial and alternating loads, often in conditions of abrasive friction and limited supply of lubricant. The use of detonation coating for these purposes may be a very promising direction. The small overall dimensions of most parts, complex

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configuration and relatively high manufacturing accuracy make it advisable to use detonation spraying. The adhesion strength of the sprayed layer to the substrate can reach 200-250 MPa with a thickness of up to 2.0-2.5 mm, and the hardness is not inferior or superior to the original hardness of the sprayed surface. Due to the cyclical nature of the process, the heating temperature of the part is significantly lower than the level of structural changes, it is excluded from overheating and, consequently, warping, loss of properties obtained during heat treatment [6-9].

During detonation spraying, heating and dispersal of the particles of the sprayed material is carried out at the expense of the energy of the detonation products of the gas mixture. The speed of propagation of the detonation wave is 2000-4000 m/s, and the temperature reaches 2200-5500 ° C (depending on the composition of the mixture). This ensures that the particles reach speeds of 600-1000 m/s.

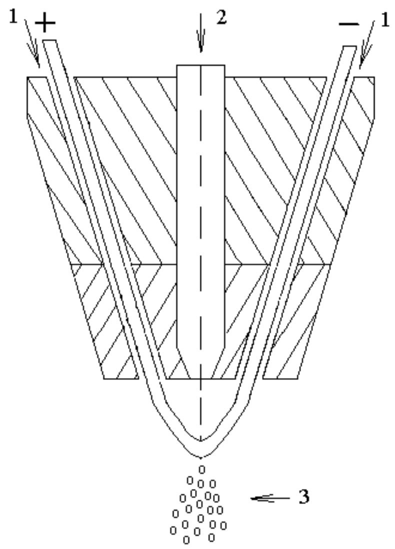

Fig. 3. Arrangement of electric arc metallization:
1-sprayed material (wire); 2-compressed air nozzle;
3 particles of the molten material

Detonation deposition is a cyclical process. The device for spraying (Fig. 4) is a channel of round or rectangular cross-section, closed at one end. Combustible gas and powder are fed into the channel through special mechanisms. For ignition, use 3 fuses, which are located near the closed end.

The operating cycle of a detonation gun consists of the following processes:

1) Filling the chamber with flammable gas;

2) Dosing and feeding of the sprayed powder;

3) Ignition and combustion of a combustible mixture that leads to the occurrence of a detonation wave;

4) Formation of particle flow;

5) The expiration of the detonation products outside the channel and the discharge of the shock wave;

6) Formation of a single spray spot on the treated surface;

7) Filling the channel with a phlegmatizing gas to remove Gorenje products (the channel is usually filled with a combustible mixture after pre-purging, which excludes the possibility of ignition in contact with hot detonation products).

Nitrogen, oxygen, acetylene, propane-butane are used as working gases.

The size and shape of parts for detonation-gas coating are limited only by the technological capabilities of devices for moving products (detonation-gas gun) and the size of the soundproof box (chamber) in which processing is performed.

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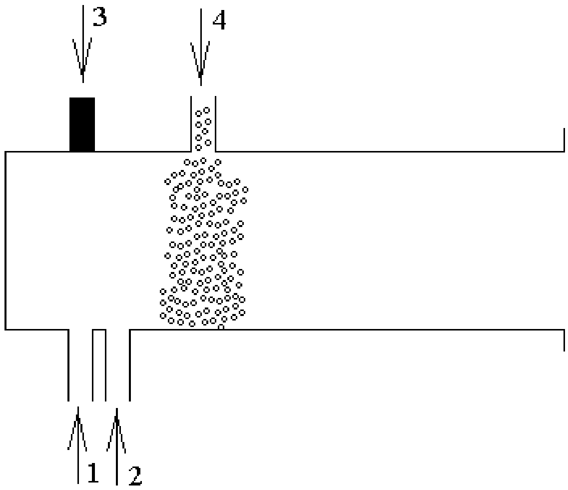

Fig. 4. The scheme of the detonation spraying:
1-supply of phlegmatizing gas (nitrogen); 2-supply of a combustible mixture; 3-explosion initiation unit; 4-powder feed

3. RESULTS AND DISCUSSION

The advantages of this technology are:

1) The possibility of obtaining a coating with increased adhesion strength (10-160 MPa) and density (porosity 0.5-1 %) due to the high kinetic energy of the particles of the sprayed material;

2) The possibility of applying strongly bonded coatings on certain types of substrates (steel, Nickel alloys, etc.) without jet-abrasive surface preparation;

3) Relative ease of installation design.

The technological scheme of the process of obtaining gas-thermal coatings, depending on specific tasks and technologies, may contain a different number of operations. In General, the entire cycle of applying thermal gas coatings can be divided into the following stages:

- Input control;
- Surface preparation for spraying;
- Main coating spraying;
- Processing of products with gas-thermal coatings (mechanical, impregnation, thermal, etc.);
- Output control.

For the formation of a thermal spray coating with a high level of properties it is necessary to conduct a preliminary surface treatment of the product. Pre - cleaning of the surface from contamination increases the probability of formation of chemical bonds between the sprayed material and the base. Creating a rough surface increases the length of the border and the number of "welding" places between the sprayed layer and the base, and can also contribute to the mechanical adhesion of the coating to the base. All this leads to an increase in the adhesion strength of the sprayed material to the product.

The quality of the coating largely depends on the cleanliness of the product surface. The presence of dirt, oxide and oil films on the surface reduces the adhesion strength of the sprayed material to the base.

After gas-thermal spraying, most often the part size and surface quality do not meet the required parameters. Therefore, often after spraying the parts with coatings are subjected to final processing (mechanical, thermal, etc.).

Product quality control after spraying is a necessary operation of the technology that ensures the reliability of the product. The multi-factor nature of the gas-thermal spraying process makes it sensitive to deviations in the mode and increases the significance of the coating quality control element.

To obtain coatings by gas-thermal spraying methods, materials in the form of powders, wire, rods (rods) and flexible cords (powder wire) are used.

The main type of materials for thermal spraying are powders. To ensure a uniform feed and good aerodynamic performance of the powder, mainly spherical (or spheroidized) particles are used. To prevent active burnout of the sprayed material, a fraction of at least 10 microns is used. The average diameter of powder particles for gas-thermal spraying and the breadth of the range of fractions used depends on the spraying technology and the required coating properties. For example, powders of Nickel self-fluxing alloys with gas-flame sputtering have a fractional composition of 36 ... 106 microns or 45 ... 125 microns (depending on the type of burner), and with plasma sputtering – 15...53 microns.

Powder materials are the most common in the practice of thermal spraying. Powders allow you to form coatings with a wide range of properties and various purposes – wear-resistant, corrosion-resistant, coatings for restoring the broken geometry of parts, decorative and others.

Detonation spraying is widespread in various sectors of the national economy, both for strengthening the surfaces of new parts and for restoring worn ones.

4. CONCLUSION

Thus, the most effective way to protect the surface of products from various types of impacts: wear, high temperatures and aggressive environments is the use of basic methods of gas-thermal coating, as well as detonation spraying.

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