Problems of Tribology, *V. 27, No 2/104-2022, 80-86*

Problems of Tribology
Website: http://tribology.khnu.km.ua/index.php/ProbTrib
E-mail: tribosenator@gmail.com

DOI: https://doi.org/10.31891/2079-1372-2022-104-2-80-86

Properties of coatings obtained by electric arc spraing for renovation of parts of machines and vehicle mechanisms

A. Lopata[1*], M. Holovashchuk[2], L. Lopata[3], E. Solovuch[4], S. Katerinich[4]

[1]National Technical University of Ukraine "Igor Sikorsky, Polytechnic Institute", Ukraine
[2]National Transport University, Kyiv. Ukraine
[3] G. S. Pisarenko. Institute for Problems of Strength of the National Academy of Sciences of Ukraine
[4]Central Ukrainian National Technical Universityi, Ukraine
E-mail: beryuza @ukr.net

Received: 20 April 2022: Revised: 20 May 2022: Accept: 07 June 2022

Abstract

The robots present the results of investigating the power of coatings, excluding electric arc (EAS) filings, and their comparison with the powers of coatings, excluding gas-flame filings. The porosity of the coating, taken from electric arc filings, was in the range of 8-10%. the adhesion strength was 80…100 MPa. The results of the investigations show the advantages and purpose of using electric arc sawing to improve and move the capacity of machine parts and transport mechanisms. In the work, the following factors are added to the process of electric arc sawing: storage of fuel sum, distance of sawing, dispersion of sawing and other. on authority cover. In the course of the investigation, the increase in resistance, adhesive strength, coating thickness, the term for the coating thickness, was determined by the parameters of the electric arc filing. The robots have considered the possibility of securing the necessary authorities influencing the surface with the method of advancing the resource of machine parts by way of regulation by the factors of EAS. Regulating the smoothness and temperature of the stream of transporting gas and particles, you can change the diameter of the droplet, increase the width and reduce the oxidation of the coating. The results of comparative analysis of the properties of coatings applied by electric arc spraying (EAS) using the products of combustion of propane-air mixture and gas-flame spraying (**FSP**) using gas-air mixture are presented. Under optimal conditions of the spraying process, the porosity of the coatings obtained by electric arc spraying is much lower compared to gas-flame spraying: 8-10% and 20-30%, respectively. Adhesion strength of coatings obtained by electric arc spraying increased by 1.8-2.2 times (from 30-40 MPa in gas-flame spraying to 100 MPa in electric arc), wear resistance increased by 2-2yu5 times.

Key words: electric arc spraying, coating**,** flame spraying, porosity, adhesion strength, wear resistance, corrosion resistance, thickness coating, gas permeability

Introduction

The service life of vehicles is inextricably linked with the problem of increasing the wear resistance of its parts. Cam - and crank-shafts are the most responsible and expensive engine parts. During operation, alternative loads on the shaft promote the following phenomena:

- friction and wear of its necks;
- fatigue failures in the neck-to-web passages and at the oil channel outlets;
- bending and twisting owing to its bending, torsion and axial vibrations [1-3].

The shaft neck - bearing coupling operates under conditions of hydrodynamic lubrication. However, the stability of conditions of hydrodynamic friction is frequently broken and semiliquid and sometimes semidry frictions arise, for example, at the start moment or other short-time overloading of the engine. Under such conditions, the wear rate of shaft and bearing surfaces increases [1-3]. However, the behavior of shaft, the webs of which have been recovered via deposition of a coating, is different. Pores in a coating are filled with the oil which flows out of pores due to the shaft rotation. The oil immediately forms a protective film located around the

Copyright © 2022 A. Lopata, M. Holovashchuk, L. Lopata, E. Solovuch, S. Katerinich. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

shaft neck. Moreover, resulted from abrasion metallic particles are pressed into pores moving away from the friction region.

Techniques for prolongation of the service life of crankshafts, which are the most expensive parts of transport means, have been studied well enough and are still being improved. As a rule, inserts and bushes, which form triboconjuctions with crankshafts, wear sooner. In most cases, they are not renewed and instead replaced with new ones. Traditionally, the working layers of inserts and bushes are made from low-friction materials on the basis of copper, tin, aluminum and their alloys. Herein scarce and expensive nonferrous metal is spent uneconomically. Increase in the service life and reduction in expenses for manufacture and maintenance of friction pair parts (crankshafts, inserts, bushes et al.) of transport machinery is one of the most important problems to be solved by scientific researchers, technologists and constructors.

The carried out researches works have shown that one of the most efficient ways to the solution of this problem is the use of electric arc spraying (EAS) for deposition of coatings. The shortage of spare parts has become a major problem in the efficient use of vehicles. The development of international cooperation leads to continuous rise in application of transport means produced abroad, whose maintenance requires steady increase in the quantity of various spare parts. Under the conditions of the broken economic ties and increasing international cooperation, the development of modern technologies for strengthening and protection of new parts against corrosion and renewal of worn ones will make it possible to improve the reliability and longevity of transport means as well as to significantly weaken the dependence on foreign providers of important expensive metal-consuming scarce parts. Herein selection of techniques for strengthening, corrosion protection and reconstruction of parts, which must provide ecologically conscious production, long service life of parts and be universal enough, simple and available, is of great importance. Methods for plasma and detonation spraying, which have been counted on in prolongation of the service life of parts for transport means, require bigger expenses because of expensive equipment and gases. In the current world engineering which deals with the development and application of techniques for deposition of protective coatings and renewal of parts using thermal spraying, more and more attention is paid to electric arc spraying. Nowadays this method is widely applied, especially in the European countries and steadily replays the traditional gas flame method thanks to many advantages as follows [1 -5]:

- the required equipment is produced and is simple and cheap;
- the developed equipment for EAS permits deposition of coatings, the quality of which does not yield coatings obtained by plasma and denotation methods;
- increased thermal effectiveness up to 57 % as compared to 13 and 17 % for gas flame and plasma spraying, respectively;
- high efficiency, which is 3-4 times higher than that for gas flame spraying;
- the absence of need in scare gases;
- availability of power sources for metal melting;
- possibilities of mechanization and automation;
- manufacture of better coatings with higher adhesion strength as compared to gas flame spraying.

The tendency to replace a gas flame rod spraying with EAS has appeared lately. However in the beginning, EAS was only aimed at corrosion protection of welded metallic constructions, and properties of electric arc coatings for other purposes have not been studied properly yet. Therefore implementation in industry of EAS in order to prolong the service life of parts and renew them for provision of transport enterprises with spare parts is an actual task.

The purpose of the work

The purpose of the work was to investigate properties of EAS-derived coatings designed for prolongation of the service life and renewal of friction pair parts (crankshafts, inserts, bushes et al.) of transport machinery.

Properties of coatings obtained by electric arc spraying

The main physicomechanical properties of EAS coatings affecting their operation characteristics are the adhesion strength and porosity. The physical and mechanical properties of experimental samples of coatings made of steel 40Kh13 by arc metallization on an EAS installation were studied [6, 7]. As a result of the conducted experiments, the dependences of the adhesion strength, porosity and gas permeability of coatings on the spraying process parameters such as the current and voltage of arc, spraying distance, speed of spraying apparatus movement relative to the base surface, pressure of the compressed air or combustion products in the distributor head of the electric arc apparatus as well as on the surface pretreatment have been established. The base surface was prepared for spraying using bead blasting treatment. The roughness of the prepared surface (R_Z) fell in the range 5-60 mcm. Before spraying samples were fixed in a special device located in the holder of the lathe. Arc spraying apparatuses were placed on the support of the lathe. The speed of the apparatus movement relative to the sample surface and the spraying distance could be governed by varying the revolution number of the spindle and the support-spindle distance.

The EAS unit was a modern universal system which combined advantages of electric arc and high-rate spraying. Its chief distinctive feature is the presence of a small high-efficiency chamber for combustion of propane-air mixture, whose ultrasonic jet left the chamber with a speed of 1500 m/s at 2200 K. The flow strength, determined by the ratio of the kinetic energy to the gas volume and characterizing the force acting on a particle in the flow, was equal to 234 kPa. The latter permitted melted metal particles to speed up to 500 m/s and to form a coating with doubled adhesion strength compared to flame spraying and sufficient for operation under extreme conditions including the presence of shock-abrasion wear.

The use of the products of propane-air mixture combustion as a spraying gas significantly decreased oxidation of sprayed metal and burning-out of alloying elements. For example, at the fuel combustion coefficient b=0.4 the carbon amount in the coating made from 40Kh13 rods practically did not differ from that in the initial rod. However at equal amounts of air and propane the carbon content in coating was lower than that in the initial material by two times, whereas in spraying by pure air the carbon content decreased by three times.

The conditions of formation and transport of particles as well as of coating formation, which differ from other methods, lead to formation of different structures in the coating material. The small amount of brittle oxides, high content of intermetallic compounds along with formation of hardening structures and high enough plasticity of the deposited layer create favorable background for application of this method for strengthening and renovation of parts of transport means and essentially widen the nomenclature of parts that can be renewed. Moreover, under high-rate spraying conditions, the coefficient of material concentration in the jet increases as the divergence angle of two-phase supersonic jet is smaller as compared to undersonic jets and is equal to 5-7°. As a result, the diameter of deposited spot decreases and the coefficient of material consumption increase.

For EAS it reaches 0.85 against 0.75 for flame spraying. As a material for spraying, a wire from any commercial material (zinc, aluminum, copper, brass, bronze, nichrome, carbon and stainless steels, etc.) can be used as well as a powdered wire or combination of any two wires. The porosity of steel coatings is within 2-4 %; density of aluminum wires is close to that of cast material. This factor is particularly important in production of anticorrosion coatings as herein significant saving of spraying material is attained at the expense of decrease in the coating thickness required for closing of through porosity, and thus the service life of coatings increases. For spraying, 2.0 mm 40Kh13 wires (GOST 5632-72) were used. The process conditions were as follows: arc voltage 32 V, spraying distance 50 - 200 mm, arc current 100-400 A, compressed air consumption 80 m^3/h, pressure 0.65 MPa; when the apparatus EDN was used, propane-butane consumption was 0.011 kg/h, pressure 0.4MPa.

Technique for researching the properties of coatings

The porosity of coatings was determined via hydrostatic weighing according to GOST 18893-73. In order to study distribution of pores through a coating and to determine their size and shape, the system of texture analysis of images Leitz TAS" (Germany) was used composed of a microscope “Ortoplan” with a TV camera, a unit for processing of TV signals and a display. The system operates under the control of a computer designed on the basis of microprocessor LS1 - II/2. To examine coatings, metallographic samples were prepared according to the standard techniques [8]. To determine gas permeability of coatings from steel 40Kh13, samples were made in the form of a bush with a hole and a conic end pin from steel 20. Before spraying, the end surface of the tin was subjected to jet-abrasion treatment for modeling of surface roughness followed by heating in air to 700-760 K for 3-5 min. In such a way, a thick oxide film was formed which prevent from the evolution of chemical interaction between the materials of coating and base. The pin was inserted into the bush, and spraying started to the achievement of required thickness of coating. Then the pin was carefully separated from the coating and taken out the bush hole. The coated sample was put into a unit for measurement of gas permeability.

The coating thickness was measured with a micrometer; the area was determined on the basis of the bush hole before spraying. The adhesion coating-part strength was estimated using a glue method [8]. Metallographic examination was performed on an optic microscope MIM - 8 with the magnification 90-200 and a SEM microscope "MSV-2" (firm "Akasi") with the magnifications 100 and 200. Samples for metallography were prepared using standard techniques [8]. Roughness of the surfaces of base and coating was estimated on a profilograph-profiler of type 201.

Results of experimental studies

The analysis of the structure of coatings produced using electric arc and flame spraying revealed that the latter provides particle sizes which are 5-6 times smaller compared to traditional spraying. Consequently, the sizes and quantity of pores in EAS coatings decreased by 2-3 times.

Gas permeability is a structure-sensitive characteristic of coating, and there is a distinct enough dependence of it on open porosity [8]. Under optimal spraying conditions, the porosity of EAS coatings is much lower than in the case of liquid metal spraying with cold air (2-4% and 9-11%, respectively), and the gas permeability is lower by approximately 30-40 times. This may be related to the essential decrease in the sizes of pore channels in coatings. Fig. 1 demonstrates the curves of pore size distribution for coatings obtained by electric arc and flame spraying.

The analysis showed that for EAS the number of pores is much smaller. Herein the minimal porosity and gas permeability are attained at spraying distances within 50-60 mm. In case of high-efficiency spraying, that is, at currents of 400 A and higher, high enough apparatus movement speed (relative to the base) is required. There was observed different dependences of the porosity (P) on the spraying distance (L_s) for coatings obtained by electric arc and flame spraying.

The porosity of EAS coatings obtained at the minimal apparatus speed, that is, after a one-run deposition, decreased with shortening the spraying distance to 100 mm, but then it increases to the values characteristic for EAS coatings. The speed increase results in decreasing porosity in coatings obtained at small distances (L_s < 80-90 mm). Slight decrease in porosity is observed in flame spraying (FSP) coatings as well. The weak effect of the spraying apparatus speed on the coating porosity at distances L_s > 80-90 mm is caused by weakening of the aerodynamic effect of the reflected plane jet and cooling of d_p<1 mcm particles to temperatures, at which they do not adhere onto base asperities.

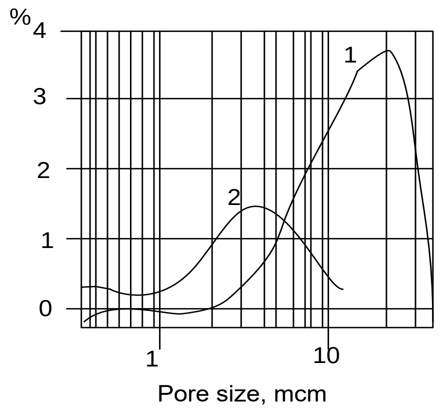

Fig. 1. Pore size distribution: (1) flame spraying FSP; (2) electric arc spraying EAS

The peculiarities of the effect of the arc current (I_a) on the coating porosity are worth noticing. Whereas at big arc currents an increase in the spraying apparatus speed (V_M) markedly decreases porosity, spraying at small currents practically does not affect it. This may be prescribed to small both spraying efficiency and mass-average particle temperature at small arc currents [8, 9]..

Properties of anticorrosion electric arc coatings depend on not only the value but also the type of porosity. The authors [8, 9] have proposed to divide porosity into a volume and a surface one as at a layer thickness commensurable with the average microasperity height a drastic change in porosity occurs, which, in its turn, is accompanied by a drastic change in structure-sensitive characteristics of coating, for example, gas permeability.

The investigation of the effect of the thickness of coating on its porosity has shown that the EAS method provides a decrease in the porosity (Fig. 2a). The profilograph indicate the fact of decrease in the surface roughness of a EAS -derived coating. The average microasperity height of the 0.1 mm thick steel coating deposited on a polished base surface at a spraying distance of 100 mm was 5-10 and 30-50 mcm for EAS and FSP, respectively.

Such a marked decrease in the EAS coating porosity (for example, at a coating thickness of 0.05 mm the porosity of coatings under the comparison differ by almost an order of magnitude (Fig. 2, a) inevitably causes still greater difference in the gas permeability (Fig. 2, b). For FSP, reduction in the coating thickness, h <0.1 mm, leads to rapid decrease in the gas permeability.

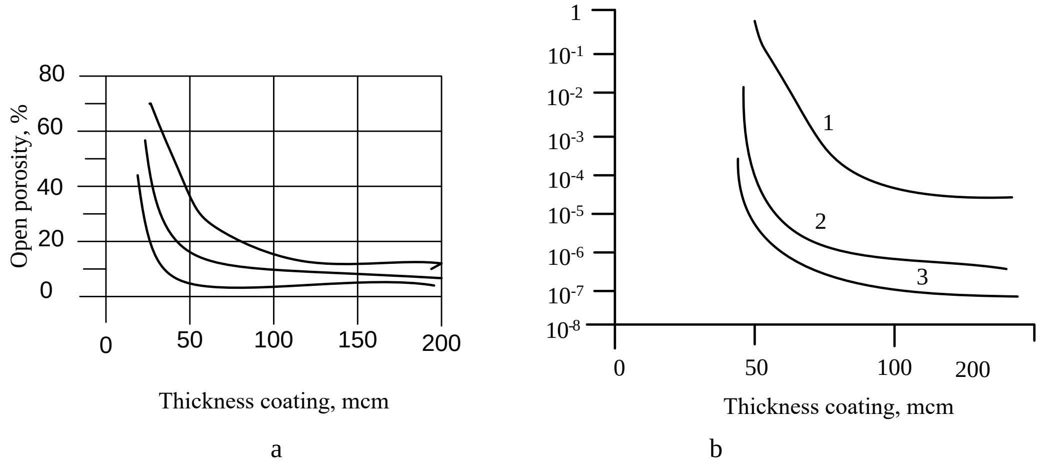

Fig. 2.The effect of the coating thickness on (a) the open porosity and (b) gas permeability: (1) FSP; (2,3) EAS at a coating thickness of (1,3) 100 mm and (2) 50 mm

The reduction in surface roughness of the EAS coating is connected with the particle size decrease and may be the main reason for lower coating open porosity at small thicknesses due to decrease in the surface component of porosity due to bigger surface roughness.

Similar picture is observed in case of EAS, but only beginning with h = 0.05 mm. The sharp rise in the gas permeability may be related to the appearance of a through porosity [8, 9]. Hence, the gas permeability of steel coatings made using the EAS method is lower than that of FSP coatings by 1-2 orders of magnitude. h = 0.05-0.1 mm this difference reaches 4-5 orders of magnitude.

To reach required adhesion strength, which is determined by mechanical or physicochemical bonds depending on the materials of the “coating-base” pair [8, 9], the base surface pretreatment is conducted. The most used technique is jet-abrasive treatment, which purifies the surface and destroys its equilibrium state with the medium by release of interaction forces of surface atoms, that is, chemically activates the base. Unfortunately, the base activity rapidly decreases because of chemical adsorption of air gases and oxidation. It is therefore desirable to shorten the time between the pretreatment and spraying as much as possible. The pretreatment makes the surface rough, which raises the temperature in the contact zone under sprayed particles on microasperity and increases the total surface of spots for welding.

The area of a rough surface is larger than that of a smooth surface, which also results in adhesion strength increasing. The rise of R_z is accompanied with increase in the adhesion coating-base strength (σ_{ad}) (Fig. 3, a). However, it is not high enough as could be expected taking into account the high particle velocity, which reaches 500 m/s. This may be related to the action of the following main factors:

- increase in the particle velocity increases the relative area of the physical particle-base contact [8, 9], which leads to an increase in the adhesion strength;

- reduction in the average particle size in EAS by 4-7 times reduces the particle crystallization time, lowers both the particle-base contact temperature and completeness of chemical interaction, which can reduce the adhesion strength. .

Thanks to the action of these factors, the adhesion strength of EAS coatings is higher by 1.8-2.2 times.

However, in manufacture of anticorrosion coatings, whose thickness is usually small (0.04-0.2 mm), the problem of the right choice of roughness becomes principal as in this case, the layer thickness can be commensurate with the height of microasperity. Insufficient roughness accompanied with big thickness of coating may cause the detachment of coating, whereas a rough surface accompanied with small thickness may become the reason of early corrosion.

As shown in Fig. 3, b, with increasing the height of base surface microasperities, the gas permeability ($K_в$) increases for coatings deposited by any method of arc spraying. However, the most marked effect of R_z on $K_в$ is observed on the coating made using an EAS. The different degree of the influence of the base roughness on $K_в$ is due to the bigger particle size in the case of compressed air spraying, when the first layer of coarse particles is jammed into pits between microasperities so that they cannot affect the coating formation process. The stronger dependence of the gas permeability of EAS coating on R_z is the result of significant inclination of this method towards formation of porous "bumps”. Conditions for this become more favorable with increasing the base roughness. It should be mentioned that in case of FSP with increasing the coating thickness the effect of R_z on $K_в$ is negligible, whereas for EAS coatings with h<0.2 mm, this effect only diminishes depending on the spraying distance.

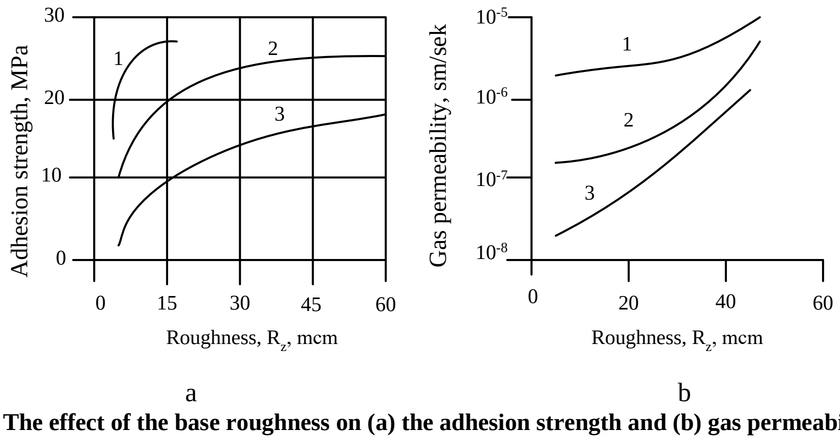

Fig. 3. The effect of the base roughness on (a) the adhesion strength and (b) gas permeability of (1) FSP and (2,3) EAS at a spraying distance of (1,3) 100 mm and (2) 50 mm.

Hence, as it was before shown, for coatings produced using an EAS, a decrease in the base roughness can lead to significant reduction in their gas permeability. This should be taken into account in the development of spraying process conditions and selection of those techniques for surface pretreatment that provide a low degree of roughness, for example, blowing with quartz sand. Herein the adhesion strength decreases as well, and at low R_z in FSP coatings the adhesion strength required for the impossibility of coating detachment may not be reached, whereas in EAS the adhesion strength is high enough even in case of using a polished base surface.

Approbation of the research results

EAS was used for:

- i) renewal of worn steel cylinder parts operating under conditions of sliding friction and lubrication;

- ii) elimination of defects and protection against metal corrosion of tubes, internal and external surfaces of reservoirs and multi-aimed welded constructions as well as various decorations using spraying with aluminum, zinc and cadmium [8,9].

In addition, covering of about 50% surface of each neck is performed under conditions of strong support of the gas flow, as the crankshaft webs forms semi-closed space. The difference in the coating formation conditions causes difference in the physicomechanical characteristics of the deposited layers on different neck spots and so their different wear. The use of EAS which includes mechanical activation of coating in the course of spraying process allows one to equalize the properties of coating along its width and depth. Crankshaft necks with coatings may be repolished in the course of the next overhaul for the required size. This is not, however, reasonable as during hard and long operation the wear resistance of the coating decreases due to filling of its pores with the wear products and other impurities. It is more reasonable to remove the old coating and deposit a new one. EAS has renewed the sizes of support webs of engine camshafts. The results of the operation testing of cam- and crankshafts with using EAS process have demonstrated that the service life of these parts is 1.5-2 times longer as compared to parts renewed using FSP method.

Conclusions

1. Comparative analysis of coating properties has revealed that via using optimal spraying conditions, the porosity of EAS-derived coatings is significantly smaller than that for FSP coatings (2-4% and 9-11%, respectively), and at a coating thickness of 0.05-0.1 mm the difference reaches 2-5 orders of magnitude. The adhesion strength of EAS-coatings is 1.8-2.2 times higher.

2. When developing the EAS process for deposition of coatings, one should choose those techniques for pretreatment of the base surface which can provide reduction in the degree of its roughness (from 5 to 10 mcm) required for decreasing its gas permeability and thus porosity.

3. As a spraying gas, EAS uses the products of combustion of propane-air mixture, varying of which makes it possible to form a neutral or a reducing medium in the zone of electric wire melting, and in such a way:

- to decrease metal oxidation and burning-out of alloying elements;

- to increase the strength and wear resistance of coatings and so to prolong the service life of transport means parts.

4. Using the EAS technology, including mechanical activation of coating in the course of spraying, permits equalization of the properties of a coating along its thickness and width.

References

1. Highly efficient technologies in mechanical engineering: Materials of the conference (October 28-30, 1998, Kharkov). Kyiv: 1998. 126 p.

2. K.A. Yushchenko, Yu.S. Borisov, V.D. Kuznetsov, V.N. Surface engineering cake. Kiev: Naukova Dumka, 2007. 559 p.

3. Korzh V.M., Popil Yu.S. Surface engineering is a new technological direct preparation and renovation of machine parts and designs. Modern machine building. 1999. No. 1. pp. 92–94.

4. S.K. Fomichev, V.N. Lopata, M.C. Ageev, A.V. Vorona Restoration and hardening of wearing parts of armored personnel carriers by electric arc spraying. "Quality, standardization and control: Theory and practice": materials of the 15th international scientific and practical conference (September 15-18, 2015, Odessa). Kyiv: ATM of Ukraine, 2015. S. 184-188.

5. L.A. Lopata, Lopata, Medvedeva N.A., T.M. Tunic Dosledzhennya of car parts type "shaft" electric arc metallization. "Design and technology of production of agricultural machines": Collection of scientific works. Kirovograd: KNTU, 2005. No. 35. pp. 409-416.

6. Welding equipment, consumables, auxiliary equipment, raw materials for the manufacture of electrodes, gas welding equipment, equipment for special methods of welding, cutting, surfacing and spraying. - Directory. Salon "Welding". - Kyiv, 1994. 100 p.

7. List of electric welding equipment and equipment for applying coatings by gas-thermal methods. Kyiv: Institute of Electric Welding. E.O. Paton of the Academy of Sciences of the Ukrainian 1990. 68 p.

8. B. Vilage, K. Rupprecht, A. Pokhmurskaya Features of gas-thermal spraying with flux-cored wires. Automatic welding. No. 10. 2011. P. 26-30.

9. Brusilo Yu.V. S.A. Dovzhuk L.A. Lopata Influence of factors of the process of electric arc spraying on the structure formation and properties of coatings. Collection of science practices of the Kirovohrad National Technical University "Technology in the agricultural industry, galuzev machine-building, automation." 2010. Issue 23. P. 287-297.

Лопата О.В., Головащук М.В., Лопата Л.А., Солових Є.К., Катеринич С.Е. Властивості покриттів, отриманих електродуговим напиленням для реновації деталей машин і механізмів транспортних засобів

У роботі представлені результати дослідження властивостей покриттів, отриманих електродуговим (ЭДН) напиленням, і їх порівняння з властивостями покриття, отриманих газополуменевим напиленням. Пористість покриття, отриманих електродуговим напиленням, знаходилася в межах 8 10%. міцність зчеплення склала 80…100 МПа. Результати проведених досліджень показують переваги та цілеспрямованість використання електродугового напилення для відновлення та підвищення ємності деталей машин і механізмів транспортних засобів. В роботі дослідження впливу факторів процесу електродугового напилення: складу горючої суміші, дистанції напилення, дисперсності розпилення та ін. на властивості покритий. При проведенні досліджень запропоновано підвищення адгезійної стійкості, щільності покриття за рахунок керування параметрами електродугового напилення. У роботі розглянута можливість забезпечення необхідних властивостей відновлюваних поверхонь з метою підвищення ресурсу деталей машини шляхом регулювання факторами ЕДН. Зокрема, регулюючи швидкість і температуру струї транспортуючого газу і частинок можна зменшити діаметр капель, підвищити щільність і знизити окислюваність покриття. Приведені результати порівняльного аналізу властивостей покриттів, нанесених електродуговим напиленням (ЕДН) з використанням продуктів згорання пропан-повітряної суміші та газополуменевим напиленням (ГПН) з використанням газоповітряної суміші. За оптимальних умов процесу напилення пористість покриттів, отриманних електродуговим напиленням значно менша порівняно з газополуменевим напиленням: 8-10% і 20-30% відповідно. Адгезійна міцність покриттів, отриманних електродуговим напиленням підвищилася в 1,8-2,2 рази (з 30-40 МПа при газополуменевому напилені до 100 МПа при електродуговому), зносостійкість підвищилася в 2-2ю5 рази.

Ключові слова: електродугове напилення, покриття, газополуменеве напилення, пористість, адгезійна міцність, зносостійкість, зносостійкість, корозійна стійкість, товщина покриття, газопроникність