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PARAMETERS OF DEPOSITION OF MULTILAYER PLASMA COATINGS FROM MATERIALS BASED ON M-CROLL

The article discusses the deposition parameters that are the most promising for operation under such wear conditions of the composition, which consist of a ceramic-metal matrix and an oxide component evenly distributed in it. The performance of such compositions is ensured by the high strength properties of the metal-ceramic matrix. The constant reproduction of this layer when working under friction conditions, evenly distributed throughout the entire volume of the material, creates the desired effect of self-lubrication. All of the above features suggest that plasma wear-resistant powder coatings will find wide application in technology, both protective and anti-friction. Atmospheric Plasma Spraying (APS) is a current commercially available technique that has been used by many researchers to create cost-effective coatings. The use of high temperatures and energy densities makes it possible to deposit coatings of refractory materials such as Al2O3, ZrO2 and mullite, which are difficult to melt with other conventional thermal spray processes.

Keywords: *metal-ceramic plasma coatings, heat-shielding and wear-resistant coatings, formed structures, physical, mechanical and operational properties, M-crawl, titanium dioxide-aluminum oxide, molybdenum.*

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ПАРАМЕТРЫ НАНЕСЕНИЯ МНОГОСЛОЙНЫХ ПЛАЗМЕННЫХ ПОКРЫТИЙ ИЗ МАТЕРИАЛЛОВ НА ОСНОВЕ М-КРОЛЕЙ

В статье рассматриваются параметры нанесения наиболее перспективными для работы в таких условиях износа композиции, которые состоят из металлокерамической матрицы и равномерно распределенной в ней оксидной составляющей. Работоспособность таких композиций обеспечивается высокими прочностными свойствами металлокерамической матрицы.

Постоянное воспроизведение данного слоя при работе в условиях трения, равномерно распределенной по всему объему материала, создает нужный эффект самосмазываемости. Все вышеперечисленные особенности позволяют предполагать, что плазменные износостойкие порошковые покрытия найдут широкое применение в техники, как защитные, так и антифрикционные. Атмосферное плазменное напыление (APS) - это действующий коммерчески доступный метод, который использовался многими исследователями для создания экономически выгодных покрытий. Использование высоких температур и плотности энергии позволяют наносить покрытия из тугоплавких материалов, таких как Al_2O_3, ZrO_2 *и муллит, которые трудно расплавить с помощью других традиционных процессов термического напыления.*

Ключевые слова: *металлокерамические плазменныхе покрытия, теплозащитные и износостойкие покрытия, формируемые структуры, физико – механические и эксплуатационные свойства, М-кроли, диоксид титана-оксидалюминия, молибден.*

1. Introduction

Currently, in various industries, there are a large number of parts and assemblies operating under friction conditions (ball and cylindrical bearings, sliding current collectors, liners, thrust bearings, guides, end and side seals, hinged devices, etc.), in which wear-resistant materials are widely used. They function under various conditions - high speeds, high loads, in the presence of boundary friction or friction with lubrication, at elevated temperatures or in a vacuum. Corrosion processes, the adverse effects of wear, are the main causes of failure of metal structures and machine parts. For these reasons, about 80-90% of parts fail in the industry. All these circumstances do not make it possible to obtain a universal material for work in friction units. There is a need to obtain various materials for the given operating conditions in friction conditions. It is known from a review of the literature [1–15] that the most promising materials for obtaining wear-resistant plasma coatings that increase the durability and reliability of mechanisms and machines are those materials that can withstand maximum loads without plastic deformation in friction pairs in a wide range of operating temperatures and having the highest resistance to abrasive wear, the ability to work in aggressive environments and vacuum. The most promising for operation in such conditions are compositions that consist of a cermet matrix and an oxide component evenly distributed in it. shock in a high temperature atmosphere. In addition, they have the combined advantages of ceramic and metal, such as hardness and toughness. In addition, the effective use of wear-resistant coatings can be significantly improved by applying a subsequent modifying effect on their structure [8]. When processing wear-resistant plasma coatings with high-energy effects, their sources have a number of advantages: firstly, the locality and high concentration of the input energy, which makes it possible to act on the necessary area of the formed wear-resistant coating, without thereby violating, due to the general heating of the entire volume of its microstructure and required properties; secondly, the possibility of strict control of all the parameters of the impacts, which make it possible to form the structure of the layer being created, to regulate its roughness and the necessary geometric dimensions, to obtain the necessary parameters of wear resistance, total porosity, and hardness. However, one should always keep in mind the ability of a high-energy modification to change and redistribute residual stresses in the formed coating, especially at small coating thicknesses [9].

2. Optimization of parameters for deposition of plasma coatings from materials based on oxide ceramics

In accordance with the method developed by us, the optimization of plasma spraying of powder coatings on the UPU-3D installation was carried out according to the utilization factor of the sprayed powder material (CIP). In this case, the morphology of individual particles of powder materials deposited on the polished surface after their interaction with the base (substrate) ("Splat–test") was also taken into account. Based on the results of inspection under a microscope for similar technological regimes as for the "Splat-Test", an optimization process was carried out based on the creation of coatings with maximum CIP (powder material utilization factor).

In the process of obtaining sprayed wear-resistant layers from the developed powder materials, there are a large number of process factors that affect the properties of the protective coatings being created. The main factors are the speed of the devices for moving the plasma torch or substrate, the distance used for spraying, the consumption of the plasma-forming and transporting gases used, the consumption of the material used for spraying, the input power, depending on the voltage and current of the electric arc of the plasma torch [16-

19]. As an example, Figures 1-7 show characteristic dependencies, which, using the KPI-universal characteristic, show the effect on the efficiency of the process of the listed conditions and deposition modes.

A qualitative optimization of all the most important parameters of APS (plasma spraying in atmospheric conditions) of the process of creating wear-resistant coatings from powder materials Mo and NiCrAlITa (for creating sublayers), as well as Mo-Al2O3-TiO2 and NiCrAlITa-Al2O3-TiO2 (to create wear-resistant layers). It was carried out in stages. The first - for fixed indicators of the arc current and nitrogen forming the plasma, the distances for creating coatings were varied. The second is the change in the amount of plasma-forming nitrogen at constant distances of deposition of powder material and the value of the applied current.

Then, at the third stage, for certain constant values of the spraying distance of the powder material and the flow rates of the plasma-forming gas-nitrogen, we changed the values of the supplied current. For NiCrAlITa, the obtained sublayer regimes (arc current of the plasma torch - 550 A, speed when moving the base Vtr. = 300 mm / s, consumption of nitrogen forming plasma - 45 l / min, distance for coating formation - 100 mm, fractional composition of the powder material - 40-63 microns, consumption of powder material - 4.0 kg/h) formed by the coating with CMM - 85%. For Mo - sublayer (arc current of the plasma torch - 600 A, speed when moving the base Vsub.=300 mm / s, consumption of nitrogen forming plasma - 50 l / min, distance for coating formation - 110 mm, fractional composition of the powder material - 40-63 microns, powder material consumption - 4.0 kg/h) formed by the coating with CMM - 80%.

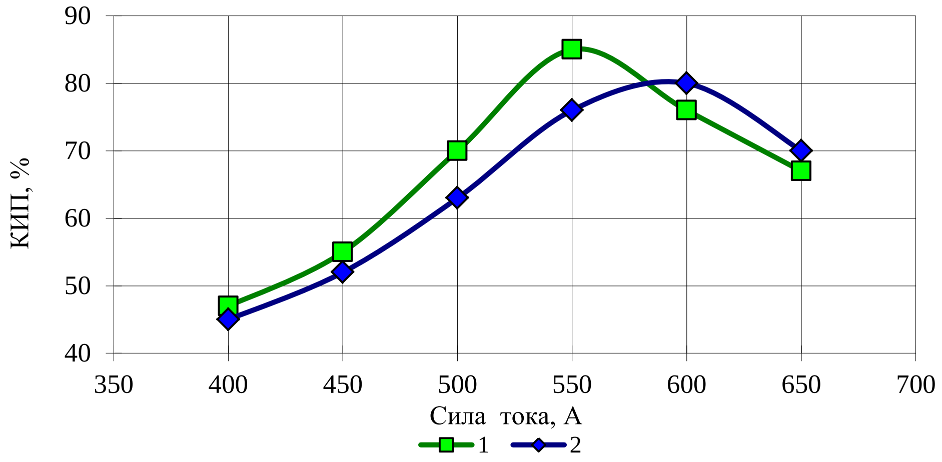

Figure 1. Influence on the parameters of the instrumentation,% of the values of the input current of the plasma torch (I, A) for the powder materials of the sublayers: 1 - NiCrAlITa and 2 - Mo; 1 - (R por.=4.0 kg/h, powder fraction 40...63 µm, R_N=45 l/min; L=100 mm); 2 - (R por.=4.0kg/h, powder fraction 40...63 µm, R_N=50 l/min; L=110 mm)

For NiCrAlITa-Al2O3-TiO2 - a wear-resistant layer (arc current of a plasma torch - 550 A, speed when moving the warp Vsub.=300 mm/s, flow rate of plasma-forming nitrogen - 50 l/min, distance for coating formation - 110 mm, fractional composition of the powder material - 40-63 microns, powder material consumption - 4.0 kg/h) formed by the coating with CMM - 80%.For Mo-Al2O3-TiO2 - a wear-resistant layer (arc current of a plasma torch - 600 A, speed when moving the base Vsub. = 250 mm / s, consumption of nitrogen forming plasma - 55 l / min, distance for coating formation - 130 mm, fractional composition of the powder material - 40-63 microns, consumption of powder material - 4.5 kg / h) formed undercoating with CMM - 72%.At the specified values of technological parameters, a microheterogeneous structure of the deposited coating is formed, containing elements that ensure its wear resistance (Cr1.12Ni2.88, α-Al2O3, γ-Al2O3, orthorhombic phase of titanium oxide TiO2, Mo compounds).

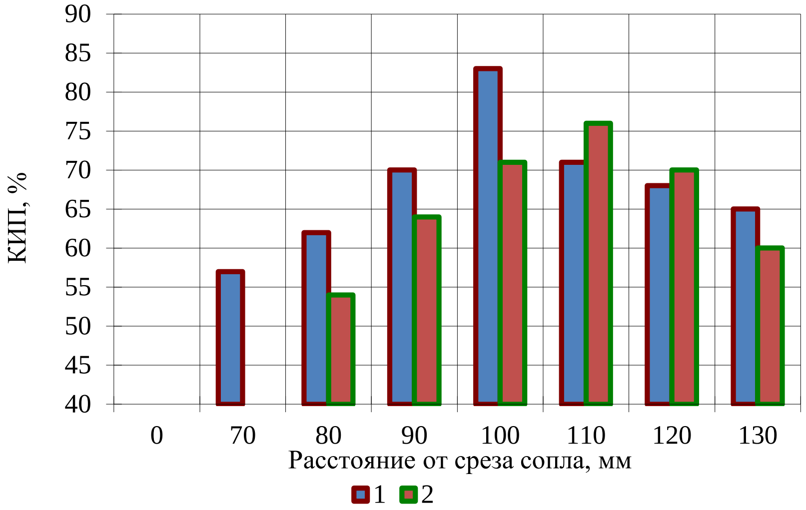

Figure 2. Influence on the performance of instrumentation,% of the coating formation distance L, mm for materials of intermediate sublayers: 1 - NiCrAlITa and 2 - Mo, 1 - (R por.=4.5 kg/h, powder fraction 40... 63 µm, R_N=45 l/min, I=550 A); 2 - (R por.=4.5 kg/h, powder fraction 40...63 µm, R_N=50 l/min; I=550 A)

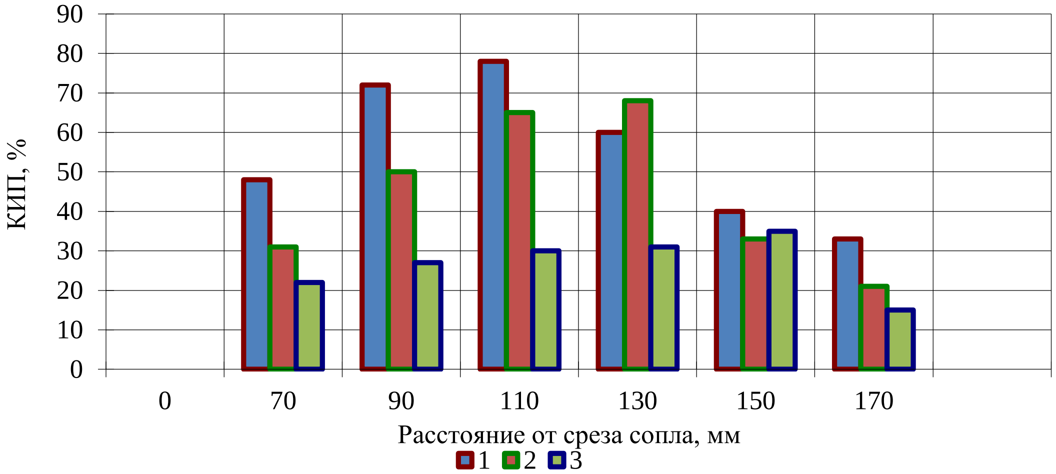

Figure 3. Influence on the parameters of instrumentation, % of the coating formation distance L, mm for powder materials of wear-resistant layers: 1 - Al2O3-TiO2-NiCrAlITa (fraction 40...63 µm; I=500 A, R_N=45 l/min, R then = 4.5 kg / hour); 2- Al2O3-TiO2-Mo (fraction 40...63 µm; I=600 A, R_N=50 l/min, Rpor=4.5 kg/h); 3 - Al2O3-TiO2-Mo (fractional composition - 63...100 microns)

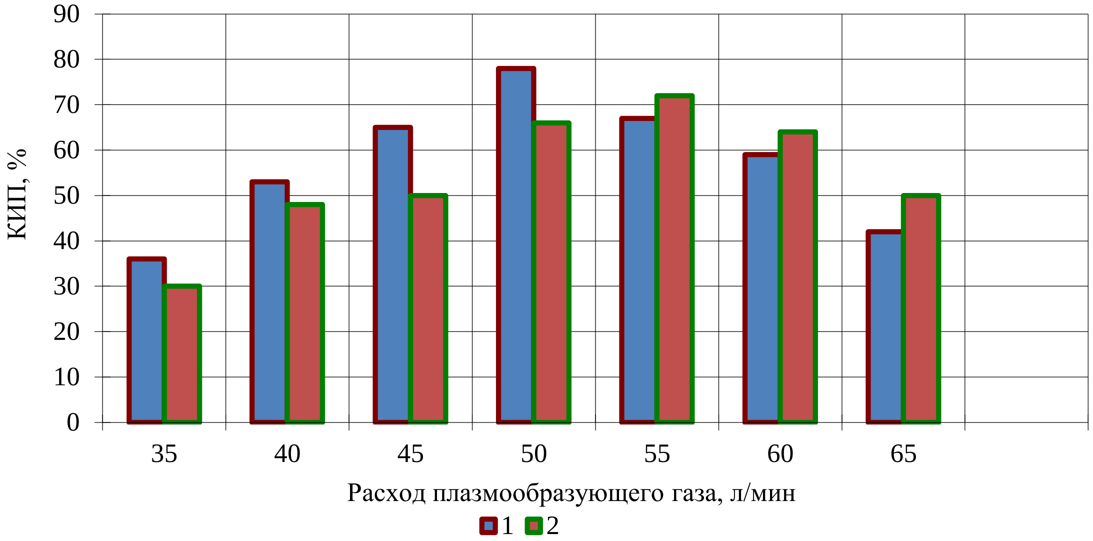

Figure 4. Influence of KPI indicators, % on the consumption of nitrogen forming plasma for powders of wear-resistant layers: 1 - Al2O3-TiO2-NiCrAlITa (L=110 mm; I=500 A); 2 - Al2O3-TiO2-Mo (L=130 mm; I=600 A) with a fraction of 40...63 µm; powder consumption - 4.5 kg/hour)

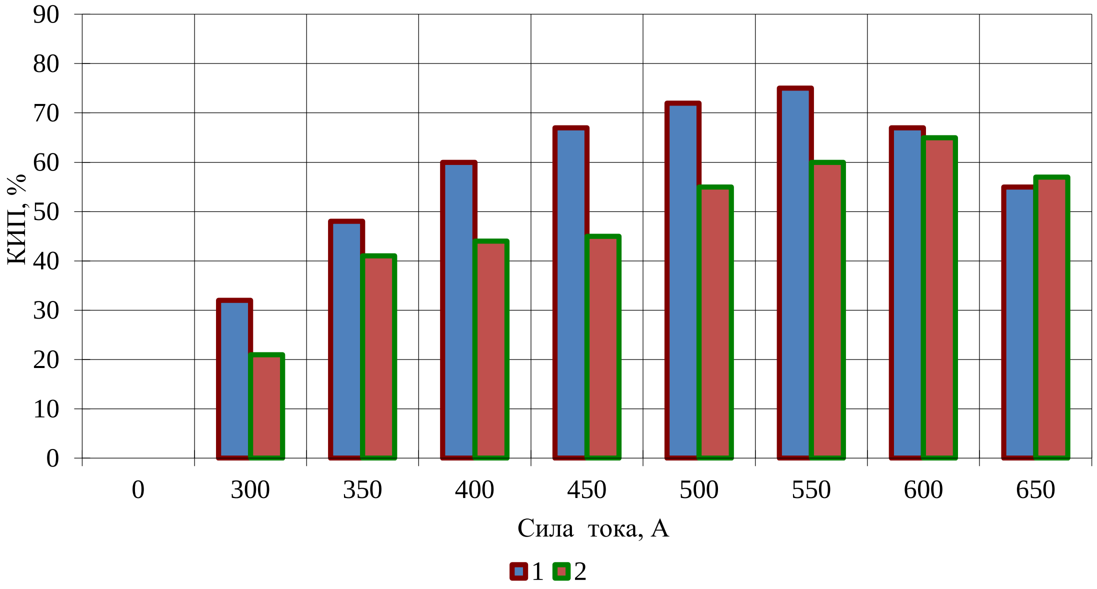

Figure 5. Influence of KPI indicators, % on the values of the plasma torch input current for powder materials of wear-resistant layers: 1 - Al2O3-TiO2-NiCrAlITa (L=110 mm; RN=50 l/min); 2 - Al2O3-TiO2-Mo (L=130 mm; RN=55 l/min), Rpor=4.5 kg/h; fraction 40...63 microns

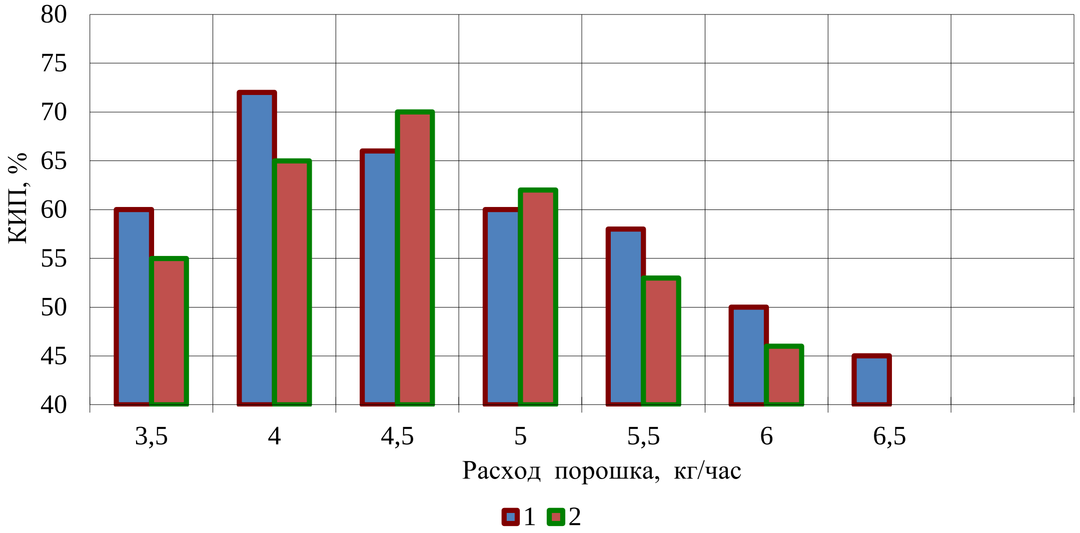

Figure 6. Influence of instrumentation indicators, % on the consumption of powder materialfor the formation of wear-resistant layers: 1 - Al2O3-TiO2-NiCrAlITa (L=110 mm; I=500 A);2 - Al2O3-TiO2-Mo (L=130 mm; R_N=55 l/min) with a fraction of 40...63 μm

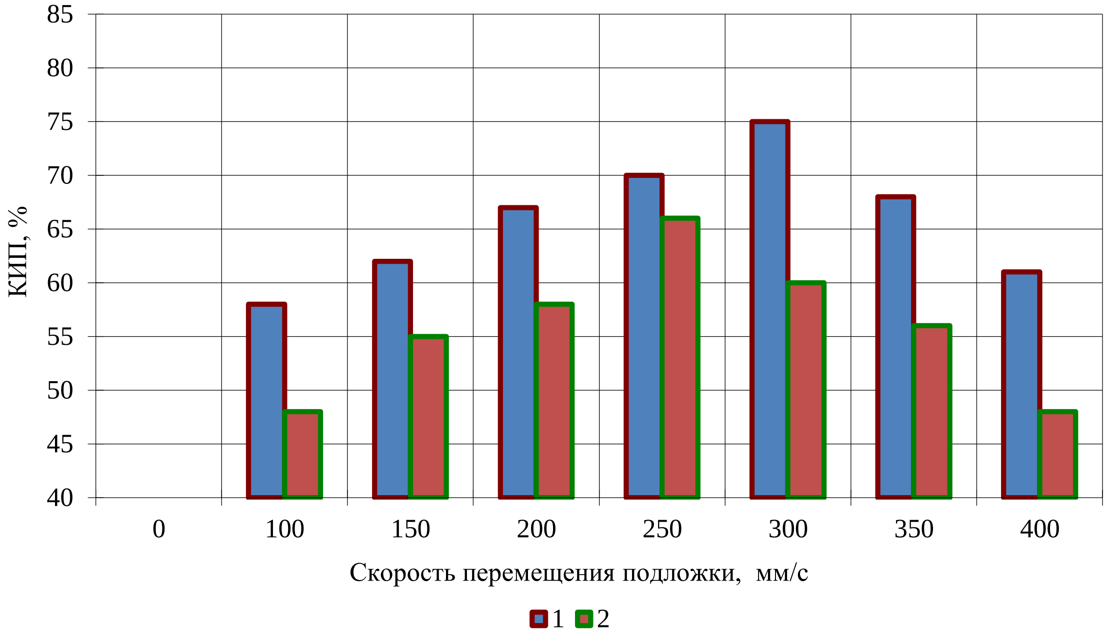

Figure 7. Influence of KPI indicators, % on the speed when moving bases for powder materials of wear-resistant layers: 1 - Al2O3-TiO2-NiCrAlITa (L=110 mm; I=500 A; Rport.=4.5 kg/h); 2 - Al2O3-TiO2-Mo (L=130 mm; I=600 A; Rpor=4.5 kg/h) with a fraction of 40...63 μm

3. Conclusion

Optimum parameters for deposition of plasma coatings based on MCrAlYTa alloys reinforced with refractory ceramic oxides are chosen. At the optimal conditions for NiCrAlITa (the flow rate of the plasma-forming gas (nitrogen) is 50 l/min, the arc current of the plasma torch is 550A, the distance from the nozzle exit to the base is 100 mm, the fractional composition of the powder material is 40-63 microns, the flow rate of the powder material - 4.0 kg/h, relative speed of the substrate Vp=300 mm/s) coatings with CMM - 85% are formed. For NiCrAlITa-Al2O3-TiO2 (consumption of plasma-forming gas (nitrogen) - 50 l/min, plasmatron arc current - 550 A, distance from the nozzle exit to the base - 110 mm, fractional composition of the powder material - 40-63 microns, powder material consumption - 4.0 kg/h, the relative speed of the substrate Vp=300 mm/s) coatings with CMM - 80% were obtained.

In addition to chemical and mechanical bonds, there are some metallurgical bonds. At the specified values of technological parameters, a microheterogeneous structure of the sprayed coating is formed, containing elements that ensure its wear resistance (Cr1.12Ni2.88, α-Al2O3, γ-Al2O3, orthorhombic phase of titanium oxide TiO2). In this case, the spreading of the molten particles on the substrate is achieved, there is no splashing and no losses upon impact with the substrate.

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