Technological Support of Plasma Coating with the Plasmatron Power Modulation

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Technological Support of Plasma Coating with the Plasmatron Power Modulation

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Abstract. The possible ways of improvement of plasma coating technologies, the results of researches and basic components of engineering technology of this process with the modulation of electric parameters of indirect and remote arc of the plasmatron are presented. Also the integrated processes with the thermal and electromechanical machining are proposed. New high-saving technologies, methods and means of technological support for the required performance indicators of coatings are developed.

1. Introduction

The goal of technological support of plasma spraying and hardening of coatings (PS) on the base of searching and optimization of design and technological solutions (DTS) of the problems of getting the competitive products is achieved, first of all, by the forecasting and evaluating of the technological realizability of advanced PS methods and, secondly, by the technological support of PS design based on these methods.

2. Design methodology of PS with parameters modulation

The methodology includes the actions algorithm on design technologies, means, methods and principles of solution of technological problems, process models.

Structure of the design process includes three stages. The first stage of the technological process design is the statement of the technological task (TT) and the technical requirements (TR) for the coating. In accordance with the operational requirements for the coating and the part parameters, these requirements are divided for: external or small-sized internal surfaces; mating and noncontacting surfaces of parts; surfaces of movable and stationary mates; increased operating loads (alternative loads, impulse loads, working in the conditions of abrasive wear).

During the *Synthesis of Technologies Principles* on the basis of the physical model the necessary physical effects in the modulation of electrical parameters, which form the basis of the chosen version of the technology of plasma spraying and hardening of coatings with parameters modulation are determined [4]. During the *Structural Technologies synthesis* schemes and algorithms of realization of electric parameters modulation variants depending on operational requirements and parameters of a

detail are created [1]. During the *Parametric synthesis* the dependencies of process criteria from factors are found and the problems of finding the optimal technological modes of spraying and hardening of coatings taking into account operational requirements and parameters of the part are solved.

At each stage of the design, depending on the operational loads and part parameters, the coating technology is selected and the following procedures are performed: choice of the method of PS and its mathematical model (flowchart and calculation scheme); choice of the solution method, including selection of the optimization method; solution; analysis of the results and decision making.

3. Research results

3.1. Forecasting and assessment of technological realizability of prospective methods of PS

Research results of the PS and hardening of coatings improving possibilities show that the expansion of its use is still constrained by such significant disadvantages as the unsatisfactory strength of the coating joint with bottom layer under impulse loads, high residual tension stress in high-thickness coatings, negatively affecting the fatigue resistance, presence of porosity.

The performed analysis of the current state of the PS process researches shows that the refinement of the PS technology by improving its spraying operation is advisable to realize by appending additives to the plasma-forming gas, by simultaneous processing of the sprayed surface and coating with the additional extension arc, by the parameters modulation of the plasmatron, as well as by combining these methods [1, 2]. However, it was found out that in this method theoretical bases of gas-dynamic, thermal and physical-mechanical processes leading to the improvement of coatings quality were practically not studied.

Refinement of the hardening operation of sprayed coatings is advisable to perform by thermo-or electromechanical machining of coatings using spinning roller or ball tool [3]. However, this important practice for plasma sprayed coatings also has not been fully explored.

The improving of the PS technology in the aspect of its development and universalisation is constrained by spreading of this technology for the application of thick coatings (more than 1 mm), as well as for coating on the internal small-sized surfaces of machine parts, for example, on the internal surfaces of the cylinders liners. For these purposes, the process of plasma spraying has not been sufficiently developed.

These unsolved issues in general represent a practical problem, which consists in improving the quality of coatings with minimal thermal impact on the substrate, increasing the resource, reliability, quality and high resistance to the specific operating loads of the machine parts surfaces .

This practical problem predetermines the scientific problem of researches, consisting in creation of theoretical and methodical bases of intensification of gas-dynamic processes and controlling of heat processes of plasma spraying with hardening of coatings on the basis of modulation of electrical parameters and combined influence of electromechanical processing of forming coating for providing with optimal technological conditions to get the required quality of machine parts coating.

The physical model of the dynamization mechanism of the plasma coating processes is based on transformation of the electric energy of impulses at modulation into thermal and gas-dynamic energy, in this manner changing parameters of a plasma jet, particles energy and the efficiency of the process as a whole [4-6]. Analysis of the physical model allows to develop principles of control of processes dynamics by modulation of electrical parameters on the basis of data controlling by the given physical components which consist in the formation of shock or intense acoustic waves in the plasma jet, intensifying energy efficiency to the sprayed material as well as in the formation of surface temperature fields of the base and discrete distributed local areas of coating penetration with optimal parameters.

The structure of complex mathematical model describing the implementation of these physical processes at the dynamization of plasma spraying and hardening of coatings, consists of three interconnected blocks and allows to describe the system "arc-plasma jet-particles-coating" [7].

Theoretic and experimental researches results and possibilities of improvement of plasma spraying and hardening of coatings by dynamization of processes based on the use of modulation of electrical parameters are described in the works [5-12].

3.2. Technological support of PS technology design

Technological support of PS technology design of high-strength wear-resistant metal coatings for machine parts with surfaces of different profiles includes the Providing of the following Components:

- first, the dynamization of PS processes by applying the modulation of electrical parameters;
- second, the systems of controlling the dynamics of these processes.

These components of PS, in turn, include a set of methodological and technical solutions that ensure the implementation of the results of research and, first of all, the description of the scheme PS [2] and its technical support. One of the option of the technical support can be the equipment that includes the installation of PS (Inventor's certificate № 1774828 of Soviet Union, Patents Russion Federation № 2211256 and № 2480533), the installation of thermo-and electro-mechanical hardening and special technical support [10-12]. Special technical support includes devices for coating of crankshafts necks (for example, patents of the RF № 2085301, № 2447951, № 129021), devices for coating of profile surfaces (for example, the "tooth" type surface Patent RF № 2175024), devices for coating of internal small surfaces, cooling systems parts, manipulators, etc.

The working out of the control system over the dynamics of plasma spraying and hardening of coatings includes the developed means of impact on the object and the set of means of collection, or control of information about the object. For an indirect arc the system of control of the dynamics of the spraying process consists in realization of the principles of maximizing pulse power or their intensity at frequencies of 3-5 KHz to increase the energy of the sprayed particles. For a straight arc the system of control of the process dynamics consists in generation of power pulses, which provides, firstly, locally discrete penetration of the coating with the optimal density of distribution of such zones and, secondly, the uniform field of temperatures with minimal spread. The regulation of the modulation parameters can be carried out by the change of capacities, active resistances of the modulator and the frequency of the generator.

Conclusions

On the basis of the research of PS process with the modulation of electrical parameters, the developed technological support and the methodology of their design it can be worked out the optimal options of the technological process, which provide depending on the specified working loads the required level of strength properties of coatings.

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