

PRODUCTION SECTION

OPTIMIZATION OF THE PROCEDURE OF PLASMA SPRAYING OF EROSION-RESISTANT COATINGS ACCORDING TO STRENGTH CRITERIA

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It is shown that mechanical characteristics of the coatings depend on their technological conditions of their deposition. We propose a procedure of optimization of the technological process and control over this process according to the criteria of strength and specific consumption of materials by analyzing an example of plasma spraying of erosion-resistant coatings. The erosion resistance exhibits the most stable correlation with the cohesive strength of the coatings. The regression equations are used to determine the maximum levels of cohesive strength of the coatings and erosion resistance for the optimal combinations of technological parameters of.

Keywords: coatings, strength, gas-thermal spraying, erosion resistance, optimization.

Introduction. The development of all technological processes (TP) is inevitably connected with the solution of the problems of optimization. In the field of development of hardening protective coatings (HPC), the problems of optimization play a key role. This is explained by the fact that numerous methods of deposition of the coatings in combination with a broad range of materials used to form the coatings and a great number of affecting factors offer numerous alternatives to the industrial engineers. In this case, the efficiency of decision-making depends on the existence of strength criteria used to control the technological processes.

State-of-the-Art of the Problem. In view of the high sensitivity of the mechanical characteristics of coatings and matrices to the conditions of their deposition, special requirements are imposed on the optimization and realization of technological processes according to the strength criteria. There exist contradictory data concerning the influence of technological conditions on the operating characteristics of the HPC [1]. This is why attempts were made to systematize technological parameters both in the form of charts of the sources of influence on the properties of the coatings [2] and in the form of hierarchical schemes of parameters [3]. There are numerous works devoted to the determination of the optimal parameters and relationships between the technological conditions and properties of the coatings [4–8], including the works dealing with the stability of gas-thermal coatings under the conditions of gas-abrasive wear [9].

In connection with the application of computers in systems of automated design of the technological processes and systems of automated control over these processes, we observe the appearance of a certain mismatch between the possibilities of computers and their application. Thus, the development of new mathematical models and software turns into an urgent problem. Modeling is based on the methods of the theory of the experiment planning and is performed by using computers. However, the developed mathematical models of the systems of automated design of technological processes and control over these processes do not cover a large number of the phenomena

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specifying the operating properties of the HPC. As a rule, they deal with separate characteristics of the coatings and methods aimed at their optimization. The developed models of gas-thermal spraying are also fairly restrictive [10, 11].

In the theory, technology, and practice of HPC, we observe the formation and successful development of a new trend connected with the optimization of technological processes according to the strength criteria [12]. The application of multiparameter optimization by the method of factor planning of the experiment enables us to determine the technological parameters guaranteeing the maximum possible strength and durability of a component with coating.

As a distinctive feature of the new trend, one can mention the investigations performed according to a single matrix of planning of the experiment by taking into account both the technological factors and the complex of mechanical and operating characteristics of the materials. Thus, the technology of HPC and the complex of investigations are combined in the same procedure.

The optimization of the technological processes according to the complex criterion of fatigue, wear, and corrosion resistances was carried out for gas-thermal coatings [13, 14]. The technology of detonation spraying was optimized according to the criterion of adhesive-cohesive equistrength and critical deformation of the base [15–17] and with respect to the complex of mechanical and operating properties [18, 19]. The electron-beam technology of heat-shielding coatings was optimized according to the criteria of isothermal and thermal cyclic creep [17, 20]. For the operating conditions of the components in rolling friction with sliding, we construct multiple regression models characterizing the dependences of the parameters of optimization on the input technological and operating factors [21]. The technology of ionic nitriding [22] and the vacuum-plasma technology [1, 23–25] were optimized according to the strength criteria. The parameters of the electrochemical technology [26], electric-spark alloying [27], and surface plastic deformation [28] were optimized according to the strength criteria, stress-strain state, and wear resistance.

According to the technological conditions, the attainment of the maximum strength and maximum durability must be accompanied by the decrease in energy and other material losses. This is why, in the process of multicriterion optimization, parallel with the strength criteria, it is customary to use economic criteria. The process of detonation spraying is optimized both according to the strength criteria and according to the cost value [16].

The substantial increase in strength and all other operating characteristics as a result of the optimization of the technological processes of HPC according to the strength criteria reveals the efficiency of the proposed approach. Thus, in our opinion, we currently have the following situation in the theory and practice of application of the HPC:

- the overwhelming majority of technological processes were chosen empirically and/or intuitively; in this case, the accepted technological parameters do not, generally speaking, guarantee the maximum possible strength and durability of the components with coatings;
- the accepted technological parameters do not guarantee the required energy saving, materials saving, and the conditions of maximum possible efficiency;
- the empirically and intuitively determined technological parameters should be regarded as the starting point of experiment planning for the subsequent regression analysis.

The aim of the present work is to develop a procedure of optimization of the technological processes of gas-thermal deposition of anticavitation coatings according to the strength criteria guaranteeing the attainment of the maximum possible strength and durability of the components with coatings for the minimum possible cost of the process of deposition. The scientific part of the work is connected with the development of mathematical models based on the strength criteria and used as basic in the software of the systems of automated design of the technological processes of gas-thermal spraying and systems of automated control over these processes.

Procedure of Investigation. The technology of deposition of an anticavitation plasma coating of 12Kh18N10T steel with a thickness of 0.4 mm on the cooled outer surface of a liner of an SMD-18N engine was proposed in [29]. The authors explain the application of the indicated material by the requirements of corrosion resistance. Since the justification of the chosen technological conditions and the thickness of sprayed coatings for the commercial industrial production is absent, it is possible to assume that the proposed technology is not optimal. Therefore, it was used as basic for the subsequent optimization according the characteristics of strength and consumption of the materials.