Plasma spray coating with ferromagnetic powder by thermo-electric plasma equipment

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Abstract. Plasma spray coating is the most preferred and readily available method of carrying out repair and restoration works in comparison to other methods at present. Though the method of plasma spraying has been known for a long time, there are still a number of unsolved issues related to the choice of optimal deposition regimes. The thermo-electric plasma system for plasma spray coating with a liquid electrode is discussed in this article. The process and optimal parameters of plasma spray coating regimes are described.

1. Introduction

Development of repair technological processes is actively increasing, and control methods of new and restoration of worn parts appear, which can effectively solve a number of problems – tear and wear of friction parts, friction reducing, etc. Leading manufacturers use the cover of various functionalities in there products for a long time [1].

On the margin of the fatigue strength many details meet the requirements of reliability and, with the restoration of the initial dimensions, are quite efficient. The main cause of failure of these products is usually a wear of the contact surfaces, and they can be easily restored by different ways of surfacing. If we proceed from the cost of new components and the cost of restoring worn ones, we can make a choice in favor of repair. Plasma spraying represents the most preferred and available way of carrying out repair and rehabilitation works in comparison to other methods. The advantages of this method are: short time of repairs; preservation of geometric shapes of the parts; possibility of spraying a wide range of materials, etc. [2-5].

If you consider that most of the restored parts are made of structural steel or cast iron, it is advisable to use as the deposited materials, powder [6].

The main process parameters in the coating process, most efficiently influencing the value and quality of coverage, are the energy of the electric discharge, which, in turn, depends on the magnitude of discharge current, the magnitude of the working gap, the particle size of ferromagnetic powder and its feed into the gap [7]. However, these parameters should be interlinked also with the speed of the relative jet and detail movement.

2. Research methodology

Fig.1 shows the structural scheme of the thermo-electric plasma system intended for electric discharge [8].

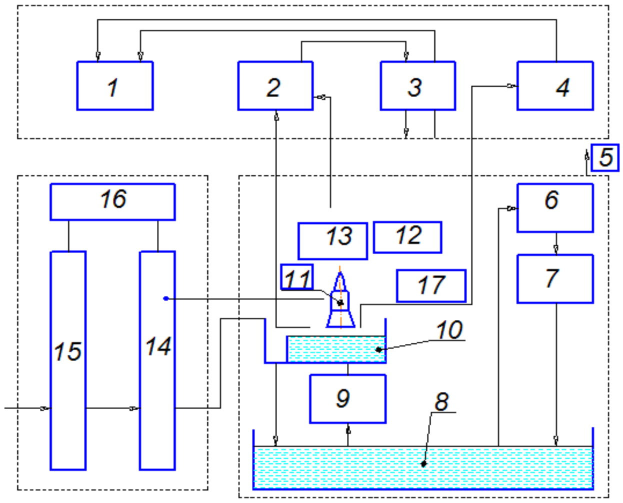


Figure 1. Structural diagram of thermo-electric plasma system:
1-voltage regulator; 2-interelectrode gap (IEG) control system; 3-electrolyte parameters control system; 4-control system of electric discharge parameters; 5-exhaust ventilation; 6-pump pumping the electrolyte; 7-filter for electrolyte purification; 8-container with an electrolyte; 9-feed pump of the electrolyte in the electrolytic bath; 10-electrolytic bath; 11 - head of plasma torch (shown in Fig. 2); 12-coordinating device; 13-workpiece; 14-rectifier unit; 15-transformer; 16-voltage regulator; 17-mounting of plasma torch.

Electrical discharge occurs between liquid and solid (metal) electrodes [9] in the range of interelectrode distance l = 1÷100 mm, current intensity I = 10÷100 A, voltage U_d = 40÷300 V. Technical water was used as electrolytic electrode.

Workflow when used as metal electrodes of the discharge chamber in the form of a truncated hollow cylinder is shown at Fig. 2.

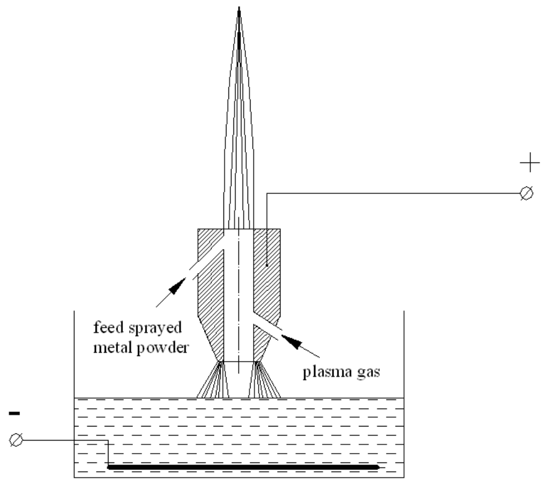


Figure 2. A device for producing plasma jet

The studies were carried out with the ferromagnetic powder coating [10]. During working the speed of movement of the selected samples was 5 cm/sec. These mechanical parameters are defined as a result of numerous experiments and provide maximum productivity in obtaining a quality coating on the samples and the details in a simple form. Ferro powder feeding was at the range of 6-7 g/min. A lower limit would not provide a sufficient amount of coverage continuity, and higher – would contributed to the "clogging" of the powder in the working gap, which reduced the stability of the process and dramatically increased wasteful consumption of powder.

The working gap is selected 4-5 mm with the ferromagnetic powder granulation varying 20-80 micrometer. An electric discharge is active under these limits, the process of saturation is stable.

The discharge current renders the greatest influence on the magnitude and quality of the coating while maintaining the optimal regime of hardening. The size ranged between 10 and 40 A. At lower currents the saturation was not active; the coating was formed with insufficient quantity and quality. At higher currents, there is a strong overheating of the surface even to the melting plots, the process resembled arc welding. Granulation of ferromagnetic powder in the selected limits for the total size and composition of the coating is not affected. However, the study of the continuity and roughness of the coating (Fig.1.) showed a direct dependence of these characteristics of granulation of the powder used.

Table 1. Indicators of continuity and roughness of coatings

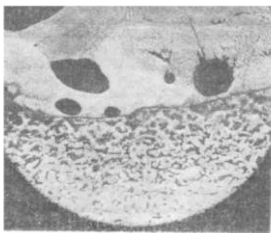
Granulation of ferro powder, micrometer	Percentage of the continuity of the machined surface, %	Indicators of roughness	
		projections height limits of the cone contour, micrometer	the average value of the layer in the depressions, micrometer
10-30	50-60	35-40	10
30-50	70-90	40-45	11
50-70	70-95	30-45	12
70-90	60-70	30-45	6

3. Discussion of results

According to the table, we can conclude that the optimal granularity of ferromagnetic powder is in the range of 30 to 70 micrometer. With less granulation emission of the powder from the working area takes place at the time of discharge, frequent "sticking" of the gap appears, the layer is characterized by great irregularity in the contour of a hardened surface, imperfections are observed during the process. At a higher granulation an incomplete melting of powder particles takes place, the surface roughness of the hardened surface increases, and imperfections are observed.

Studies have been conducted of the influence of discharge current on the qualitative characteristics of the coating. So, the increase in the discharge current leads to the increase of the applied layer value, but to values not exceeding 120 micrometer. Small currents do not provide the sufficient depth of the layer, although the continuity and roughness may be satisfactory. Too high currents increase the discharge power, it is possible to obtain a sufficiently large layer, but it can happen in reflow of surface area of the products. The surface is very rough, can contain the lapping, severe overheating, etc.

a)



b)

Figure 3. Microstructure of layers obtained in the jet of the electric discharge for 0,45 carbon steel (a) and 0,3 carbon steel (b) I=50-70 A (x100)

Fig. 3 shows the microstructure of the layers obtained in the jet of the electric discharge between solid and liquid electrodes. The most even layer with the greatest continuity, the optimal roughness of sufficient magnitude was obtained at discharge currents of 50-70 A. The smaller currents do not provide the necessary stable results on these characteristics, and currents more than 70 A are applicable for items to which virtually no requirements of roughness and denseness are made, and cover is valid that is similar to the electric arc surfacing. In subsequent studies the discharge current is 50-60 A, as ensuring optimum quality of coating.

The effect of duration of coating process on the qualitative characteristics of the layer was examined at one, two, and three consecutive passes of the jet on the treated surface. Coating was carried out in the following optimal mode: the speed of movement of the treated samples was 5

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cm/sec; feed rate of ferromagnetic powder - 6-7 g/min; granulation of ferromagnetic powder - 30-50 micrometer; working gap was 4-5 mm; discharge current - 50 to 60 A.

4. Conclusions

Studies have established that the complete formation of the layer is already done at the first pass of the sample. The secondary passage provides only a slight decrease of the defect, but at the same time slightly increases the surface roughness due to the "gripped" not melted particles of ferromagnetic powder.

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