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IMPACT OF ELECTRIC ARC POWER VARIABILITY ON PLASMA SPRAYING QUALITY

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This article presents the results of experimental studies on the power fluctuations of the electric arc in various types of plasma torches with different power sources. The influence of these fluctuations on the technological parameters of the plasma jet and the coating formation process during pulsed plasma spraying is discussed. It has been experimentally established that the nature of the fluctuations is directly related to the power fluctuations of the power source, the type of plasma torch, and the arc fluctuations, which has significant implications for the quality of the obtained coatings.

Modern trends in technology development, especially in the aviation industry, lead to an increase in specific loads on machine components. This necessitates the implementation of advanced technologies that enhance the quality of both new and refurbished products. One such technology is plasma spraying, where the electric arc plasma torch plays a key role. Understanding the characteristics of plasma torches and their impact on the quality of plasma coatings is a relevant task, as it can significantly improve the efficiency of technological processes. [1, 2] This article presents the results of both experimental and theoretical studies aimed at investigating the power fluctuations of the electric arc and their effects on the parameters of plasma spraying.

The purpose of this study is to investigate large-scale low-frequency fluctuations of the electric arc parameters and their impact on the technological characteristics of the plasma spraying process. A significant number of studies have been conducted on the investigation of pulsations in electric arc plasmas [3, 4]. However, high-frequency oscillations and arc modulation have mainly been considered, while issues related to large-scale, low-frequency fluctuations in the power of the electric arc and related technological parameters of plasmatrons have largely been ignored.

Experimental studies on observing large-scale fluctuations were conducted using a specialized experimental setup that provided synchronous recording of fluctuations in parameters such as arc current and voltage, pressure of the plasma-forming gas, temperature, and velocity of the plasma flow. A tungsten-rhenium

thermocouple was used to measure temperature, while fluctuations in the brightness of the plasma jet were recorded using a photodiode FD-6G. This approach ensured high accuracy and reliability of the obtained data.

During the experiments, it was found that large-scale fluctuations in the range of 100-300 Hz are observed in all investigated plasma torches and setups. The amplitude of fluctuations in power, current, and arc voltage, as well as pressure in the plasma torch channels, varied depending on the type of plasma torch and power supply. The results of the oscillogram analysis are summarized in a table. The investigation of factors leading to low-frequency fluctuations in the arc's electrical parameters showed that such fluctuations most often arise due to deficiencies in the power supply. A slight reduction (by 15-20%) in the supply voltage parameters in one of the phases can cause significant changes in the power consumed by the plasma torch, which, in turn, affects the technological characteristics of the plasma jet.

Large-scale fluctuations are also observed in technological plasma torches, related to fluctuations in the power supply voltage, the type of plasma torch, and arc oscillations. An increase in the working gas flow leads to an increase in the amplitude of power fluctuations. This increase is particularly noticeable with a rise in nitrogen flow, likely due to intense flow turbulence and enhanced shunting processes of the arc. These processes superimpose on the fluctuations caused by changes in the supply voltage. An increase in the working gas flow also leads to an elongation of the arc, and under conditions of supply voltage pulsations, shunting processes are intensified, which, in turn, reflects an increase in the relative amplitude of the arc voltage fluctuations.

It is important to note that this type of fluctuation does not lead to the creation of shock waves within the linear dimensions of the plasma torch and the distance to the substrate, nor does it cause the dispersion of powder particles. However, fluctuations in the technological parameters of the plasma torch can complicate the feeding of powder into the plasma jet, which, in turn, deteriorates the quality of the obtained coatings.

Thus, the results of the conducted research emphasize the importance of considering the fluctuations in the power of the electric arc during the plasma spraying process. Understanding these processes can contribute to the development of more efficient technologies in the aerospace industry and other fields where high-quality coatings are required. Further research in this area may lead to the creation of more advanced power supplies and plasma torches, which will undoubtedly have a positive impact on the quality and durability of products.

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