Studies of non-stationary processes on the surface of the hafnium CATHODE during ignition of ATMOSPHERIC-PRESSURE ARC DISCHARGE

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An electric arc plasmatron with an expanding gas-discharge path, a vortex stabilization of the arc and a special nozzle with two observation windows which allow to observe the cathode surface during the operation of the plasmatron was developed.

Based on the analysis of the processes occurring in the near-electrode areas, it was found that arc burning can be divided into three phases. The first phase (approximately the first 100 ms after the ignition of the discharge) is the binding of the electric arc to the cathode surface, accompanied by non-stationary processes on the cathode surface. The second phase is the stationary burning of the arc throughout the operation of the plasmatron. The third phase, the attenuation of the arc after the plasmatron’s power is switched off. In this paper, we study the processes occurring on the cathode surface in the first phase of the electric arc burning.

The studies were carried out in argon working medium at currents of 100–200 A and a plasma-forming gas flow rate of 1.5 g/s. Pure hafnium was used as the material for the manufacture of the cathode.

Using the Phantom Miro M110 high-speed camera, the state of the cathode was monitored from the first moment of electric arc ignition with a frame rate of 50,000 s–1. Video frames obtained from the camera were converted into temperature fields to further study the evolution of the cathode surface heating from the moment the plasmatron was started.

From the second viewing window, spectra were recorded on a three-channel Avaspec 2048 high-speed spectrometer with a frequency of 1000 spectra / s. The spectra obtained make it possible to observe changes in the temperature and composition of the plasma during non-stationary processes occurring at the cathode. The current-voltage characteristics were also recorded.

At the time of arc ignition, the cathode, in the arc binding zone, goes into a liquid state. The video clearly shows the hydrodynamic flows that occur on the surface of the liquid phase. Over time, the liquid channel is formed, which is drawn into the region of the plasma torch, followed by the formation of constriction and explosion. For this phenomenon, a physical explanation is given and theoretical estimates are made. The maximum temperatures were detected at which a) a phase transition occurs and b) the cathode material begins to be released into the plasmatron channel.