JOULE HEAT GENERATION IN THERMIONIC CATHODES OF HIGH-PRESSURE ARCS*

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Effect of Joule heat generation in the cathode body is investigated in the framework of the model of nonlinear surface heating, which is a widely used tool of simulation of plasma-cathode interaction in high-pressure arc discharges[1]. Special attention is paid to investigation of thermal balance of the cathode and the near-cathode plasma layer. Calculation results are reported for tungsten cathodes and argon arcs under the following conditions, which are typical for experiments with high-pressure arc discharges (e.g., Ref. 2): (1) plasma pressure 2.6bar, cylindrical cathode of radius 0.75mm and height 20mm or 24mm, current transfer occurs in the spot or diffuse modes; (2) plasma pressure 1bar, cylindrical cathode with a hemispherical tip of radius 1mm and height 12mm, current transfer occurs in the diffuse mode; (3) plasma pressure 1bar, solitary spot on a large planar cathode.

It was found that the voltage drop inside the cathode is much smaller than the voltage drop in the near-cathode plasma region in all the cases and at all currents investigated, which justifies the model being used. The Joule heat generation has virtually no effect on thermal and electrical characteristics of the diffuse mode at low currents, of the spot mode on the cylindrical cathode, and of the solitary spot mode.

On the other hand, the Joule heat generation produces a significant effect on characteristics of the diffuse mode at high currents. In particular, the current-voltage characteristic of the diffuse mode becomes Z-shaped in the current range $105\text{A} \lesssim I \lesssim 130\text{A}$. The maximum of the temperature of the cathode, which in the case without Joule heating is positioned at the edge of the front surface of the rod cathode and at the center of the front surface of the cathode with the hemispherical tip, is shifted to the lateral surface and its value is significantly reduced, in many cases to values below the melting point of tungsten. At high currents, $I \gtrsim 270\text{A}$, the power dissipated in the cathode due to Joule heating exceeds the power coming to the cathode from the plasma.

1. M. S. Benilov, "Understanding and Modelling Plasma-Electrode Interaction in High-Pressure Arc Discharges: A Review", J. Phys. D: Appl. Phys., vol. 41, no. 14, p. 144001 (2008).
2. L. Dabringhausen *et al*., "Different Modes of Arc Attachment at HID Cathodes: Simulation and Comparison with Measurements", J. Phys. D: Appl. Phys., vol. 38, no. 17, pp. 3128-42 (2005).

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