BOUNDARY CONDITIONS AT THE PLASMA-CATHODE INTERFACE IN HIGH-PRESSURE ARCS*

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Transport of electron energy from the near-cathode space-charge sheath into the bulk plasma is an important effect dominating heat exchange in cathodic part of high-pressure arc discharges. Therefore, a physically justified numerical model of bulk plasma in high-pressure arc discharges should take into account deviations between the electron and heavy-particle temperatures. As far as deviations from ionization equilibrium are concerned, two approaches are possible: to take them into account only in a near-cathode layer or in both the near-cathode layer and the bulk plasma. In the framework of the first approach, the model of near-cathode layer takes into account, in addition to the space charge, also non-equilibrium ionization. In the framework of the second approach, the near-cathode layer represents a space-charge sheath in which volume ionization and recombination are negligible. The two approaches have been compared[1] between themselves and with the experiment on atmospheric-pressure argon arc, for which both approaches are justified. It was found that they predict values of the arc voltage which are close to each other and the experiment for arc currents between 100 and 200A, however for lower currents the second approach predicts a less constricted and colder arc attachment and, consequently, significantly higher arc voltages than those found in the experiment and predicted by the first approach. Since the second approach is at least no less accurate than the first one, its predictive capabilities with regard to the arc-cathode interaction may be improved. Physically justified boundary conditions at the interface between the bulk plasma and the cathode are needed to this end. These conditions should account for the existence of the near-cathode space-charge sheath and have not been derived up to now. A derivation and validation of these boundary conditions is the subject of this work.

1. M. Baeva, D. Uhrlandt, M. S. Benilov, and M. D. Cunha, "Comparing two non-equilibrium approaches to modelling of a free-burning arc", Plasma Sources Sci. Technol., vol. 22, No. 6, p. 065017 (2013).

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