BIFURCATIONS OF REGIMES OF CURRENT TRANSFER TO CATHODES OF HIGH-PRESSURE ARC DISCHARGES

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A pattern of stable steady-state modes of current transfer to thermionic cathodes of high-pressure arc discharges has been established previously [1, 2] for a cathode in the form of circular cylinder with a flat front surface. It comprises a diffuse mode that exists at all currents and a spot mode that exists at low currents. In this work we study a pattern and stability of steady-state modes of current transfer to thermionic cathodes of complex geometries which are closer to ones of real devices. Axially symmetric tungsten cathodes of two shapes have been considered: rod cathodes with a hemispherical tip and with a spherical protrusion on top; and rod cathodes with variable curvature of the front surface. Steady-state modes of current transfer have been calculated as described in [1] and their stability has been studied as described in [2].

For both cathodes, only axially symmetric steady-state modes of current transfer have been found. For a cathode with a protrusion on its top, there are two separate modes. Figure 1 shows the current-voltage characteristics *U(I)* of these two modes. (Here *U* is the near-cathode voltage drop and *I* is the arc current.) Also shown is the dependence of the maximum temperature of the cathode surface on the arc current. Stable and unstable sections of each mode are shown by solid or, respectively, dotted lines. One of the modes (mode *a*) exists only at low currents and comprises two branches separated by a turning point. The stable branch of this mode is diffuse and there seems to be something that can be identified as a poorly pronounced spot on the unstable branch. The other mode (*b*) exists at all currents, is S-shaped, and manifests a smooth transition from a thermal regime characteristic of the spot mode (at low currents) to a thermal regime characteristic of the diffuse mode (at high currents). There is a certain current range in which the mode *b* is spot-like while the mode *a* does not exist. In other words, there is a current range in which only a spot mode exists. As the cathode radius decreases (at a constant height of the cathode and a constant radius of the protrusion), this pattern is gradually transformed into the above-described one typical for a cylindrical cathode with a flat surface. This transition occurs through a bifurcation of a special type which occurs at a certain value of the cathode radius.

In the case of a cathode with variable curvature of its front surface, only mode *b* was found in the whole current range investigated, from very low to very high currents; see Figure 2. For the considered conditions, this mode is also S-shaped, and manifests a smooth transition from a thermal regime characteristic of the spot mode (at low currents) to a thermal regime characteristic of the diffuse mode (at high currents). In other words, there is a current range in which the diffuse mode does not exist. As the front surface of the cathode becomes flat (at a constant height), this pattern is gradually transformed into the above-described one typical for a cylindrical cathode with a flat surface.

Thus, variations of geometry of a thermionic arc cathode may dramatically change the pattern of steady-state modes of current transfer. In particular, the diffuse mode at low currents may disappear. This effect may play a role in operation of cathodes of arc devices [3, 4].

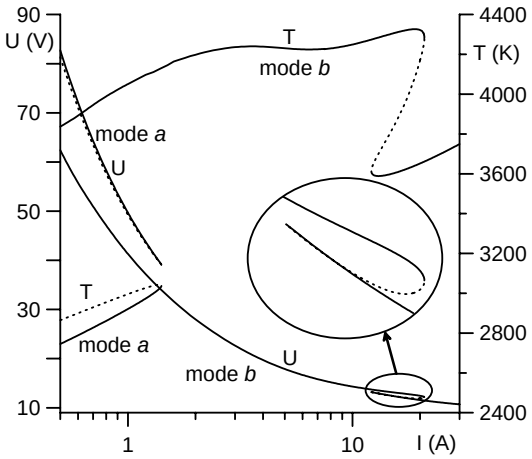

Fig. 1 Current-voltage characteristics and the maximum temperature of the cathode surface for a tungsten cathode in the form of a rod of radius 0.75mm and a height of 12mm with a hemispherical tip. A spherical protrusion of radius of 200μm is located at the top of the tip. Ar, p=2bar.

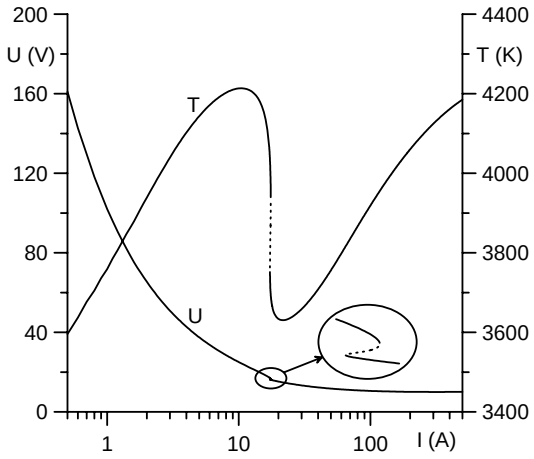

Fig. 2 Current-voltage characteristics and the maximum temperature of the cathode surface for a tungsten cathode in the form of a rod of radius 1mm and a height of 10mm. Cathode with an ellipsoidal tip with minor and major axis of 0.85mm and 1mm, respectively. Ar, p=1bar.

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References

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