STABILITY OF CURRENT TRANSFER TO CYLINDRICAL THERMIONIC CATHODES*

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Considerable advances have been achieved in recent years in the theory and modelling of steady-state current transfer from high-pressure plasmas to thermionic cathodes by means of the model of nonlinear surface heating. A crucial property of this model is the existence of multiple steady-state solutions for the same arc current, some of these solutions describing diffuse modes of current transfer and others describing spot modes. The general pattern of current-voltage characteristics of various modes was found to be rather complex; even the diffuse mode possesses an *N*-*S*-shaped CVC in some cases.

An important issue in problems with multiple steady-state solutions is which of them are stable. As far as the problem of current transfer to thermionic cathodes is concerned, no stability theory is yet available. One can think of applying the model of nonlinear surface heating also to analysis of stability of steady-state current transfer.

The switching from a diffuse mode to a spot mode in the framework of this model is caused by instability of a steady-state axially symmetric heat balance in the cathode body with respect to 3D perturbations. The mechanism of the instability is as follows. At low currents, the diffuse mode operates on the growing section of the dependence of the density of energy flux from the plasma on the local surface temperature. It follows that there is a positive feedback in diffuse regimes: a local increase of the surface temperature results in an increase of the local energy flux from the plasma, the latter causes a new increase of the local temperature etc., thus the thermal instability may develop. The positive feedback, however, is opposed by thermal conduction, which tends to smooth out perturbations, i.e., produces a stabilizing effect. The (in)stability of the diffuse mode is a result of competition of these two mechanisms.

This reasoning indicates that the model of non-linear surface heating includes both a positive feedback and a stabilizing mechanism and therefore may be a suitable tool for analysis of stability. In the present work, stability of the diffuse mode of current transfer from high-pressure plasmas to thermionic cathodes is analytically studied in the framework of the model of nonlinear surface heating for the case of a cylindrical cathode with an insulating lateral surface. Spectrum of perturbations is calculated analytically, thus providing an insight into the physics and reference points for numerical simulations of stability. It is shown, in particular, that the instability of the diffuse mode appears if the external resistance is insufficient to compensate the negative differential resistance of the discharge; a non-trivial result, given the thermal nature of the model.

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