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THE DEVELOPMENT OF HYDRODYNAMIC AND THERMAL INSTABILITIES IN A LIQUID METAL JETS IN THE CATHODE SPOT OF A VACUUM ARC*

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The explosion of the liquid metal jets is considered to be the basic mechanism of the birth of new cathode spot cells [1-4]. In this work a two-dimensional axisymmetric model has been developed to describe the formation of a liquid metal jet, the droplet pinch-off and temperature runaway in the droplet-jet neck during melt splashing from the cathode crater in a vacuum arc. The development of hydrodynamic and thermal instabilities has been self-consistent simulated in a copper current-carrying liquid metal jet in the “inertial” mode of the melt splashing (see Fig. 1). In this case, a jet with a longitudinal velocity gradient is formed and the droplet-jet neck becomes unstable due to the action of capillary forces (Rayleigh–Plateau instability). As a result, the neck radius decreases rapidly and the droplet splits off. In a current-carrying jet, this process is accompanied by a strong increase in the current density in the neck and its rapid heating due to the Joule effect to a critical temperature at certain values of current from the cathode spot plasma. It is shown that the heating process has the nature of a temperature runaway and, accordingly, can lead to its electric explosion. Assuming a constant current density on the jet surface, its minimum “explosion” value was calculated depending on the diameter, velocity and initial temperature of the jet. It is shown that for craters and jets of low-current arcs this density does not exceed 10^7 A/cm^2 and, accordingly, can be provided by the ion current from the plasma of the cathode spot.

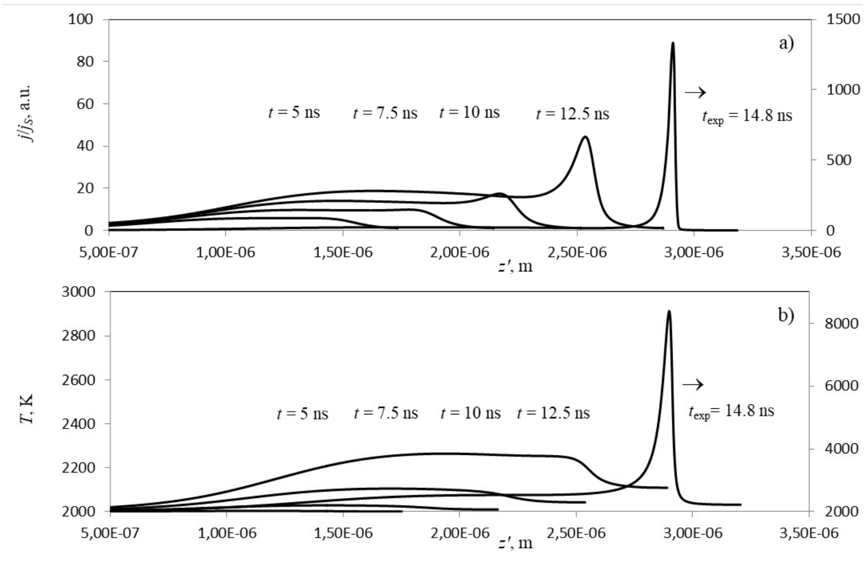

Fig. 1. Temporal evolution of the current density a) and temperature b) distributions along the jet.

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