EVOLUTION OF MITL PARAMETERS DURING THE PASSAGE OF A POWERFUL CURRENT PULSE*

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When a submicrosecond current with a linear density of more than 1 MA/cm flows over MITL, a significant heating of the metal occurs, up to melting, evaporation, and ionization. In the experiments, a thick-walled tube made of stainless steel was used as a MITL model. To simulate the processes occurring in a thick-walled tube when a current with a high linear density is passed through it, numerical calculations were carried out. A system of one-dimensional one-temperature magnetohydrodynamic equations was solved (in [1], a similar problem was studied for thin-walled tubes – the wall thickness is less than the skinning thickness of the magnetic field).

To describe the properties of a real substance, wide-range semi-empirical equations of state [2] were used, taking into account phase transformations (melting and evaporation) and the possibility of realizing metastable states, as well as the dependence of transport properties (conductivity and heat capacity) on temperature [3, 4]. The parameters of the tube made of stainless steel and the time dependence of the current in numerical calculations were used those that were used in the experiments.

At different times, the distributions of pressure, temperature, substance density, and current density over the wall thickness of a tube with an outer diameter of 3 mm and a wall thickness of 220 μm were obtained. It can be seen that by the time of 100 ns, the current density is almost uniformly distributed over the thickness; the substance density decreased most of all at the outer boundary of the tube in the region where the temperature increased the most. By this moment, the substance of the tube from the outer boundary and slightly more than to the middle of its thickness is already in a liquid state; the remaining part near the inner boundary has not yet had time to melt to the end and is in a two-phase state of a solid–liquid.

The time for the melting wave to reach the inner surface of the tube is clearly seen in the time dependence of the resistive voltage calculated on the inner surface of the tube. The same voltage was measured in experiments; comparing them, it can be stated that the time of the melting wave reaching the surface of the inner boundary of the tube and its duration coincide in experiments and numerical calculations.

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