PHENOMENOLOGICAL MODEL OF PINCH EFFECT IN THE WORKING CHAMBER OF A LIQUID-METAL COMMUTATING DEVICE

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Among numerous devices for electric circuits commutation, those with a liquid-metal working medium occupy a special place due to their advantages in comparison with the conventional ones [1, 2, 3]. Their main merits include the possibility of direct influence of a controllable electromagnetic signal on the liquid metal, the operation without welding and contacts sticking, the absence of additional mechanical elements, self-regeneration after the controllable signal is removed.

Among the devices with a liquid-metal working medium, magnetohydrodynamic (MHD) commutating devices should be singled out [1, 2]. One of promising areas of the application of their operation principle is the designing of a current limiter and a current breaker. In some constructions, the interaction of a controllable electric current with a self-magnetic field can causes the pinch-effect [3].

The dynamics of working fluid under the action of electromagnetic forces in these devices can be described, in principle, by a system of MHD equations. This makes it possible to evaluate the so-called current-time characteristics describing the actuation time of a commutating device at various current values. Meanwhile, the problems related to the pinch-effect arise in a liquid metal when the controllable electric current reaches a certain critical value depending on a number of parameters remain unsolved [4].

To analyze the conditions of pinch-effect origination in channels of commutating devices and evaluate the time of its development, a complicated mathematical model should be examined. We suggest a phenomenological model, which simplifies the process of evaluation of the necessary dynamic characteristics.

By way of example, we examine a U-shape hydraulic system of a device with a liquid-meal working medium, whose discharge and receiving sections are connected by the working chamber. A controllable electric current passes through the working chamber and the magnetic system winding and generates a field of forces, moving the liquid metal from the discharge section into the receiving one. After the free surface of the liquid metal reaches a certain critical position, the pinch-effect arises leading to a bursting of the liquid-metal section of the electric circuit and, respectively, to a break in the controllable electric circuit.

We present an equation of the liquid metal motion in the commutating device, whose solution describes the behavior of the free surface level in the working chamber. The field of electromagnetic forces is computed, and the dynamics of liquid-metal neck is analyzed.

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