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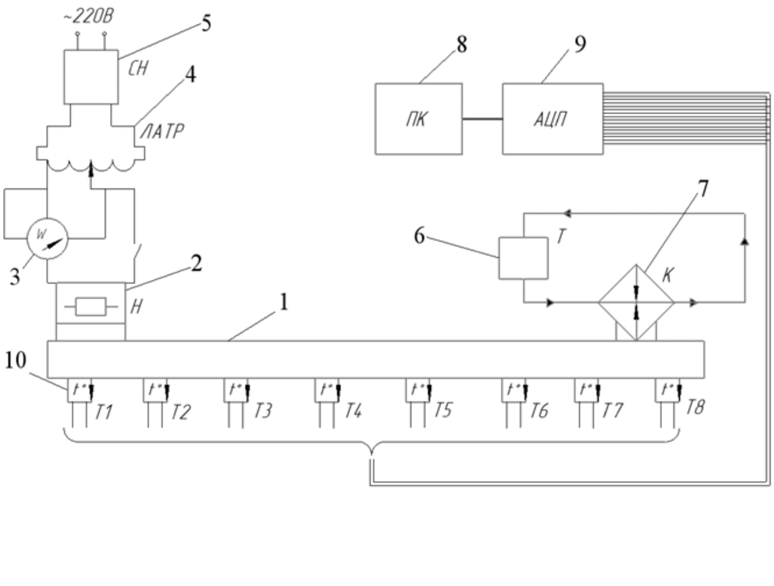
MAXIMUM HEAT TRANSFER CAPACITY OF FLAT HEAT PIPES WITH METAL-FIBER CAPILLARY STRUCTURE

Scientific and technological progress is characterized by the creation of new and more advanced electronic devices of various sizes. This, in turn, leads to the need to create more powerful cooling systems capable of diverting large heat fluxes with minimal losses. Flat heat pipes can be used as heat dissipation elements of such systems. They are able to cool both large surfaces, for example, in the elements of electronic equipment, as described in [1], and miniature devices – smartphones, tablets, laptops [2]. Due to the shape of its body, flat heat pipes fit as tightly as possible to the heat dissipation elements of electronic devices. Thus, the thermal resistance between the heat pipe body and the heat source is significantly reduced. However, flat heat pipes, as well as round ones, have certain limitations of their heat transfer capacity, namely:

- hydrodynamic limitation that occurs due to the excess of the total pressure loss on the movement and evaporation of the coolant over the total capillary pressure;
- restriction on boiling caused by the appearance of film boiling of the coolant at certain values of the supplied heat flow;
- sound restriction caused by the blockage of the steam flow due to its approach to the speed of sound at the exit from the heating zone;
- restriction caused by the removal of fluid flow by the counterflow of steam.

This research studies the influence of different types of restrictions on the maximum heat flux, which can be supplied to flat heat pipes with a metal-fiber capillary-porous structure. The scheme of the experimental setup used in the series of experiments is presented in Fig. 1.

The investigated element was a copper flat heat pipe, the general appearance of which is shown in Fig. 2



1 - flat heat pipe; 2 - heater in the heating zone; 3 - wattmeter; 4 - laboratory autotransformer; 5 - voltage stabilizer; 6 - thermostat; 7 - capacitor; 8 - personal computer; 9 - analog-to-digital converter; 10 - copper-constantan thermocouples (8 pieces)

Figure 2. Flat heat pipe (photo)

The wall thickness of the pipe and the capillary-porous structure was 0.5 mm, the thickness of the vapor space was 0.8 mm (Fig. 3). The flat heat pipe was made by pressing from a round heat pipe with a diameter of 5 mm, a total length of 224 mm, a heating zone length of 40 mm and a condensation zone of 65 mm. The length of the fibers of the capillary structure was 3 mm, fiber diameter 50 μm, porosity - 75%.

The supply and removal of heat from the flat heat pipe was organized using a flat heater and a flat condenser, respectively. The pipe was pressed against them, and between the surface of the pipe and the surfaces of the heater and condenser was a layer of heat-conducting paste to reduce the contact thermal resistance.

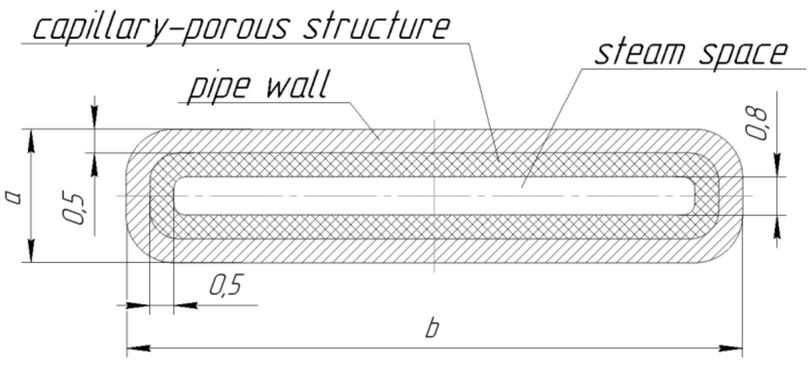


Figure 3. Cross section of a flat heat pipe (dimensions in mm)

The research showed that in the main part of the studied temperature range the hydrodynamic constraint is the most critical and if it is not reached, in the case when the capillary pressure of the capillary-porous structure exceeds the total losses for the liquid and vapor phase, then other constraints will not be reached automatically and the efficiency of the flat heat pipe will be maintained (Fig. 4).

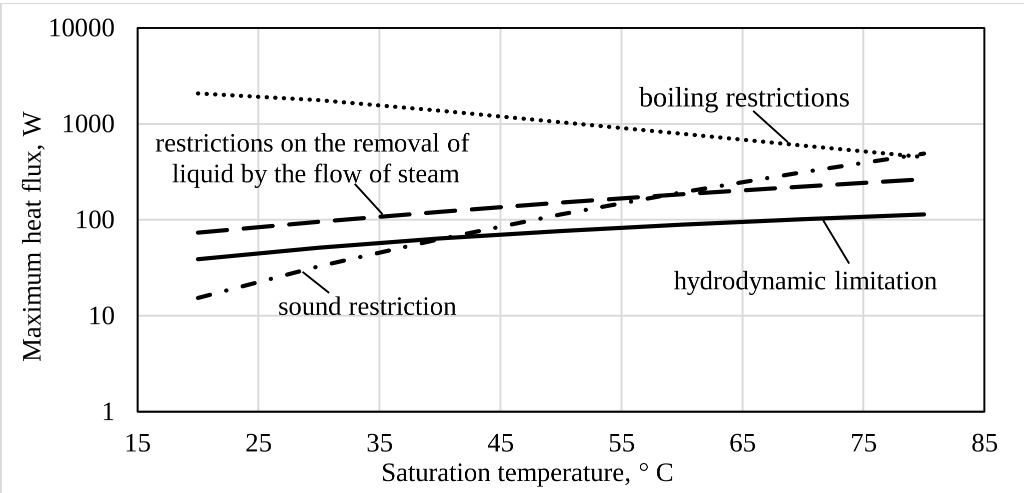


Figure 4. Existing limitations of heat transfer capacity for a flat heat pipe

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