EFFECT OF HEATER DIAMETER ON CRITICAL HEAT FLUX IN BOILING

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The laws of boiling burnout are of considerable theoretical and practical interest, but in some respects have been little investigated. In particular, it is not completely clear how the heater geometry affects the critical heat flux, although the existence of such an effect has been repeatedly demonstrated.

References [1-4] present the results of measurements of the critical heat flux q_* in boiling water for heaters of different sizes. However, it is not possible to establish from these data the precise nature of the dependence of the critical flux on the heater diameter d.

This question was examined more systematically in [5] in relation to the boiling of pure liquids. In [5] the effect of heater diameter on q_* was investigated for water and ethanol with the heater arranged both horizontally and vertically. In this case the diameter was varied from 0.1 to 6 mm. The literature contains no data on boiling burnout for d < 0.1 mm and there is little information on the effect of heater size on q_* in boiling mixtures. This problem was first investigated in [6] for aqueous solutions of butanol and ethanol using nichrome wires with d = 0.5 mm and plates 6 mm wide. The present paper gives the results of measurements of q_* for heaters of various diameters and certain pure liquids and binary mixtures. Values of q_* were determined for horizontal cylinders 0.02 to 6 mm in diameter. The heaters from 0.5 to 6 mm in diameter were made of Ix18N9T stainless steel, those from 0.5 to 0.05 mm in diameter from nichrome, and those 0.02 mm in diameter from copper.

Stainless steel of this grade and nichrome are similar in composition. Therefore it may be assumed that the material of almost all the heaters was the same.

Before the experiment the heaters, polished with micron emery paper and degreased with acetone, were subjected to stabilization.

The investigations were conducted under conditions of pool boiling at atmospheric pressure.

Boiling burnout was pinpointed visually: at diameters of 0.2 mm and above from the local reddening, and at diameters below 0.2 mm from the appearance on part of the surface of a "comb-like" vapor film which, with further increase in load, spread over the entire heating surface.

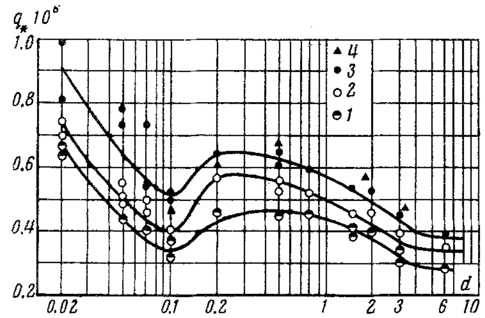

Fig. 1

Figure 1 shows the critical heat flux density q_* as a function of the diameter of the cylindrical heater d for experiments with benzene (curve and points 1), acetone (curve and points 2), and ethanol (curve and points 3). Here, however, on curve 3 we have also plotted data on ethanol (points 4) taken from [5]. The results obtained are in agreement with the data of [5] for d ≥ 0.1 mm.

As may be seen from the figure, there is a region in which the effect of the heater diameter is substantial and extreme values of q_* are observed, a sharp increase in q_* being observed at d < 0.1 mm.

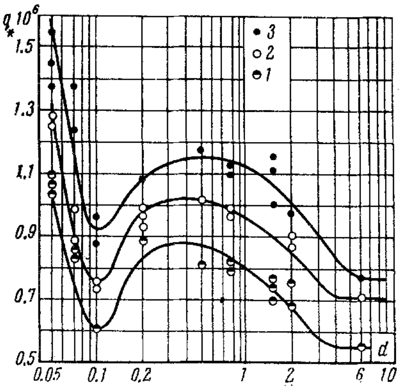

Fig. 2

Figure 2 shows the dependence of q_* on d for a boiling binary mixture of acetone and water with volume concentrations of 10, 20, and 30% water (curves and points 1, 2, and 3, respectively). The nature of the dependence of q_* on d for these mixtures is the same as for pure liquids.

Attempts to generalize the experimental data obtained by the method proposed in [5] did not lead to positive results.

These investigations show that the effect of the heater diameter on the critical flux in boiling is more complex than previously assumed [5].

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