EXPERIMENTAL STUDY OF CRITICAL HEAT FLUXES IN BOILING

I. G. Shekriladze, Yu. Sh. Verulava,
L. E. Vasadze, and G. B. Kapanadze

UDC 536.423

We present results of an experimental test of a method for studying critical heat fluxes in boiling water without destroying the electrically heated experimental sections.

In various experimental methods used to determine critical heat fluxes in boiling, the experimental sections are directly connected in an electric power circuit [1-3]. We describe the results of an experimental test of a method of studying critical heat fluxes by using the spontaneous drop in electric current flowing through the experimental section as crisis is approached to cut off the power supply and thus prevent the destruction of the section.

The problem of preserving the experimental section in its initial form in an experiment on the boiling crisis is rather important, particularly in technical studies directed toward increasing the critical heat fluxes. A reliable solution of this problem permits a sharp reduction in the time required to perform the experiments and a decrease in the amount of work to construct the experimental sections, which in many cases involve complex geometry and technological fabrication.

Figure 1 shows a schematic diagram of our experimental arrangement for studying critical heat fluxes in the boiling of water and organic coolants in a large volume. A characteristic feature of the arrangement is the introduction into the ammeter in the secondary winding of the current transformer of an optical sensor which transmits a signal to the protection unit at the instant the current drops. Upon receiving the signal from the optical sensor, the protection unit, which is made of standard elements (transistors, relay, thyristors), triggers the magnetic starter to cut off the power supply to the experimental section. As the heat flux gradually increases, the optical sensor lags behind the ammeter reading by a definite specified amount. As the critical heat flux is approached, the experimental section begins to overheat, its electrical resistance increases, and the electric current drops. The optical sensor responds to this current drop, and the protection unit cuts off the power

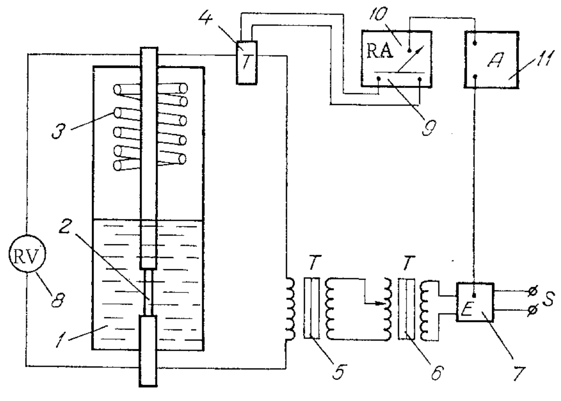

Fig. 1. Schematic diagram of experimental arrangement: 1) evaporator; 2) experimental section; 3) condenser; 4) current transformer; 5) low-voltage transformer; 6) voltage regulator; 7) magnetic starter; 8) voltmeter; 9) ammeter; 10) optical sensor; 11) protection unit.

Translated from Inzhenerno-Fizicheskii Zhurnal, Vol. 40, No. 6, pp. 1019-1021, June, 1981. Original article submitted April 1, 1980.

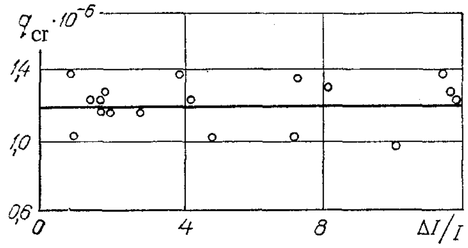

Fig. 2. Dependence of measured value of critical heat flux q_{cr} (W/m^2) on $\Delta I/I$, %.

supply to the experimental section. In this method, the critical heat flux is found from the maximum electric current and potential drop reached before the experimental section is automatically cut off. These values are determined from visual readings or by recording instruments.

It is easy to show that the smaller the difference between the readings of the ammeter and optical sensor the greater the chances of maintaining the section in its initial form. On the other hand, it is obvious that as this difference is decreased there is an increase in the probability of cutting off the power supply because of random current fluctuations. This can lead to an error in determining the critical heat flux.

To test this technique, we performed experiments to determine the dependence of the measured value of the critical heat flux on the difference between the readings of the ammeter and optical sensor. The experiments were performed on a vertical stainless-steel pipe 11 mm in diameter and 60 mm high. The boiling of distilled water was studied at atmospheric pressure.

Figure 2 shows the results of experiments performed on a single experimental pipe. The horizontal line corresponds to the average value of the critical heat flux under these same conditions according to the data of [4]. The figure shows that our measured values of the critical heat fluxes for values of $\Delta I/I$ from 1 to 12% are in satisfactory agreement both with one another and with the data in the literature. It should be noted that the value of the critical heat flux found by burnout of the experimental pipe at the end of the experiments also agrees with the data shown in Fig. 2.

Thus, when certain conditions are satisfied, this method offers a completely reliable solution of the problem of studying the boiling crisis by reusing the same experimental sections.

NOTATION

q_{cr}, critical heat flux; I, electric current; ΔI, difference between readings of ammeter and optical sensor in units of electric current.

LITERATURE CITED

1. V. A. Chernobai, S. V. Perkov, and A. F. Vasil'ev, "Determination of the heat-transfer crisis in boiling," Vestn. Kiev. Politekh. Inst., 9, 46 (1972).
2. A. N. Kichigin, "Sensitivity of bridge and thermocouple methods of determining the heat-transfer crisis in boiling," Teplofiz. Teplotekh., 30, 70 (1976).
3. P. G. Poletavkin, V. I. Petrov, L. D. Dodonov, and I. T. Alad'ev, "A new method of studying heat transfer in the boiling of liquids," Dokl. Akad. Nauk SSSR, 90, 775 (1953).
4. G. I. Bobrovich, I. I. Gogonin, and S. S. Kutateladze, "The effect of the size of the heating surface on the critical heat flux in boiling in a large volume of liquid," Zh. Prikl. Mekh. Tekh. Fiz., No. 4, 137 (1964).