RESULTS OF EXPERIMENTAL STUDY OF BOILING HEAT TRANSFER MULTIFACTORING

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Installation and methodology for conducting experiments on boiling heat transfer multifactoring are described. The results of experimental study of boiling of saturated and subcooled benzene on end surfaces of copper and stainless steel cylinders at upward and downward orientations in the gravity field are presented. Experimental data on boiling of hexane at various angles of inclination relative to downward orientation also are presented.

Key words: *heat transfer, multifactoring, heating, electric heaters, saturated liquid.*

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The aim of video shooting and studying dynamic effects accompanying boiling at downward oriented heating surface and heat transfer was set clearly in the work [1]. Experimental area was prepared for these purposes and the installation with metering devices was rigged up. Experimental installation diagram is shown on figure 1.

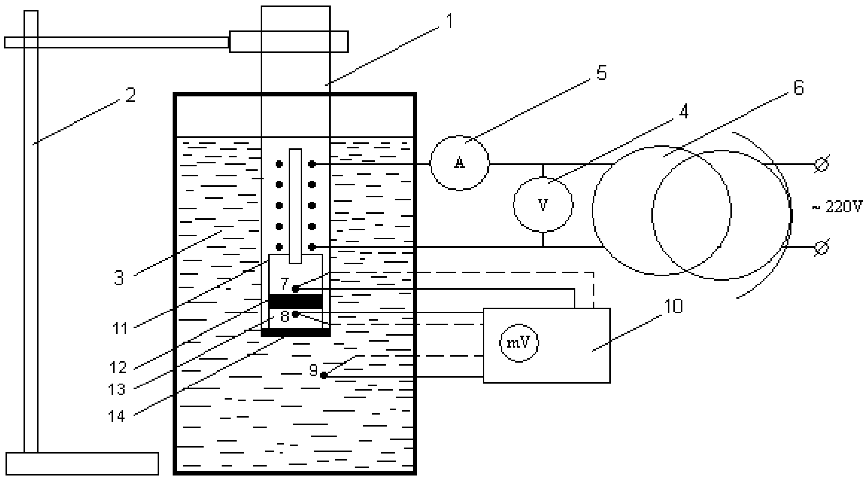

Figure 1. Experimental Installation Diagram

Experimental area (vertical cylinder) 1 with upper end is set on arm 2 and run in a glass vessel 3 filled up with heat exchanger. Benzene and hexane were used as heat exchangers.

Test experiment was run for confirming the accuracy of experimental study methodology, good operational shape of the devices, implementing boiling process and obtaining initial heat transfer data. Power of electric heater was measured by electrical devices - D-566 voltmeter 4 and D-533 amperemeter 5. Voltage was adjusted with lab autotransformer 6. Electromotive force generated in thermocouples 7, 8, 9 was measured by Щ 300 millivoltmeter 10. Boiling surface temperature on heating surface, for both options (copper, stainless steel), were determined by recalculating the readings of thermocouple 8 [2]. Liquid temperature was identified by thermocouple 9. An error during the experiment

would not exceed 10%. Standard procedures for measuring specific heat flow q, heat transfer coefficient α and other thermal parameters were used. During the experiment specific heat flow q was determined according to the temperature drop on stainless steel plate 12 placed between copper cylinders 11, 13. The main method to measure the heat flow was additionally controlled by the power of the electric heater (considering heat losses). During preliminary experiments thermal powers measured by both methods were compared with each other. Difference between the heat flows measured by both methods ranged within ±25% indicating the reliability of the basic method.

Bubble boiling process was run at the end surface 14 of vertical cylinder, in the gravity field under its vertically upward and vertically downward orientation conditions. The results of both experiment series are presented on figure 2.

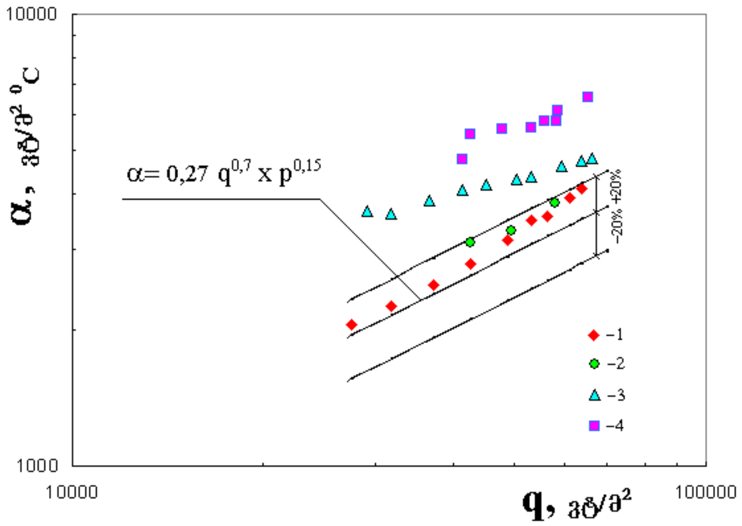

Figure 2. Data of Experimental Heat Transfer at the End Surface of Copper Cylinder Oriented Upwards and Downwards During Benzene Boiling:
1 – saturated liquid boiling at upward oriented surface; 2 – supercooled liquid boiling at upward oriented surface; 3 - saturated liquid boiling at downward oriented surface; 4 - supercooled liquid boiling at downward oriented surface; continuous line – heat transfer law of developed boiling

As seen from experimental data analysis, common regularity for downward oriented surface of the developed boiling loses is effectiveness. We have the variety of specific heat transfer curves depending on additional factors clearly representing the heat transfer multifactoring phenomenon.

Analogous test were also run at copper and stainless steel surfaces in case of hexane boiling. Besides, experimental research of hexane boiling heat transfer process to study the influence of the stainless steel cylinder end surface orientation was performed. The results of this research are presented on figure 4.

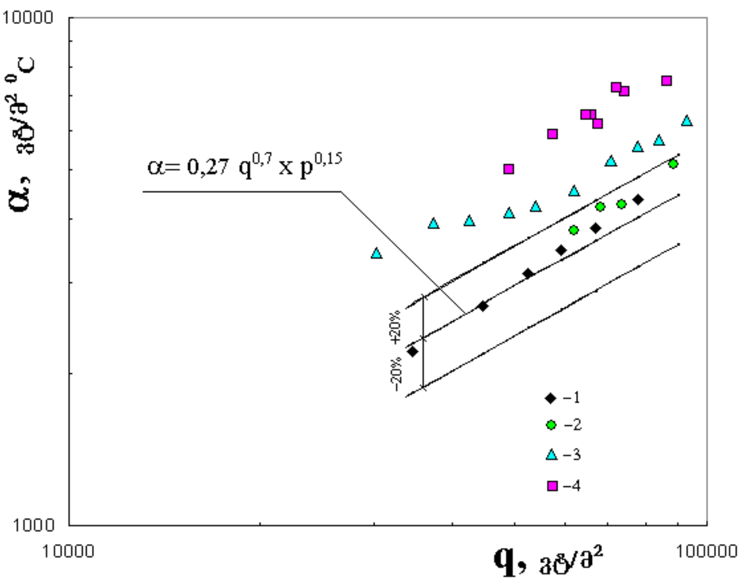

Figure 3. Data of Experimental Heat Transfer at the End Surface of Stainless Steel Cylinder Oriented Upward and Downward During Benzene Boiling:
1 – saturated liquid boiling at upward oriented surface; 2 – supercooled liquid boiling at upward oriented surface; 3 - saturated liquid boiling at downward oriented surface; 4 - supercooled liquid boiling at downward oriented surface; continuous line – heat emission law of developed boiling.

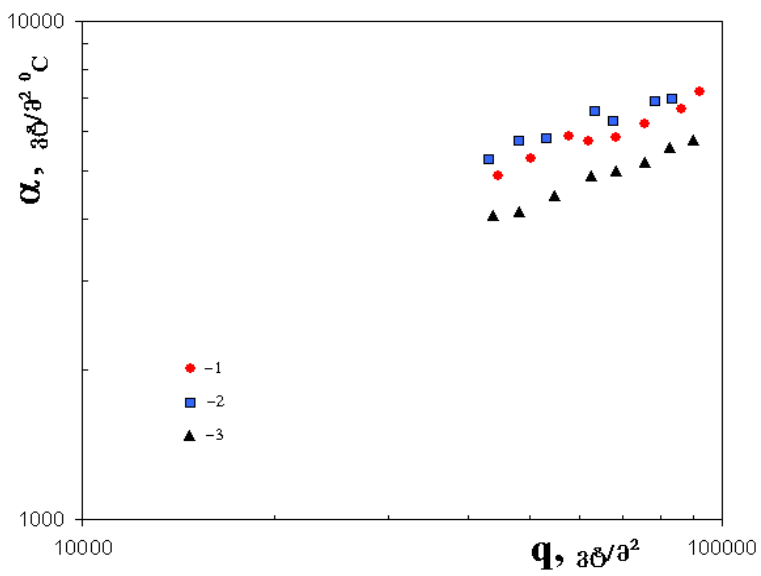

Figure 4. Data of Experimental Heat Transfer at the End Surface of the Cylinder Oriented Upward and Downward During Hexane Boiling:
1 – saturated liquid boiling at the surface of the stainless steel deviated by 10%;
2 – saturated liquid boiling at the surface of the stainless steel deviated by 20%;
3 - saturated liquid boiling at the surface of the stainless steel deviated by 30

As it is seen from the figure, the heat transfer curves are distinctly layered depending on the angle of dip. In addition, the heat transfer intensity drops down together with the increase of the angle of dip which also represents the boiling multifactoring.

So, as it was expected, as a whole, significant volume of new experimental material which proved not only the multifactoring scale of the boiling process, but allowed us to identify its particular regularities was obtained [3].

In particular, splitting of base integral law of the developed boiling into different curves as a result of the heating surface orientation, liquid supercooling and change of heat conductivity of surface material was clearly determined by the experiments, and the main part in this process was plaid by the change of the surface orientation.

Video shooting of the dynamic effects accompanying boiling at downward oriented heating surface identified two classes of heat transfer modes to be researched: the first – leading role of liquid convection and the second – leading role of the liquid evaporation. In addition, both classes belong to the multifactoring boiling modes and in their usage context, the main difference between them should be indicated by the nature of the influence of thermal parameters of the heat surface on the heat transfer coefficient.

R E F E R E N C E S

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