A Study of nucleate boiling water on Fusible alloys surface

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Abstract.

An experimental results of bubble boiling study of water on the surface of various melts. It is shown that the nucleation centers are available as a foreign matter, and the fluctuating nature of education. The source of such formations is the boundary layer between immiscible liquids, which structure is closer to a solution of water in the melt. Experimentally found that the tear diameter vapor bubbles and the rate of boiling is practically independent of the temperature gradient, in contrast to the density of active boiling centers. Comparison of different characteristics for the boiling on melts surfaces indicated that the melt composition has an effect only on the di- mansions of vaporization centers. In addition, such boil process characteristics like the density of active centers of vaporization and boiling speed do not differ for the different melts.

Keywords: immiscible liquid, boiling on the melts surface, vaporization center, nucleation center

Introduction.

In modern conditions, the widespread use of low-melting alloys is associated with the production and use of liquid metal coolants in power engineering and machine building; Foundry production (production of melted models and rods, materials for castings); early warning systems for fires (temperature sensors, fire extinguishing valves, etc.); thermometry (working body for thermometers of various types); vacuum technology (seals, brazed seams, etc.); microelectronics and medicine (fixation, prosthetics, etc.). This is due to the significant advantages of low-melting alloys in comparison with pure metals and conventional alloys, including in terms of their use as coolants [1].

In the group of low-melting alloys are combined, having a melting point below the melting point of tin. The basis of such alloys is tin and lead with additions of cadmium and bismuth. Metals are introduced into alloys in such quantities that fusible triple and more complex eutectics are formed.Liquid alloys possess high values of thermal conductivity coefficients, and, consequently, are able to effectively remove heat from the surface of the heater. On the other hand, because of the high boiling temperatures of the low-melting alloys, heat transfer can take place at atmospheric pressure over a wide range of temperatures. In addition, the phenomenon of cavitation during the flow of a liquid alloy can be neglected. It can be assumed with sufficient accuracy that the regularities of the flow of liquid alloys and simple liquids are analogous. In the technique, thanks to the listed features of liquid-metal coolants, so-called binary plants have become widespread, in which two substances, liquid metal coolant and water, are used as working bodies. In this connection, boiling in a multilayer system consisting of a liquid metal coolant represented by a fusible alloy and water as the most commonly used heat medium of a nonmetallic nature is of definite interest.

Formulation of the problem.

One of the main features of modern studies of bubble boiling at the interface between two liquid phases, both domestic and foreign scientists, is to distinguish the individual sides of this complex phenomenon in a "pure form" [2, 3]. To a greater extent, this refers to the study of the density of the heat flux as a quantity directly related to the practical use of such systems. At the same time, in our opinion, the process of nucleation and development of steam vials in a multilayer system is of great interest.In this case, the vapor deposition centers can be: firstly, particles of contaminants preserved on the surface of the melt; secondly, there is always a certain amount of gases present in the liquid in the dissolved form.If the boiling process takes place in the metal-water system, then the presence of gas in the superheated layer of the latter can be explained by the reactions of decomposition on a metal surface under the action of catalysts. For example, in Refs [4, 5], a study was made of the process of formation of vapor bubbles in the boiling of water on the surface of mercury, which was accompanied by the evolution of gases due to a chemical reaction in which mercury acted as a catalyst:

$$2H_2O \xrightarrow{Hg,T} 2H_2 + O_2$$

Similar reactions occur when glycerol boils on the melt of tin, when a thermal reaction of its reduction to aldehydes takes place:

$$CH_2(OH) - CH(OH) - CH_2(OH) \xrightarrow{Sn,T} CH_2(OH) - CH\ (OH) - \underset{\displaystyle H}{\underset{|}{C}} = O + H_2$$

Thirdly, in the area of direct contact of two immiscible liquids, an intermediate layer is formed [6]. The process of nucleation of the vapor phase can occur in this layer, which is a solution for which the solvent is a substance with a higher density and a higher boiling point, i. E. melt, and dissolved - a substance with a lower density and more.

Table. 1. Composition and Temperature of Evaporation of Evidential Compositions

Alloy	Composition	Melting temperature
Melot	bismuth 48% lead 24% tin 28%	64 °C
Wood	bismuth 50% lead 25% tin 12.5% cadmium 12.5%	68 °C
Rose	bismuth 50% lead 25% tin 25%	94 °C

Low boiling point, i.e. water. As the x-ray diffraction analysis of the molecular structure of solutions has shown [7], quasicrystalline groupings of homogeneous molecules are formed in them, there are amyx- copic drops of pure liquids. Thus, the solution structure is microheterogeneous. In addition to density fluctuations, concentration fluctuations also occur.

Methodology and methods of research.

The aim of this study was to study the process of bubbly boiling of water on various liquid metal surfaces, as well as to elucidate the effect of the substance of the heating surface on the quantitative characteristics of the process. Distilled water GOST 6709-72 was used for the study. As a heating surface, low-melting alloys based on bismuth were selected (Table 1).Determination of the separation diameter of vapor bubbles, the boiling rate and the density of the active centers of vaporization was carried out at different values of the temperature head using the procedure described in [8]

Discussion of the results of the stud

Experiments have shown that in the presence of a minimum temperature head in the melt-water system degassing begins. In the melt, it is carried out by forming gas cavities in the annular gap between the melt and the walls of the vessel (Fig. 1).

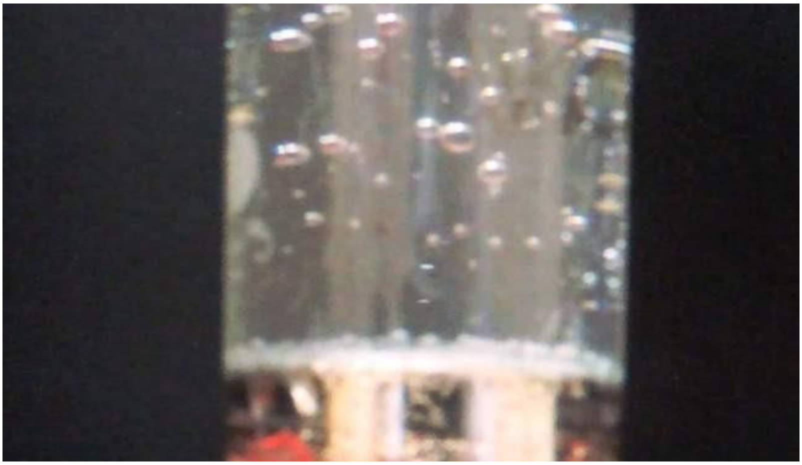

Fig. 1

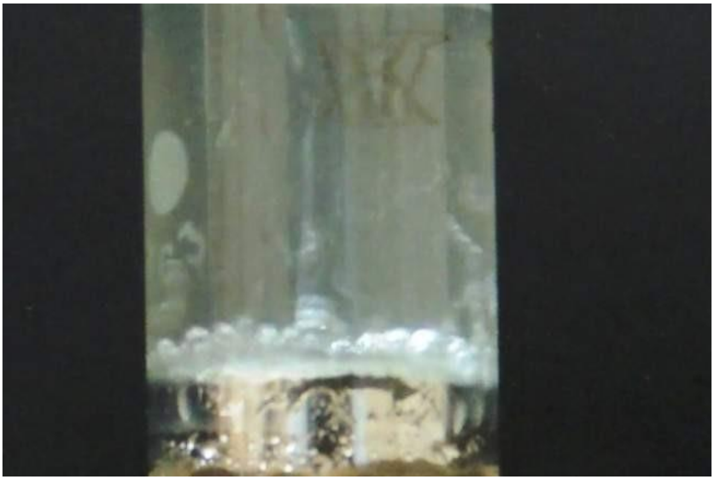

Fig.2.

With increasing temperature, the entire surface of the melt is covered with a number of bubbles (Figure 2).Further, with an increase in the surface temperature of the melt, its surface is cleaned of vapor bubbles and the process of emergence begins-

Fig.3

(Fig. 3). The formation of these cavities is apparently connected with the presence of air bubbles in the thickness of the melt .Finally, at sufficiently high temperature headings, a process of bubbling water boils begins: at different points of the surface of the melt vapor bubbles form, grow, take a mushroom shape, come off and float up (Fig. 4). Since their development is accompanied by

Fig.4.

is given by constant wave perturbations of the surface of the melt, the bubbles travel from the nucleation to the detachment to distances several times greater than their tear off diameter.

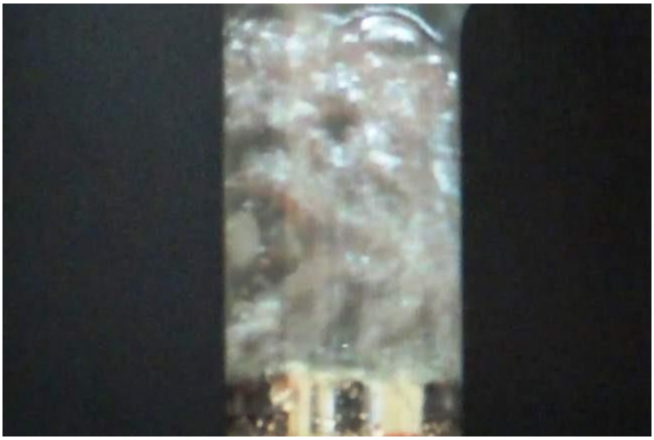

Fig.5.

With an increase in the temperature head, the frequency of bubble separation increases significantly, and then a rapid boiling begins, accompanied not only by an intense wave process at the surface of the melt, but also by spraying its upper layer into the water column (Fig. 5). When the system is cooled, it passes all the above described states in the reverse order, excluding degassing .This process was repeated many times, both in the forward and backward directions, and it was always the same.

The results of the experimental determination of the separation diameters of vapor bubbles, the boiling point and the density of the evaporation centers for different values of the temperature head are given in (Table 2). The observed character of the bubbling boiling of water on melts has the same stages as the processes of boiling of glycerin described in [5, 9] and paraffin on the surface of mercury and tin. However, if the glycerin boils on the melt of tin to obtain a relatively quiet-

Table. 2. Results of the Experimental Determination of the Characteristics of the Bubble Boiling of Water on Light-Fuel Spices

Substance	Average value of the separation diameter of vapor bubbles, m	Boiling speed, m / s	The average density of active centers of vaporization, m-2
Alloy (Melot)	0.0024 0.0024	0.111 0.110	2380 3750
Wood Alloy	0.0022 0.0021	٠.١١٥ 0.114	٣٩٨٠ ٣١٩٠
Alloy Rose	0.0021٠.٠٠٢٢	٠.١١٣ 0. 114	3670 3280

boiling requires an overheating of the order of 50 ° C, then for the Wood water-alloy system, an overheating of the order of 10 ° C is sufficient for this .At the same time, the average values of boiling characteristics, such as the separation diameter of vapor bubbles, the density of the active nucleation centers and the boiling rate, are of the same order of magnitude as when boiling water on solid heating surfaces [5, 10, 11]

Conclusions.

Analysis of the results of the study made it possible to draw the following conclusions: the average values of the separation diameter of the vapor bubbles are practically independent of the temperature head and differ for different melts. At the same time, for each heating surface and a certain value of the temperature head, a scatter of bubble diameters of the order of 10-15% from their mean value was observed. This fact indicates that, firstly, there are boiling centers of various sizes in the intermediate layer, and, secondly, the dimensions of these centers are influenced by the diffusion and intermolecular interactions between the melt and water.The rate of boiling with an increase in the temperature head practically does not change in the investigated temperature range. Moreover, the nature of the heating surface apparently does not have a significant effect on this value. The density of the active centers of vaporization in the temperature range under study depends only slightly on the material of the heater, and is mainly determined by the magnitude of the temperature head. The experimental study carried out showed that for more complete and detailed study of bubble boiling at the interface between two liquid phases, it is necessary to take into account the influence of the properties of the boundary layer between them. Diffusion processes, as well as the chemical interaction between its molecules, certainly have a definite influence on the nucleation and growth of vapor bubbles inside it and in the future, it can affect heat exchange as a whole.

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