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SHAPE OF THE VAPOR BUBBLE UPON EXPLOSIVE BOILING

B. P. Avksentyuk and V. V. Ovchinnikov

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A relation for the shape of a vapor bubble forming during propagation of a vaporization front is proposed.

In a liquid superheated above certain threshold values of the saturation temperature, vaporization fronts form at the surface of the vapor bubble due to instability of the liquid–vapor interface [1–3]. The propagation velocity of the vaporization fronts in a metastable liquid is constant in time and can reach several dozen meters per second. The explosive character of boiling is caused by formation of vaporization fronts at a highly metastable state of the liquid.

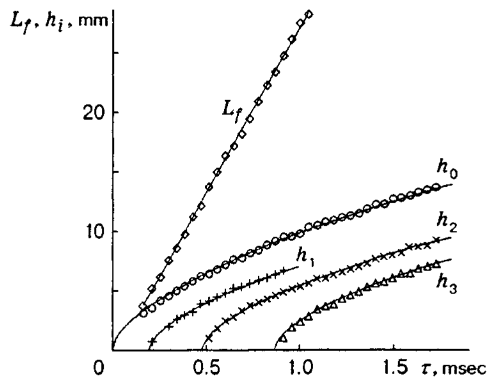

Fig. 1

A detailed description of the experimental setup and procedure used in this study is given in [4]. Figure 1 shows the results obtained from a cine film of heterogeneous explosive boiling of benzene registered over a cylindrical test section 2.5 mm in diameter. Prior to boiling, the liquid was superheated by 172 K, and the pressure in the working volume under saturation conditions was 10.1 kPa. In the experiment, the heating of the test section was quasi-steady. The distance L_f from the place of emergence of the initial bubble to the vaporization front and the transverse (normal to the heat-releasing surface) dimensions of the vapor bubble are shown in Fig. 1 as functions of time in four cross sections: at the point of origin of the bubble (h_0) and 5, 13, and 24 mm away from this place (h_1, h_2, and h_3, respectively). The curves shown in the figure are fitting functions. The growth rates of the vapor bubble in the normal and transverse directions after the formation of vaporization fronts are seen to differ substantially from one another.

The transverse size of the bubble increases linearly in time, which indicates that the propagation velocity of the vaporization front is constant. In the case under consideration, the vaporization front propagates with a velocity of 27.6 m/sec. Variation of transverse dimensions obeys the laws $h_0 = a\tau^n$ and $h_i = b(\tau-\tau_{fi})^n$,

Kutateladze Institute of Thermal Physics, Siberian Division, Russian Academy of Sciences, Novosibirsk 630090. Translated from Prikladnaya Mekhanika i Tekhnicheskaya Fizika, Vol. 41, No. 2, pp. 122–123, March–April, 2000. Original article submitted April 13, 1999.

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where $i = 1$, 2, and 3, τ_{fi} is the arrival time of the front at the ith cross section, $a = 9.8$, $b = 8$, and $n = 0.6$. All the dimensions and times indicated above are given in millimeters and milliseconds, respectively.

The growth laws for the transverse dimensions of the bubble behind the vaporization front are similar in different cross sections. The power exponents are identical for all cross sections. Hence, the generatrix of the bubble caused by propagation of the vaporization front under saturation conditions can be described by the equation $h = b(L/v_f)^n$, where v_f is the propagation velocity of the vaporization front and h and L are the transverse and longitudinal dimensions of the bubble.

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