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Warmteoverdracht aan kokende binaire vloeistofmengsels

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Voor kernreactoren, waarin vloeibare metalen als koelvloeistof worden gebruikt, biedt de toepassing van binaire metaalmengsels misschien voordelen, tenminste als – in verband met de kookpunten – bij zeer hoge temperaturen wordt gewerkt. De aluminiumhulzen zullen dan door andere materialen met hogere thermische en chemische bestendigheid moeten worden vervangen. Momenteel is men reeds in staat bij temperaturen tot 1000 °C te werken. Men zal dan de samenstelling overeenkomstig de theorie van § 4.2.2 tevoren moeten bepalen.

Weliswaar zijn reeds metaalmengsels praktisch toegepast, zoals 56 % Na en 44 % K, doch voor deze samenstelling werd het eutecticum genomen, waardoor het smeltpunt tot kamertemperatuur werd verlaagd [40].

SUMMARY

CH. 1. The different parts of a boiling curve are discussed (fig. 1). A survey of the conditions and factors, which are of importance with respect to the region of convection and the region of nucleate boiling, is presented on the basis of data derived from literature. Special attention is paid to the behaviour of the nucleate boiling peak flux.

The existence of a critical temperature of the heating surface for the region of nucleate boiling follows from a number of experimental data, and can also be deduced theoretically. It is shown that the criterion for the occurrence of filmboiling, which is used in the theory of CH. 4, is in principle equivalent to the criterion following from VAN DER WAALS' equation of state (fig. 2).

CH. 2. The method, which has been described by MCADAMS et al. [64] for water boiling at atmospheric pressure, has been extended in order to determine the boiling curves for binary mixtures boiling at an arbitrary pressure. For that purpose a central section of a horizontal electrically heated platinum wire was used as a test surface, acting at the same time as a resistance thermometer.

The temperature difference between heating surface and boiling liquid was calculated from equation (6), which has been deduced from the platinum resistance equation (4). The electrical resistance of the test section at the boiling temperature of a liquid mixture can be measured directly (fig. 6) and was used as a reference value for the thermometer.

CH. 3 and CH. 4. Reproducible boiling curves have been determined for water and for water – methylethylketone and water – 1-butanol mixtures, boiling at atmospheric pressure (figs. 10, 43, 11 and 14) and at subatmospheric pressures (figs. 10 and 13). For some mixtures, containing water in excess, a considerably higher peak flux was observed than for water, at the same or at a lower critical temperature of the heating surface (fig. 12).

The peak flux has been determined as a function of concentration at atmospheric pressure for the binary systems: water – methylethylketone (fig. 15), water – acetone (fig. 16), water – ethanol (fig. 17), water – 1-propanol (fig. 18), water – t-butanol (fig. 19), water – 1-butanol (fig. 20), water – 1-pentanol (fig. 21), water – 1-octanol (fig. 22), water – ethyleneglycol (fig. 23), water – ammonia (fig. 24), dioxane – methanol (fig. 25) and 2-chloroethanol – di-iso-propyl-ether (fig. 26), and for some mixtures of the ternary system: water – ethanol –

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1-butanol (table 3). For some of these systems the experiments have also been carried out at subatmospheric pressures (figs. 29-34).

A maximum value of the peak flux occurs at a certain low concentration of the most volatile component, e.g. two maxima occur for water - 1-butanol and water - 1-pentanol. This effect is explained qualitatively to be connected with the simultaneous occurrence of a minimum growth rate (theory of VAN WIJK [110, 108]) and the average size of vapor bubbles, released from the heating surface (figs. 38-1, 38-3 and 38-5).

The effect of obtaining higher peak fluxes in binary mixtures is shown to be practically independent on the constitution of the heating surface, though higher absolute values are obtained with oxidised wires (fig. 28).

CH. 5. The influence of pressure on the absolute values of the peak flux maxima and on their ratio to the corresponding value in the less volatile pure component has been determined systematically in the range from 0.1-50 ata.

The absolute values of the maxima increase gradually with increasing pressure in this range. Maximum ratios between 2.3 and 3.1 occur for the systems investigated at higher pressures, i.e. water - ethanol (fig. 45), water - 1-propanol (fig. 46), water - 1-butanol (fig. 47), water - 1-pentanol (fig. 48), water - acetone (fig. 49), water - methylethylketone (fig. 50) and water - ammonia (fig. 51), at relatively low pressures between 1 and 10 ata (figs. 52 and 53). With increasing pressure, all ratios approximated a value of 2.0 in the range from 10-50 ata.

As a consequence heat flux values in nucleate boiling can be obtained with binary mixtures boiling in this range, exceeding considerably the maximum values, which are attainable with water boiling at an arbitrary pressure.

CH. 6. The peak flux in surface boiling has been determined for water (figs. 57, 58 and 64) and (at pressures above 50 ata) for the binary systems: water - ethanol (fig. 59), water - 1-propanol (fig. 60), water - 1-butanol (fig. 61), water - 1-pentanol (fig. 62) and water - methylethylketone (fig. 63).

The absolute values and the ratio of the maximum peak flux for mixtures to the peak flux for water at the same pressure and at equal subcooling, decrease gradually with increasing pressure. An average ratio of 1.15 is obtained at 120 ata for a subcooling of 55 °C.

The peak flux to 20 0/0 wt 1-propanol (at a constant liquid temperature of 240 °C) exceeds the corresponding value to water (at a comparable constant temperature of 263 °C) with 35 0/0 in the range from 50-125 ata (fig. 64).

The effect of obtaining higher peak fluxes with an oxidised heating surface in comparison with a platinum wire, vanishes for values beyond 120 cal sec⁻¹ cm⁻² (table 7).

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