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POOL BOILING—BINARY LIQUID MIXTURES

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Abstract—Pool boiling data were obtained for pure *n*-propanol, pure water and eleven of their mixtures at atmospheric pressure. A horizontal wire with a stable surface was used for all the experimental data reported here. The test section of nickel–aluminium alloy was 0·03 cm in diameter and 7·26 cm long. Its surface was stabilized by an annealing process and by prolonged boiling. All the data points obtained in the fully developed nucleate boiling region were correlated by the equation

$$\Delta T = (\Delta T_1 x_1 + \Delta T_2 x_2)\left[1 + (x - y^*)\left(\frac{\alpha}{D}\right)^{0.5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{dT}{dx}\right)\right].$$

In this equation ΔT, ΔT_1 and ΔT_2 are the $(T_{wall} - T_{sat})$ differences for the mixture of concentration x, for the pure component 1 and for the pure component 2, respectively, required for obtaining the same heat flux. The correlating equation has no empirical constants but the knowledge of the boiling curves for the two pure liquids, obtained on the same heat transfer surface, is necessary. The largest deviation of the predicted coefficient from the experimental value in this investigation, was 16·6 per cent.

NOMENCLATURE

SI-system is recommended but any set of consistent units may be used except in equation (1) in which the temperature is in °C and x_1 and x_2 in mole fractions.

A,	a constant in equation (1);
C,	specific heat;
$d = \sqrt{\frac{\sigma}{g(\rho_L - \rho_G)}}$,	Laplace constant (characteristic length in Nusselt and Péclét numbers);
D,	mass diffusivity;
E,	constant in equation (2);
F,	defined by equation (6);
g,	acceleration of gravity;
h_{fg},	latent heat of evaporation;
J_p,	Jakob number, in pure liquid, equation (4);
J_m,	Jakob number, in mixture, equation (7);
k,	thermal conductivity;
P,	pressure;
Q,	heat flux;
R_p,	radius of a bubble in a single component liquid;
R_m,	radius of a bubble in a binary mixture;
t,	time;
T_w,	wall temperature, absolute scale;
T_s,	saturation temperature of a liquid, absolute scale;
T_{sw},	saturation temperature of water, absolute scale;
$\Delta T = T_w - T_s$,	apparent temperature difference;
ΔT_1,	apparent temperature difference for component 1;
ΔT_2,	apparent temperature difference for component 2;
x,	mass fraction in the liquid phase;
x_1,	concentration of the lighter component, mass fraction;
x_2,	concentration of the heavier component, mass fraction;
y^*,	mass fraction of the lighter component in equilibrium with the liquid phase;
α,	thermal diffusivity;
ρ,	density;
σ,	surface tension;
$\Delta\theta$,	defined by equation (10);
K,	$\frac{P}{[g\sigma(\rho_L - \rho_G)]^{0.5}}$;
Nu,	$\frac{hd}{k_L}$;
Pe,	$\left(\frac{Q}{h_{fg}}\right)\left(\frac{\rho_L}{\rho_G}\right)\left(\frac{C_L}{k_L}\right)d$.

Subscripts

L,	liquid;
G,	vapour.

Abbreviations

NPA,	n-propyl alcohol;
H_2O,	water.

INTRODUCTION

POOL boiling heat transfer coefficients for binary mixtures may be correlated by either of two recently published correlations [1, 2]. Stephan and Körner [1] developed an expression for the Gibbs' thermodynamic potential for the formation of a vapour bubble in a single-component liquid and in a binary mixture. An examination of these two expressions allowed them to conclude that the energy required to form a vapour bubble in a binary mixture is a function of the mass transfer driving force $(y^* - x)$. Subsequently an empirical correlation was developed, of the following form

$$\Delta T = (\Delta T_1 x_1 + \Delta T_2 x_2)[1 + A|y^* - x|] \qquad (1)$$

in which A is an empirical constant different for every binary mixture. ΔT, ΔT_1 and ΔT_2 are the differences between the wall temperature and saturation temperatures of the mixture and of the pure components respectively required for the same heat flux. The authors stated that the value of A can be regarded as constant for the whole range of concentrations in the case of mixtures having a vapour–liquid equilibrium relationship approaching ideal behaviour. But with the mixtures for which this relationship diverges considerably from ideality the assumption of the constancy of A is a major assumption.

Calus and Rice [2] correlated their pool boiling data for several binary mixtures by modifying an existing correlation for boiling single-component liquids. Their correlation has the form

$$\frac{Nu}{K^{0\cdot 7}}\left(\frac{T_s}{T_{sw}}\right)^4 \quad E\left[\frac{Pe}{1 + |y^* - x|\left(\dfrac{\alpha}{D}\right)^{0\cdot 5}}\right]^{0\cdot 7} \qquad (2)$$

In this equation E is an empirical constant depending on the surface–liquid combination.

The object of this work is to show that the value of A in equation (1) may be defined in terms of the physical properties of binary mixtures, and that it varies considerably with the concentration of a mixture. The correlating relationship is verified with experimentally obtained pool boiling data for several mixtures of n-propyl alcohol and water. This binary system was chosen as an example of binary mixtures having a highly non-ideal vapour–liquid relationship.

THEORETICAL BACKGROUND

The analytical work of Scriven [3] on the subject of vapour bubble growth in single-component liquids and binary mixtures, and the work of Stephan and Körner [1] and van Stralen [4] on nucleate boiling of binary liquid mixtures provide enough information to define the value of A in equation (1) as a function of the concentration and of the relevant physical properties.

Scriven [3] developed a relationship between the radius of a vapour bubble growing in a superheated infinite liquid and the time and the physical properties of the liquid, by the equation

$$R_p = \left(\frac{12}{\pi}\right)^{0\cdot 5} J_p (\alpha t)^{0\cdot 5} \qquad (3)$$

where J_p is the Jakob number for a single-component liquid

$$J_p = \frac{C_L \rho_L \Delta T}{\rho_G h_{fg}}. \qquad (4)$$

He extended this analysis to binary mixtures and obtained a relationship (equation (72) of the Scriven's paper [3]) which transformed into a more convenient form is

$$R_m = \left(\frac{12}{\pi}\right)^{0\cdot 5} \frac{(\alpha t)^{0\cdot 5}\,\Delta T}{\dfrac{\rho_G h_{fg}}{\rho_L C_L}\left[1 + (x - y^*)\left(\dfrac{\alpha}{D}\right)^{0\cdot 5}\left(\dfrac{C_L}{h_{fg}}\right)\left(\dfrac{dT}{dx}\right)\right]}. \qquad (5)$$

Taking note of the definition of the Jakob number, equation (5) differs from equation (3) by the expression in the square brackets which it is convenient to denote as

$$1 + F = 1 + \left\{(x - y^*)\left(\frac{\alpha}{D}\right)^{0\cdot 5}\left(\frac{C_L}{h_{fg}}\right)\frac{dT}{dx}\right\}. \qquad (6)$$

It follows from Scriven's analysis that the factor F defined by equation (6) acts as a correction to the apparent temperature difference, which is defined as the difference between the wall temperature and the saturation temperature of the bulk liquid mixture. However, the effective temperature difference driving force for the evaporation of a two-component liquid layer surrounding the vapour bubble is smaller than the apparent ΔT. This liquid layer, due to equilibrium evaporation, is richer in the less volatile component and therefore its saturation temperature is higher and the temperature difference driving force is smaller by a quantity $\Delta\theta$. $\Delta\theta$ is the difference between the saturation temperature of the liquid layer around the bubble and the saturation temperature of the bulk liquid. Therefore the effective driving force is $(\Delta T - \Delta\theta)$.

Van Stralen [4, 5] suggested using a modified Jakob number in equation (3) to account for the diminished temperature difference driving force. The modified Jakob number for binary liquid mixtures has the form

$$J_m = \frac{\rho_L C_L}{\rho_G h_{fg}}(\Delta T - \Delta\theta). \qquad (7)$$

With this correction equation (3) for a bubble growing in a binary mixture can be written as

$$R_m = \left(\frac{12}{\pi}\right)^{0\cdot5} \frac{(\alpha t)^{0\cdot5}}{\dfrac{\rho_G h_{fg}}{\rho_L C_L}} (\Delta T - \Delta\theta) \qquad (8)$$

Equations (5) and (8) define the same process in a binary mixture and therefore if their right hand sides are equated the following relationship is obtained

$$\Delta T - \Delta\theta = \frac{\Delta T}{1 + (x - y^*)\left(\dfrac{\alpha}{D}\right)^{0\cdot5}\left(\dfrac{C_L}{h_{fg}}\right)\left(\dfrac{\mathrm{d}T}{\mathrm{d}x}\right)} \qquad (9)$$

which can be abbreviated to

$$\Delta\theta = \Delta T \frac{F}{1 + F} \qquad (10)$$

Thus equation (10) defines the lowering of the apparent temperature difference driving force in terms of the vapour–liquid equilibrium relationship, the transport properties and the thermodynamic properties of the binary mixture.

It is proposed to assume, as an approximation, that equation (10) is valid also in nucleate boiling on a solid surface. Making this assumption we ignore the fact that a bubble growing on a heat transfer surface is situated in a thin layer of liquid having a temperature gradient and a concentration gradient as well. But these gradients are not as large as they are in a non-nucleating portion of the boundary layer because the process of heat conduction to the bubble lowers the temperature of the surrounding liquid and of the heat transfer surface itself.

Stephan and Körner [1] considered the relationship between the temperature difference driving force required to obtain the same heat flux with a binary mixture and with each of the two pure components. They provided experimental evidence that the ΔT for a mixture varies linearly with the concentration if the vapour–liquid equilibrium relationship approaches ideality i.e. the mass transfer driving force $(y^* - x)$ is very small. They concluded that in such a situation the temperature driving force can be calculated from the relationship

$$\Delta T = \Delta T_1 x_1 + \Delta T_2 x_2 \qquad (11)$$

where ΔT_1 and ΔT_2 are the driving forces for the pure components and x_1, x_2 are the concentrations of these pure components. Their thermodynamic analysis proved that the mass transfer driving force $(y^* - x)$ is one of the more important factors in the determination of the Gibbs' thermodynamic potential for the formation of a vapour bubble. Hence they developed an empirical correction factor $[1 + A|y^* - x|]$ to be used as a multiplier in equation (11) to correct for the non-ideality of the mixture. Thus the correlating equation (1), quoted in the introduction, was obtained in which the value of A is a property of every binary system and an absolute value of the mass transfer driving force $(y^* - x)$ is used. The authors themselves indicate that to treat A as a constant is a minor approximation with respect to binary systems approaching ideal behaviour, but it is a major approximation in the case of binary systems highly non-ideal.

There is no doubt that the relationship defined by equation (11) is correct for ideal mixtures but it is necessary to define a more precise correction factor to be used with it for non-ideal mixtures. The temperature difference correction $\Delta\theta$ defined by equation (10) and having an analytical origin is more suitable for the purpose. Thus the effective driving force for a binary mixture is

$$\Delta T = \Delta T_1 x_1 + \Delta T_2 x_2 + \Delta\theta \qquad (12)$$

the meaning of ΔT, ΔT_1 and ΔT_2 being the same as in the Stephan and Körner correlation.

Substitution for $\Delta\theta$ from equation (10) and rearrangement of equation (12) gives

$$\Delta T = (\Delta T_1 x_1 + \Delta T_2 x_2)(1 + F). \qquad (13)$$

Insertion of the expression for F from equation (6) gives

$$\Delta T = (\Delta T_1 x_1 + \Delta T_2 x_2) \left[1 + (x - y^*)\left(\frac{\alpha}{D}\right)^{0\cdot5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{\mathrm{d}T}{\mathrm{d}x}\right)\right] \qquad (14)$$

It should be noted that all the quantities in equation (14) are based on the weight fraction concentrations.

On account of the approximation made by applying the factor F in a situation more complex than that of heat transfer to a bubble in an infinite fluid, it is essential that the correlating equation (14) should be verified with experimental data.

Comparing equations (1) and (14) the following comments should be made: the empirical constant A of equation (1) plays the same role as the expression

$$\left(\frac{\alpha}{D}\right)^{0\cdot5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{\mathrm{d}T}{\mathrm{d}x}\right)$$

in equation (14). Its value changes with concentration. The mass transfer driving force in the correction factor F is used with its own sign, the factor F having a positive sign as tne quantities $(x - y^*)$ and $\mathrm{d}T/\mathrm{d}x$

are always of the same sign. The discrepancy between the expressions $[A|y^* - x|]$ and F is quite large for highly non-ideal binary systems as can be seen in Fig. 1 where these factors for the NPA–H_2O system are plotted against the weight fraction of NPA in the mixture. If an exact value of the ratio $[A|y^* - x|]/F$ was required a slight re-adjustment to the numerator would have to be made on account of mole fraction concentrations being used in computing it. For a binary system approaching ideality in the vapour–liquid relationship these curves would tend to merge with the horizontal co-ordinate of Fig. 1.

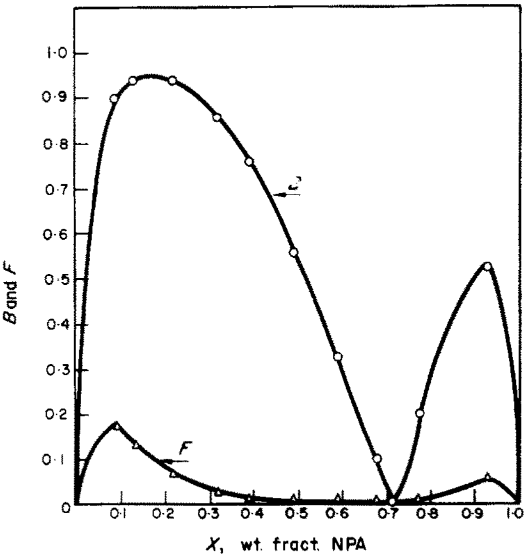

FIG. 1. Variation of correction factor B and F with concentration of NPA in water.

$$B = A|y^* - x|$$

$$F = \left[\left(x - y^*\right)\left(\frac{\alpha}{D}\right)^{0.5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{dT}{dx}\right)\right]$$

EXPERIMENTAL RESULTS

Boiling curves were obtained experimentally for pure n-propanol (NPA), pure water and 11 mixtures of them of various concentrations, including the azeotropic composition (71 wt% NPA). These are presented in Table 1 in the form of equations based on the data points from the fully developed nucleate boiling region. Also some of the curves are shown as plots of heat flux against temperature difference in Figs. 4–6. All the experimental work was carried out at atmospheric pressure, and the same wire was used in all the experiments. Hence it will be assumed that the characteristics of the heating surface were the same for all these boiling curves.

The test section wire of nickel–aluminium alloy was 0·03 cm in diameter, and 7·26 cm long. A detailed description of the pool boiler, of the test section and of the preparation of its surface, as well as of the experimental procedure, are given in [2,6]. The overall experimental error in the value of the heat transfer coefficient was estimated to be about ±5 per cent [2, 6].

Table 1. Experimental boiling curves Q in W/m², ΔT in °C
Single component liquids
pure water $Q = 2{\cdot}78\,(\Delta T)^{4{\cdot}85}$
pure n-propanol $Q = 0{\cdot}0001479\,(\Delta T)^{6{\cdot}5}$

Binary mixtures	
9·0 wt% NPA	$Q = 8{\cdot}3176\,(\Delta T)^{3{\cdot}22}$
13·1 wt% NPA	$Q = 10{\cdot}965\,(\Delta T)^{3{\cdot}17}$
21·9 wt% NPA	$Q = 4{\cdot}5709\,(\Delta T)^{3{\cdot}57}$
31·8 wt% NPA	$Q = 0{\cdot}69183\,(\Delta T)^{4{\cdot}2}$
39·25 wt% NPA	$Q = 0{\cdot}000331\,(\Delta T)^{6{\cdot}4}$
49·0 wt% NPA	$Q = 0{\cdot}000446\,(\Delta T)^{6{\cdot}54}$
59·0 wt% NPA	$Q = 0{\cdot}000010471\,(\Delta T)^{7{\cdot}9}$
68·0 wt% NPA	$Q = 0{\cdot}006\,165\,9\,(\Delta T)^{5{\cdot}8}$
71·0 wt% NPA	$Q = 0{\cdot}017783\,(\Delta T)^{5{\cdot}4}$
77·5 wt% NPA	$Q = 0{\cdot}028840\,(\Delta T)^{5{\cdot}22}$
93·0 wt% NPA	$Q = 0{\cdot}029512\,(\Delta T)^{5{\cdot}03}$

DISCUSSION OF RESULTS

To verify equations (14) and (1) with the experimental data the boiling curves for the two pure single-component liquids are expressed in the following form

$$\text{pure NPA: } \Delta T_1 = 3{\cdot}873\,Q^{0{\cdot}154} \qquad (15)$$

$$\text{pure water: } \Delta T_2 = 0{\cdot}81\,Q^{0{\cdot}2545} \qquad (16)$$

The use of equation (14) requires knowledge of the variation of the factor F with concentration. The gradient of the boiling point curve dT/dx, forming one of the components of the factor F, was obtained by fitting a polynomial to the curve $T = f(x)$ and subsequently differentiating it with respect to x. A plot of the factor F against concentration is shown in Fig. 1. By means of equations (14)–(16) and Fig. 1 the boiling heat transfer coefficients for the whole range of concentrations at a flux of $Q = 400\,000$ W/m² and $Q = 100\,000$ W/m² were predicted. All those calculations were done using weight fraction concentrations.

To predict the boiling heat transfer coefficients by means of the Stephan and Körner correlation, the factor $[A|y^* - x|]$ was calculated for the whole range of concentrations. An empirical· value of A in the

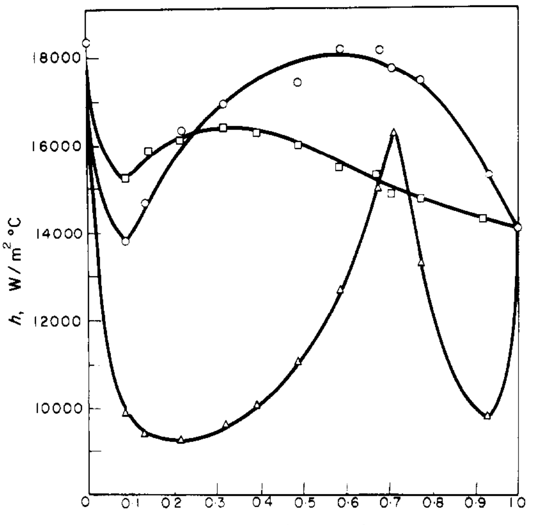

FIG. 2. Experimental and predicted boiling heat transfer coefficients for NPA–H_2O mixtures at $Q = 400000 W/m^2$. ○, experimental; □, equation (14), this work; △, equation (1), reference [1].

expression $[A|y^* - x|]$, recommended in [1] for the whole range of concentrations of n-propanol in water, is 3·29. Also the absolute values of the mass transfer driving force $(y^* - x)$ must be used. The variation of this factor wlth concentration is shown in Fig. 1. The boiling heat transfer coefficients were then predicted by means of equations (1), (15) and (16), and Fig. 1 for the heat fluxes $Q = 400000$ W/m^2 and $Q = 100000$ W/m^2. These calculations were conducted on the basis of mole fraction concentrations as required by [1].

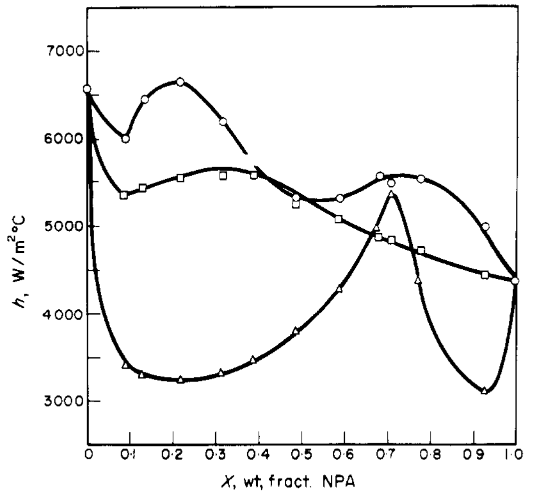

FIG. 3. Experimental and predicted boiling heat transfer coefficients for NPA–H_2O mixtures at $Q = 100000 W/m^2$. ○, experimental; □, equation (14), this work; △, equation (1), reference [1].

The predictions by equations (1) and (14) are compared with each other and with the experimental coefficients in Figs. 2 and 3 and Table 2. The coefficients predicted by equation 1 deviate considerably more from the experimental values than those predicted by equation (14), the highest deviation for the former being 51 per cent and 16·6 per cent for the latter. This indicates that the use of a constant value of $A = 3{\cdot}29$ for the whole range of concentration is not justified. The constant A in equation (1) corresponds to the expression

$$\left(\frac{\alpha}{D}\right)^{0\cdot5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{dT}{dx}\right)$$

Table 2. Deviation of the predicted from the experimental coefficients

x wt. fract. NPA	$Q = 400000$ W/m^2			$Q = 100000$ W/m^2		
	h W/m^2 °C experim.	eq. (1) % deviat.	eq. (14) % deviat.	h W/m^2 °C experim.	eq. (1) % deviat.	eq. (14) % deviat.
0	18300	0	0	6580	0	0
0·090	13800	−21·5	+10·5	6020	−43·2	−10·8
0·131	14650	−38·0	+ 8·5	6450	−48·3	−15·5
0·219	16300	−43·2	− 1·2	6660	−51·0	−16·6
0·318	16950	−43·3	− 3·2	6210	−46·4	−10·6
0·3925	15050	−33·6	− 8·3			
0·490	17400	−36·8	− 8·1	5320	−28·5	+ 0·8
0·590	18200	−30·5	−14·8	5320	−19·3	− 4·7
0·680	18200	−17·6	−15·9	5590	−11·1	−12·3
0·710	17750	− 8·2	−16·0	5500	− 1·4	−11·8
0·775	17000	−21·8	−12·9	5550	−20·9	−14·9
0·930	15300	−36.0	− 6·5	5000	−37·8	−14·0
1·000	14100	0	0	4390	0	0

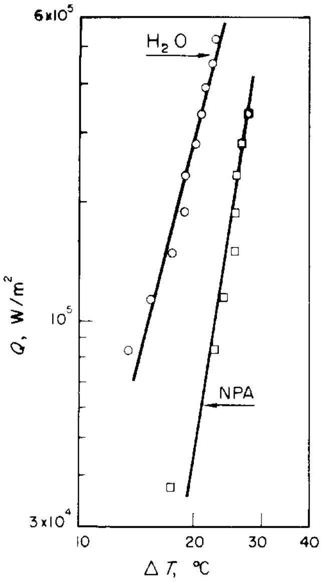

FIG. 4. Experimental boiling curves for pure NPA and pure water.

in equation (14), which clearly must vary with the concentration of a binary mixture.

By a procedure similar to the calculation of heat transfer coefficients, the boiling curves for each of the 11 binary mixtures were predicted by means of equations (1) and (14)–(16) and Fig. 1. The results, for the concentrations 49·0 and 93·0 weight per cent NPA in water, chosen as representative of all the eleven mixtures, are shown in Figs. 5 and 6.

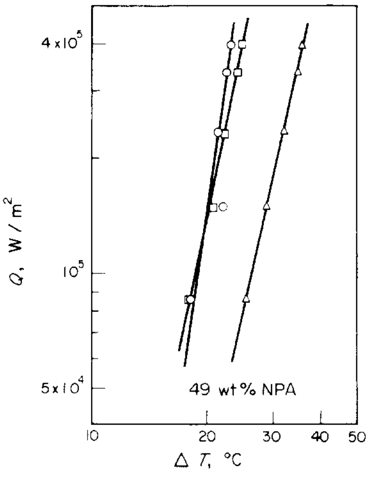

FIG. 5. Experimental and predicted boiling curves for 49 wt% NPA in water. ○, experimental; □, equation (14), this work; △, equation (1), reference [1].

The percentage deviations of the ΔT predicted by the two methods (equations (1) and (14)) from the experimental ΔT are about the same as in the case of the heat transfer coefficients, as would be expected.

The agreement of equation (14) with the experimental data is reasonably good. Most of the deviations are about the same as, or slightly higher than, the estimated experimental error. The use of the factor F for the process of boiling on a solid surface constitutes a minor approximation. In this geometry the driving force ΔT is not uniform around the growing bubble but no analytical correction to ΔT on this account is yet available. An experimental correction could be devised if it was possible to test all the available binary boiling data. However this is not possible at present due to the lack of data on the physical properties required for the calculation of the factor F.

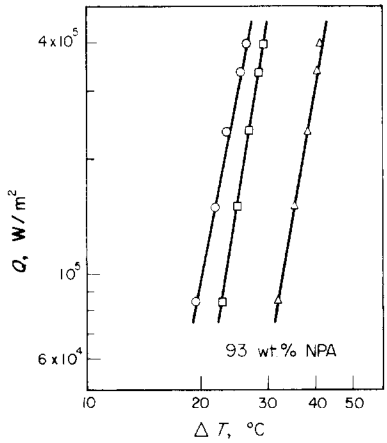

FIG. 6. Experimental and predicted boiling curves for 93 wt% NPA in water. ○, experimental; □, equation (14), this work; △, equation (1), reference [1].

In view of the observations made in [2, 7] about the significance of the surface–liquid combination factor it is important that the boiling curves for both pure liquids should be obtained on the same test section. This condition was satisfied in the present work.

To compare the correlation developed here (equation (14)) with that of [2] all the 84 experimental data points are plotted in Fig. 7 in accordance wlth equation (2). The best line of slope 0·7 drawn through the points gives 0·00057 for the constant E in equation (2). The points representing two pure components and 11 concentrations of NPA in water are well intermixed and 87 per cent of them are within the ±20 per cent accuracy lines.

On this evidence, it should be concluded that equation (14) gives slightly better agreement with the experimental data.

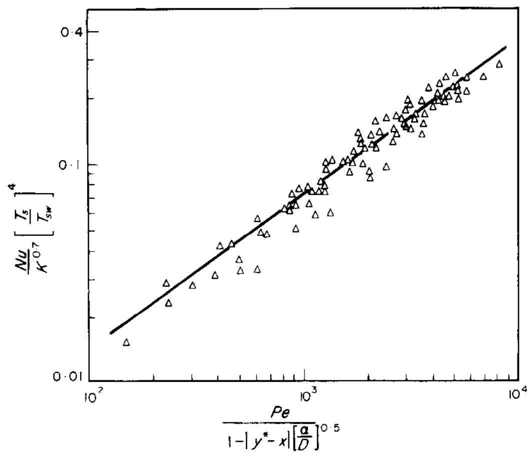

FIG. 7. Correlation of all the experimental data by means of equation (2), reference [2]. Number of points for the following concentrations: pure H_2O—10, 9% NPA—7, 13·1 NPA—8, 21·9% NPA—7, 31·8% NPA—8, 39·25% NPA—4, 49% NPA—5, 59% NPA—6, 68% NPA—6, 71% NPA—5, 77·5% NPA—5, 93% NPA—5, pure NPA—8.

CONCLUSIONS

1. The correlating equation (14) developed here has no experimental constants and can be used to predict either nucleate boiling heat transfer coefficients or boiling curves for binary liquid mixtures provided the boiling curves for the pure components, obtained on the same heat transfer surface, are available.

2. The variable factor F in equation (14) is strictly applicable to the process of a bubble growing in an infinite superheated fluid, therefore its application to nucleate boiling on a heat transfer surface constitutes an approximation. However the fact that the predicted coefficients deviate less than 16·6 per cent from the experimental coefficients, i.e. by not much more than the experimental error in this investigation, indicates that the approximation is justified.

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EBULLITION EN RESERVOIR-MELANGES LIQUIDES BINAIRES

Résumé—Des résultats d'ébullition en réservoir ont été obtenus pour du *n*-propanol pur, de l'eau pure et onze de leurs mélanges à la pression atmosphérique. Pour tous les résultats expérimentaux obtenus il a été utilisé un fil horizontal à surface stable. L'élément d'essai en alliage nickel–aluminium à 0,03 cm de diamètre et 7,26 cm de long. Sa surface est stabilisée par un processus de trempe et par ébullition prolongée. Tous les points obtenus dans la région entièrement développée d'ébullition en réservoir sont unifiés par la relation suivante:

$$\Delta T = (\Delta T_1 x_1 + \Delta T_2 x_2)\left[1 + (x - y^*)\left(\frac{\alpha}{D}\right)^{0,5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{\mathrm{d}T}{\mathrm{d}x}\right)\right]$$

Dans cette équation ΔT, ΔT_1 et ΔT_2 sont les différences $(T_{\text{paroi}} - T_{\text{sat.}})$ pour le mélange de concentration x, et respectivement pour les composantes pures 1 et 2, différences nécessaires pour obtenir le même flux thermique. Cette équation n'a pas de constantes empiriques mais il est nécessaire de connaitre les courbes d'ébullition pour les deux liquides purs, obtenues sur la même surface de transfert thermique. Le plus grand écart entre le coefficient estimé et la valeur expérimentale est de 16,6%.

BEHÄLTER-SIEDEN ZWEISTOFFGEMISCHE

Zusammenfassung—Pool-Boiling-Werte für reines *n*-Propanol, reines Wasser und acht verschiedene Mischungen davon wurden bei Atmosphärendruck gemessen. Bei allen hier gezeigten Versuchen wurde ein waagerechter Draht mit stabiler Oberfläache verwendet. Die Versuchsstrecke aus Nickel–Aluminium-Legierung hatte 0,3 mm Durchmesser und eine Länge von 7,26 cm. Die Oberfläche war durch längeres Sieden stabilisiert. Alle Meßpunkte im Bereich des vollausgebildeten Blasensiedens werden korreliert durch die Gleichung

$$\Delta T = (\Delta T_1 x_1 + \Delta T_2 x_2)\left[1 + (x - y^*)\left(\frac{\alpha}{D}\right)^{0.5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{\mathrm{d}T}{\mathrm{d}x}\right)\right]$$

In dieser Gleichung stellen ΔT, ΔT_1 und ΔT_2 die $(T_{\text{Wand}} - T_{\text{Satt}})$ Differenzen dar, die jeweils gebraucht werden, um im Gemisch von der Konzentration x, der reinen Komponente 1 und der reinen Komponente 2 die gleiche Wärmestromdichte zu erhalten. Die Korrelationsgleichung besitzt keine empirischen Konstanten, doch ist die Kenntnis der Siedekurven der beiden reinen Flüssigkeiten, bei gleicher Heizfläche, erforderlich, Die größte Abweichung des vorherbestimmten Koeffizienten vom experimentellen Wert betrug bei dieser Untersuchung 16,6 %.

КИПЕНИЕ БИНАРНЫХ ЖИДКИХ СМЕСЕЙ В БОЛЬШОМ ОБЬЁМЕ

Аннотация—Получены данные по кипению в большом объёме n-пропанола, чистой воды и смесей этих жидкостей одиннадцати различных составов при атмосферном давлении. Во всех экспериментах использовалась горизонтально расположенная проволока со стабилизированной поверхностью. Рабочий участок представлял собой отрезок проволоки из никель-алюминиевого сплава диаметром 0,03 см и длиной 7,26 см. Его поверхность стабилизировалась путём отжига и предварительного кипячения. Все точки для данных, полученных в области полностью развитого пузырькового кипения, обобщаются уравнением

$$\Delta T = (\Delta T_1 x_1 + \Delta T_2 x_2)\left[1 + (x - y^*)\left(\frac{\alpha}{D}\right)^{0,5}\left(\frac{C_L}{h_{fg}}\right)\left(\frac{dT}{dx}\right)\right]$$

В этом уравнении ΔT, ΔT_1 и ΔT_2 представляют собой разности $(T_{\text{СТ}} - T_{\text{НАС}})$ для смесей с концентрацией X, для чистого компонента 1 и чистого компонента 2 соответственно, необходимые для получения одинакового теплового потока. В корреляционное уравнение не входят эмпирические константы, но необходимо знание кривых кипения, полученных на одной и той же поверхности теплообмена для двух чистых жидкостей. Наибольшее отклонение расчётных коэффициентов от экспериментальных значений в данном исследовании составляло 16,6 %.