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Study on surface rewet caused by uniform collapse of flow film boiling

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Abstract—An experiment is performed on hot surface rewetting caused by the collapse of film boiling of R-113 flow in a 10 mm i.d. circular passage through a copper block. The temperatures in the copper block during the cooling process are measured by thermocouples embedded in it. Boiling curves are obtained by solving the heat conduction equation in the block. It is concluded that in a flow boiling system, while the heat transfer characteristics and rewetting mechanism change according to the flow pattern changing with the flow quality, the wall superheat at the onset of surface rewetting as well as that at quenching is almost constant.

1. INTRODUCTION

REWETTING of a hot surface is important in the cooling process not only in a loss of coolant accident of a nuclear reactor but also of other industrial quenching techniques. Hot surface rewetting relates closely to heat transfer in post-CHF (critical heat flux), that is, film and transition boiling heat transfers. The heat transfer and heat transfer mechanism of film boiling in the high wall superheat region has been investigated fairly well [1–5]; especially in dispersed flow film boiling it is generally known that the heat transfer between the wall and droplets approaching near to it is almost negligible [4, 5]. However, when the wall superheat of the film boiling becomes lower, it is not known how the liquid comes into contact with the wall and then how the contact affects the heat transfer.

In the process of cooling down a heated wall, rewetting of the wall surface is concerned closely with the solid–liquid contact, and governs the termination of this process. Since the rewetting plays such a key role, it is very important to make the mechanism of rewetting clear and to obtain the temperature of rewetting.

Studies of rewetting have been actively pursued in pool boiling by many investigators, especially with regard to the minimum heat flux temperature. For rewetting in pool boiling, two principal mechanisms have been proposed—a hydrodynamic mechanism [6, 7] and a thermodynamic mechanism [8]. A comprehensive review of the recent advances in both experimental and theoretical aspects is given by Nishio [9], who asserted that the minimum heat flux temperature depended heavily on liquid properties and suggested a practical correlation which will be discussed later.

On the other hand, studies of rewetting in flow boiling are fairly limited. Iloeje *et al.* [10] and Groeneveld and Stewart [11] suggested three different controlling mechanisms for forced convection rewetting: (1) collapse of vapor film, (2) axial conduction controlled rewet, (3) dispersed flow rewet. Iloeje *et al.* [10] investigated transient dispersed flow rewetting using an inconel tube and water, and showed that the minimum film boiling temperature in the high quality region increases with increasing mass velocity and decreasing quality. Groeneveld and Stewart [11] and Cheng *et al.* [12] made similar experiments using a unique hot patch technique [13], by which steady-state film boiling could be established by controlling the heat flux. They also used an inconel tube and water. In their method of decreasing the heat flux stepwise, the minimum film boiling temperature was obtained by measuring the axial temperature distribution. Groeneveld and Stewart proposed an experimental correlation over a wide range of quality.

The present study is an attempt to investigate the rewetting in flow boiling of Freon-113 flowing upward in a round passage through a heated copper test block. This experiment has the following features: hot patches provided upstream and downstream of the test block are used to prevent the propagation of rewetting, consequently the surface rewetting caused by a uniform collapse of film boiling is realized for wide ranges of the flow parameter. A copper test block with large thermal capacity is used to obtain a reliable boiling curve from film to nucleate boiling including transition boiling.

2. EXPERIMENTAL APPARATUS AND PROCEDURE

A schematic diagram of the test loop is shown in Fig. 1. Subcooled Freon-113 is supplied by a circulating pump (1) to a vertical preheater tube (5), flowing upward through it and entering the test section (6) placed at the top of the preheater tube. The

NOMENCLATURE

c_p	specific heat
d	inner diameter of test block
D	outer diameter of test block
G	mass velocity
h	heat transfer coefficient
L	length of test section
P	pressure
Pr	Prandtl number
q	heat flux
r	radial distance
T	temperature
t	time
U	velocity
X	quality.

Greek symbols

δ	vapor film thickness
λ	thermal conductivity
ρ	density.

Subscripts

cent	mid-plane of test block
g	vapor
in	inlet of test block
q	onset of large-scale liquid contact
rw	onset of rewetting
out	outer surface of test block
w	inner surface of test block.

Freon-113 flow is observed at a sight window (7) provided at the exit of the test section and is returned to a condenser (9). The stainless steel preheater tube is 1.5 m long, 10 mm i.d., corresponding to the i.d. of the test section, and is uniformly heated by an alternating current controlled by a transformer (13). The test section is composed of three identical cylindrical copper blocks of d = 10 mm, D = 70 mm and L = 100 mm, as shown in Fig. 2(A), and the round passage penetrating the test section smoothly is arranged vertically. The middle block is the test block, and the other blocks are the upstream hot patch A and downstream hot patch B which are used to prevent the propagation of rewetting. A 2.0 kW sheathed heater is wound around the outer surface to heat each block, and sheathed chromel–alumel (C–A) thermocouples with bare junctions are located in the block at five different locations as shown in Fig. 2(B) (TC 1–5). Accurate distances from the inner surface to the hot junctions are very important in calculating the temperature at the inner surface; the thermocouple locations in the test block are given in Fig. 2(B).

The experimental procedure was as follows: a mass velocity G, a pressure at the inlet of the preheater tube and an inlet quality of the test block X_{in} were set to desired values. Prior to heating the test block, hot patches A and B only were heated to about 180°C, which corresponds to a wall superheat $\Delta T_s = T_w - T_s$ = 100 K, at which stable steady-state

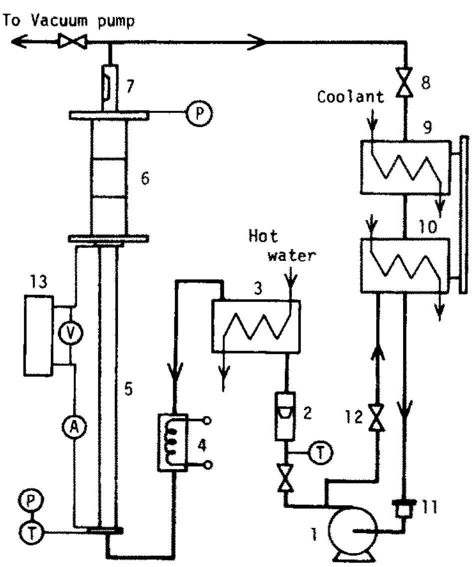


FIG. 1. Experimental apparatus: (1) pump; (2) flowmeter; (3) preheater; (4) control heater; (5) preheater tube; (6) test section; (7) sight window; (8) pressure control valve; (9) condenser; (10) storage tank; (11) dryer; (12) by-pass valve; (13) transformer; Ⓟ pressure gauge; Ⓣ thermocouple; Ⓥ voltmeter; Ⓐ amperemeter.

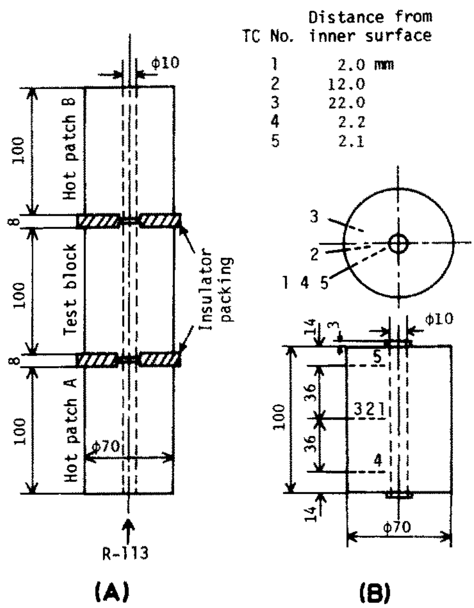


FIG. 2. Details of the test section and test block.

film boiling was established. These conditions were always held constant during each experimental run. The test block was then heated stepwise by controlling power input to it; in each step the equilibrated temperatures in the block were measured. When the heat flux exceeded the critical heat flux, the wall temperature of the test block began to rise sharply. The power input was then reduced and adjusted to settle the wall temperature down to about 230°C corresponding to $\Delta T_s \fallingdotseq 150$ K. Stable steady-state film boiling was thus established in the test block, and was maintained for a while. Then the power input to the test block was cut off, and a transient experiment of cooling down the test block was started. The wall temperatures in the test block during this cooling process were recorded. The temperature history (the so-called cooling curve) was used later to obtain a boiling curve.

In this experiment, the pressure and the quality at the inlet of the preheater tube (5) were kept at 0.31 MPa and −0.33 (subcooling), respectively. The inlet quality of the test block X_{in} was controlled by adjusting the power input to the preheater tube. However, X_{in} was calculated by including the power input to hot patch A. The quality change by the hot patch was less than a few percent of the quality change produced by the preheater tube. The pressure P at the mid-plane of the test block was calculated by the linear approximation using the pressures at the inlet of the preheater tube and at the outlet of the test section. It was in the range of 0.26–0.30 MPa (saturation temperatures $T_s = 78.9$–84.6 C), depending on mass velocity and quality.

The experimental ranges covered were:

mass velocity: $G = 412, 629, 1037, 1466$ kg m^{-2} s^{-1}

inlet quality: $X_{in} = 0.6$ to $-0.29(\Delta T_{subcool} \fallingdotseq 39.1$ K).

Furthermore, a very high subcooling run, $X_{in} = -0.42$, was performed without operation of the preheater (3), control heater (4) and preheater tube (5). Figure 3 shows the experimental conditions and also, for reference, a flow pattern map derived from Baker's chart [14] for Freon-113 at a pressure of 0.28 MPa.

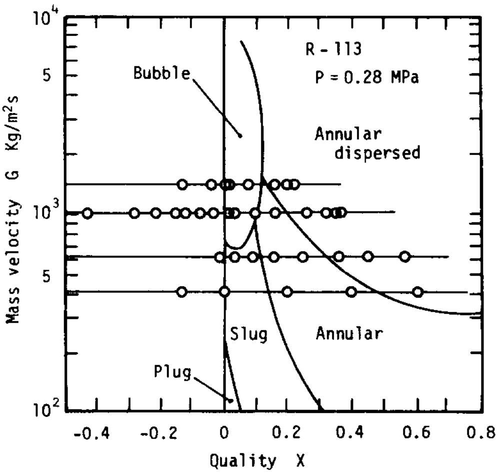


FIG. 3. Experimental range presented on Baker's chart.

3. DERIVATION OF TEMPERATURE AND HEAT FLUX

The cooling curves for thermocouples (TC) 1, 4 and 5 show no differences in temperature until quenching begins, they also show very small differences of temperature in the wall superheat range of 40–10 K, in which the temperatures fall rapidly. Therefore, assuming that the axial heat conduction is negligible, the one-dimensional heat conduction equation in the radial direction is

$$\rho c_p \frac{\partial T}{\partial t} = \frac{1}{r}\frac{\partial}{\partial r}\left(\lambda r \frac{\partial T}{\partial r}\right).$$

Solving the above equation, the time-dependent temperature distribution at radius r is obtained. The boundary conditions are

$$r = r_1 : T_1$$

$$r = r_{out} : \text{abiabatic}$$

where r_1 and T_1 are the location and the temperature measured by TC 1, respectively. The control volume method and the fully implicit method [15] were used in the calculation. A grid of ten equally-divided radial increments was used between $r_1 = 7$ mm and $r_{out} = 35$ mm; then the mesh length Δr becomes 2.8 mm and the time constant $(\Delta r)^2/(\lambda/(\rho c_p))$ is 0.07 s. Considering this value, the time step Δt was chosen as 0.1 s. The calculation was also carried out for a time step of 0.5 s; the result was fairly close to that of the case of 0.1 s. The time spent to cool down the test block was about 20–30 min. The temperature T_w and heat flux q_w at the inner surface $r = r_w = 5$ mm are derived from energy balances on the control volumes $((r_w + r_1)/2, (r_1 + r_2)/2)$ and $(r_w, (r_w + r_1)/2))$ using the obtained temperature distribution between r_1 and r_{out}. The distance from the inner surface $r = r_w$ to the location of TC 1 $(r = r_1)$ is 2 mm. As it is smaller than one mesh length of 2.8 mm, there is no trouble in the inverse problem. The amount of heat transfer from both hot patches to the test block through the Teflon insulators was calculated to be less than 1 kW m^{-2} per unit area of the inner surface of the test block. It is therefore negligible compared with q_w. The relation of the temperature T_w and the heat flux q_w at the inner surface of the test block was drawn as the boiling curve, which was examined to analyze the rewetting phenomenon.

4. EXPERIMENTAL RESULTS AND DISCUSSION

4.1. *Boiling curve*

Some examples of the boiling curves thus derived are presented in Figs. 4–6. These are the results obtained at the same mass velocity $G = 1037$ kg m^{-2} s^{-1}

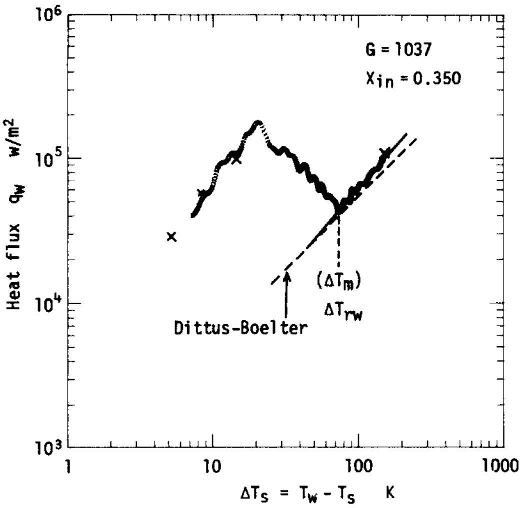


FIG. 4. Boiling curve representing the cooling process.

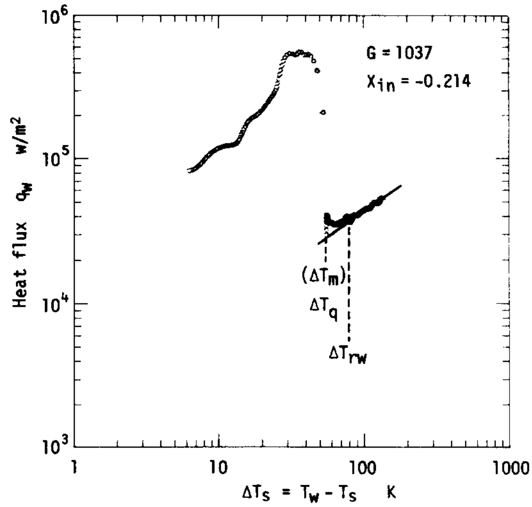


FIG. 6. Boiling curve representing the cooling process.

for the inlet qualities $X_{in} = 0.350$, 0.016 and -0.214, respectively. The symbol $\times$ in Figs. 4 and 5 represents the results of steady-state measurements when the heat flux was increased stepwise. The one at the highest superheat represents a position of the steady-state film boiling when the transient experiment was started. The symbol ○ computed from the cooling curve is plotted at time intervals of 1 s, so that the time spent during any temperature interval during the cooling process is proportional to the number of symbols in the intervals.

The boiling curves in Figs. 4–6 clearly show that the heat transfer behavior in this process always shifts with decreasing wall superheat from film boiling via transition boiling to nucleate boiling under any conditions. But the shape of the boiling curves is greatly affected by the inlet quality X_{in}.

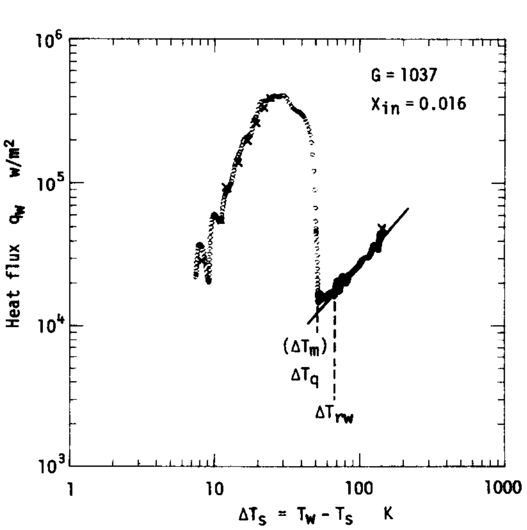
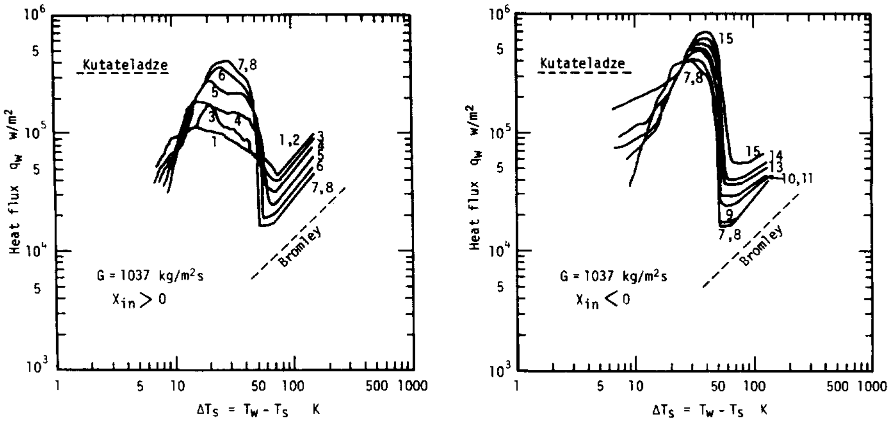


FIG. 5. Boiling curve representing the cooling process.

The effect of X_{in} can be clearly illustrated by plotting boiling curves of different inlet quality at the same mass velocity on the same plot. Figure 7 shows the results separated into two plots, one in the saturated region and the other in the subcooled region. The inlet quality for each run number is presented in the table together with bulk velocity which was obtained by assuming no slip at the vapor–liquid interface. To compare the boiling curve obtained by the present experiment with other results, two well-known correlations for pool boiling are shown in Fig. 7, the critical heat flux by Kutateladze [16] and the film boiling heat flux by Bromley [17]. In Bromley's correlation, a constant $C = 0.943$ is chosen and $L = 0.1$ m corresponding to the length of the present test block is applied. Figure 7 shows that the boiling curves are significantly affected by the inlet quality, particularly in the saturated region. This might be ascribed to the flow pattern varying with the quality. It is possible to guess roughly the flow pattern from Baker's chart. But, in this experiment the flow state was observed through the sight window (Fig. 1(7)) provided at the outlet of the test section. The flow state in the test section was judged from the observation, and also by referring to the visual experimental results of flow boiling of R-113 by other investigators [1, 18, 19]. These results show that the film boiling state in the high wall superheat region is separated into the dispersed flow and the inverted annular flow by the inlet quality range of 0.1–0.2, and it is only slightly affected by the mass velocity. Consequently, the characteristics of the boiling curve in each quality region are explained as follows.

High quality region; *inlet quality being higher than* 0.2. When wall superheat is large, since the boiling state becomes dispersed flow film boiling, as already known, a main mechanism of the heat transfer is



No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Xin	0.371	0.350	0.329	0.268	0.166	0.097	0.030	0.016	-0.022	-0.069	-0.110	-0.143	-0.214	-0.286	-0.420
Uin m/s	20.9	20.6	18.6	15.3	9.42	5.74	2.26	1.55	0.73	0.73	0.73	0.73	0.73	0.73	0.73

FIG. 7. Variation of boiling curves with flow quality.

convection by the vapor flow; the liquid droplets contribute little to the heat transfer [4]. This is demonstrated for the high wall superheat region in Fig. 4 which shows a broken line calculated from the Dittus–Boelter equation for vapor single phase turbulent flow, $Nu = 0.023(U_{in}d/\nu_g)^{0.8}\ Pr_g^{0.4}$. When the wall superheat becomes smaller, the droplets deposited on the wall surface begin to contact the wall, and the heat transfer caused by the wall–droplets contact begins to contribute to the total amount of heat transfer. Therefore, the boiling curve begins to depart at ΔT_m from the vapor single phase trend in the high wall superheat region (see Fig. 4). In case of very high quality, as the total number of liquid droplets depositing on the surface decreases, the increase of heat flux becomes moderate, as shown in Fig. 7.

Low and subcooled quality region; inlet quality being lower than 0.1. When wall superheat is large, the boiling state must be inverted annular film boiling, i.e. a thin vapor film is established along the wall surface. Accordingly, as the wall superheat decreases, the vapor film must become thinner until the vapor film collapses. Once the vapor film collapses, the wet area on the wall surface extends very rapidly, consequently a sharp rise of the heat flux appears as shown in Figs. 5 and 6.

4.2. *The temperature at onset of rewetting*

Plotting the boiling curves on linear coordinates extends the large wall superheat region and allows a more careful analysis of the rewetting phenomenon. Since the rewetting mechanism is changed by the inlet quality, it is difficult to determine the temperature at the onset of rewetting from a simple examination of the shape of the boiling curve.

As a first-order approximation, the rewetting temperature was taken as T_m, which is the temperature on the boiling curve at which the wall is clearly rewetted, namely: (1) in the case of dispersed flow (Fig. 4), T_m is the temperature at which the boiling curve begins to depart from the trend of film boiling; (2) in the case of inverted annular flow (Figs. 5 and 6), T_m is the temperature at which the heat flux increases sharply; (3) in other cases (Fig. 7(5)), T_m is the temperature at the minimum heat flux point.

Figure 8 shows the relation between the wall superheat at the rewetting temperature $\Delta T_m = T_m - T_s$ and the inlet quality X_{in}. The symbols ●, ○ and ⦶ show the estimated T_m in cases (1), (2) and (3), respectively. The broken line shows the correlation of the minimum heat flux temperature for pool boiling by Nishio [9] and the solid line shows the maximum possible temperature at which liquid can contact a surface by Lienhard [20]. The results of this study in the inverted annular regime are in good agreement with Nishio's correlation except in the highly subcooled region. ΔT_m in the middle region increases with increasing inlet quality, and ΔT_m in the dispersed flow region is almost uniform in the range of 68–75 K.

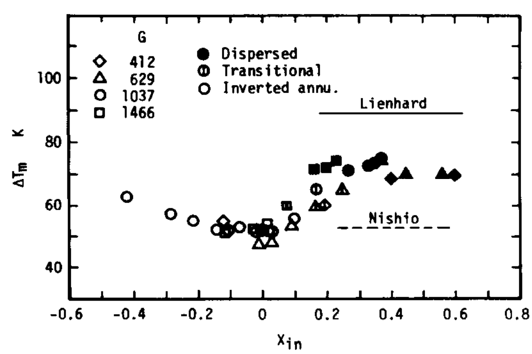


FIG. 8. Wall superheat at the onset of rewetting as the first-order approximation.

A more careful examination of the boiling curves in the inverted annular region (see Figs. 5 and 6) shows that a particular temperature, T_{rw}, which differs from T_m exists, and at this temperature, the heat flux begins to increase away from the trend in the high wall superheat region. T_{rw} probably represents the temperature when the rewetting actually begins. This can be explained as follows: as the vapor film along the surface becomes very thin with the decreasing wall temperature, the liquid can occasionally contact the wall surface through fluctuations of the liquid–vapor interface. When the wall temperature decreases to near T_m in dispersed flow, the wall–liquid contact occurs and direct heat transfer by the contact becomes significant. Finally as the wall temperature decreases to T_m, the very thin vapor film collapses totally on the wall surface, and the heat flux increases rapidly.

The temperature at the onset of rewetting T_{rw} in the inverted annular and in the middle region were obtained as described above. T_{rw} in the dispersed flow region corresponds to T_m in the dispersed flow region; thus, this T_m corresponds to T_{rw}. The temperature at the onset of large-scale liquid contact, quenching, T_q, was defined as the temperature at which the heat flux increased sharply. This corresponds to T_m for the inverted annular flow data. The wall superheats at the onset of rewetting ΔT_{rw} and of quenching ΔT_q are plotted in Fig. 9 for X_{cent}, which is the quality at the mid-plane of the test block. X_{cent} was obtained by adding the heat flux at the rewetting or the quenching to X_{in}, respectively; in general, there was little difference between X_{cent} and X_{in}. ΔT_{rw} and ΔT_q for $X_{in} > -0.03$ are also shown in the upper scale in Fig. 10 to show the trend against the bulk velocity, because authors believe that the inlet enthalpy can be approximated to the saturated condition. ΔT_{rw} differs from ΔT_m within the inverted annular flow region ordinarily, and is almost in the range 67–75 K over a wide quality region except in the highly subcooled region. The values are about ten-odd degree Kelvin lower than the maximum liquid–solid contact temperature of Lienhard [20]. ΔT_q is also in the range of 47–55 K except in the highly subcooled region. These values are in good agreement with Nishio's correlation, though they are slightly dependent on the velocity.

Groeneveld and Stewart [11] performed experiments of flow film boiling using an inconel tube and water, and obtained the minimum film boiling temperature T_{mfb}. They showed that both the mass velocity and quality did not have any significant effect on T_{mfb} in the saturated region, but in the subcooled region, a large increase in T_{mfb} with increase in liquid subcooling was observed. Cheng *et al.* [12] performed experiments similar to Groeneveld and Stewart's, and showed that the results were in good agreement with a correlation proposed by Groeneveld. However, Cheng *et al.* also showed that the minimum film boiling temperature increases with increasing mass velocity and decreasing quality. This is in accordance with the result that Iloeje *et al.* [10] showed earlier for dispersed flow.

The results of our study are in good agreement with that of Groeneveld and Stewart in the trend and quality, although both the liquids and metals used in the experiments are different. In the present experiment, R-113 and copper were used while Groeneveld and Stewart used water and inconel. However, a primary difference between our work and the other investigators is the slope of the data in the subcooled region. The increase of the wall superheat with subcooling in our study is moderate while the slopes of the data by Groeneveld and Stewart and Cheng *et al.* are larger. This can be explained by the differences in the properties of the liquid and the tube materials used in the experiments. R-113 used in our study has

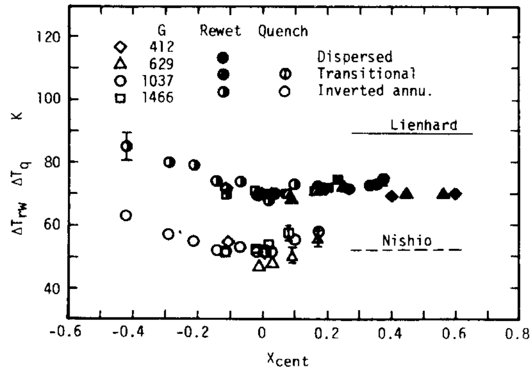


FIG. 9. Wall superheat at the onset of rewetting and of large-scale contact.

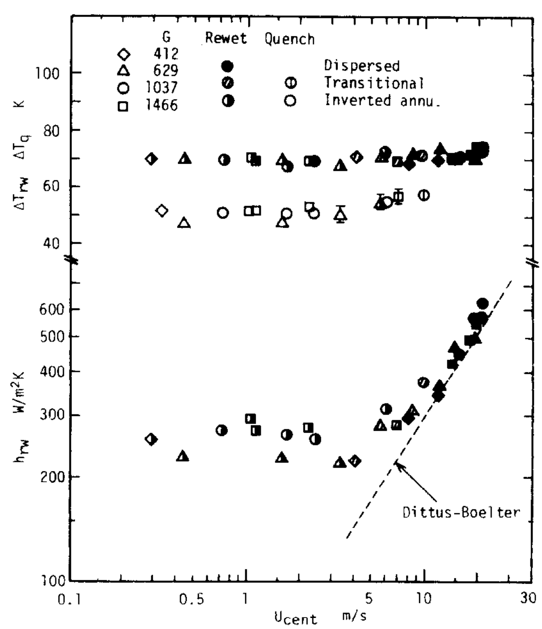


FIG. 10. Wall superheat and heat transfer coefficient at the onset of rewetting.

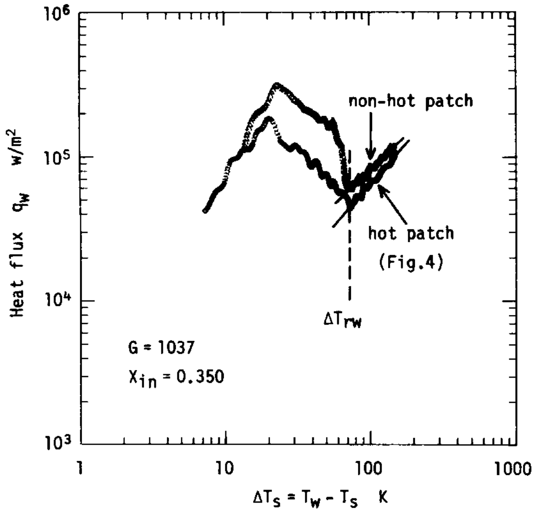


FIG. 11. The effect of the hot patches on the boiling curves.

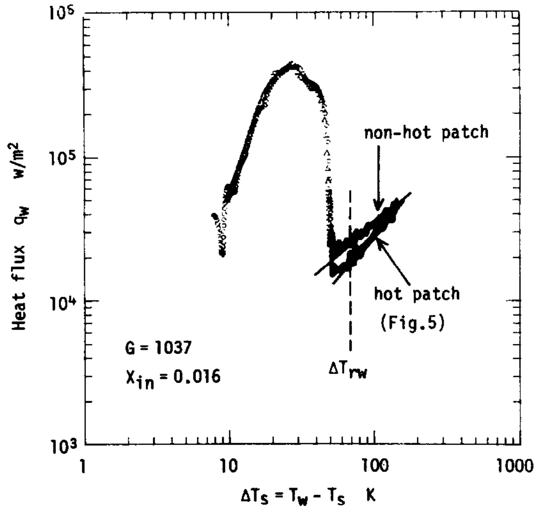


FIG. 12. The effect of the hot patches on the boiling curves.

a much smaller heat of vaporization and specific heat than water, and copper has a much higher thermal conductivity than inconel. Thus a subcooled liquid like water contacting a metal like inconel requires a significant temperature drop on the wall to produce a saturated liquid. On the other hand, R-113 on copper requires a much lower temperature drop to produce saturated liquid. The vapor film along the wall becomes thinner for subcooled liquids compared to saturated liquid, thus leading to higher ΔT_{rw} and ΔT_q for the subcooled case. This is distinctly shown in Fig. 7, and the heat flux in the subcooled region increases with increasing liquid subcooling.

Ueda *et al.* [18] performed experiments similar to ours, but used a test section without a hot patch, and showed that the wall superheat at the onset of rewetting is more dramatically affected by the inlet quality. Their results in the range of $X_{in} > 0.2$, the dispersed flow region, are in good agreement with our study. Also, Ueda *et al.* [21] performed experiments in which droplets impinged on a vertical hot surface at atmospheric pressure to examine the heat transfer caused by this contact. The heat transfer caused by wall–droplet contact is a fundamental part of post-dryout dispersed flow film boiling. They showed that in the case of the combination of R-113 and copper, the wall superheat at the onset of rewetting was about 70 K, which is in good agreement with the range of 67–75 K in the present study.

In our study, the non-hot patch tests were performed to compare with the regular experiment using the hot patches. The wall temperatures of the up- and downstream hot patches were set to the saturation temperature. Figure 11 shows the comparison between boiling curves of non-hot patch and hot patch tests in the case of the dispersed flow and Fig. 12 in the case of the inverted annular flow. The heat fluxes in film boiling in the non-hot patch test show higher values than those of the regular experiments in both qualities. The liquid near the test block is always touching and wetting at both the upstream and downstream edges of the test block, thus causing heat transfer there. Consequently the total amount of the heat transfer increases over that of pure film boiling. The wall superheats ΔT_{rw} and ΔT_q were also obtained in the non-hot patch test at almost the same wall superheat as in the regular experiment. This result means that the spontaneous rewetting caused by the film boiling collapse occurs at ΔT_{rw} on the entire surface.

The lower scale in Fig. 10 shows the heat transfer coefficient at the onset of rewetting h_{rw} obtained from the heat flux q_w and the wall superheat ΔT_{rw} at the onset of rewetting. The results in the velocity range higher than 7 m s^{-1}, dispersed flow film boiling, are fairly close to the Dittus–Boelter correlation as described in the previous section. On the other hand, the results in the inverted annular flow are almost constant in the range of 200–300 kW m^{-2} K^{-1}. Calculating the vapor film thickness along the wall surface from $\delta = \lambda/h_{rw}$, δ becomes about 0.04 mm for $h_{rw} = 250$ kW m^{-2} K^{-1}.

5. CONCLUSIONS

Experiments were performed to investigate the rewetting of a hot surface caused by the collapse of film boiling of R-113 flowing upward through a circular passage in a copper block. Using the hot patch technique, the spontaneous rewetting was obtained, and the wall superheats at the onset of rewetting were obtained. The following conclusions were obtained:

(1) The shape of the boiling curve during the cooling process in the flow boiling system changes with the flow pattern depending on the flow quality.

The rewetting mechanism also changes with the quality.

(2) The temperature at the onset of rewetting, at which the wall–liquid direct contact begins to contribute to the heat transfer, exists in not only dispersed flow but also in inverted annular film boiling. The wall superheat at the onset of rewetting ΔT_{rw} is nearly constant in the range 67–75 K in the saturated region; however, in the subcooled region, ΔT_{rw} increases with liquid subcooling.

(3) The temperature at the onset of large-scale liquid contact accompanied by a sharp rise of the heat flux is brought on the extension of the wetted area caused by the collapse of the vapor film. This temperature clearly exists in the inverted annular flow region, and is easily detected. This wall superheat is nearly constant in the range 47–55 K, and is only slightly affected by velocity.

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ETUDE DU REMOUILLAGE DE SURFACE CAUSE PAR LE COLLAPSUS DE L'EBULLITION EN FILM DANS L'ECOULEMENT

Résumé—On expérimente sur le remouillage d'une surface chaude lors du collapsus de l'ébullition en film de l'écoulement de R-113 dans un passage circulaire de 10 mm de diamètre à travers un bloc de cuivre. Les températures du bloc de cuivre pendant le refroidissement sont mesurées par des thermocouples inclusifs. Les courbes d'ébullition sont obtenues en résolvant l'équation de conduction thermique dans le bloc. On conclut que tandis que les caractéristiques du transfert de chaleur et le mécanisme de remouillage changent avec la qualité de l'écoulement, la surchauffe de la paroi lors de l'apparition du remouillage de la surface et de la trempe est à peu près constante.

UNTERSUCHUNG DER WIEDERBENETZUNG INFOLGE EINES GLEICHMÄSSIGEN ZUSAMMENBRUCHS DES FILMSIEDENS IN ERZWUNGENER STRÖMUNG

Zusammenfassung—Die Wiederbenetzung einer heißen Oberfläche infolge eines Zusammenbruchs des Filmsiedens bei erzwungener Strömung von R-113 durch eine kreiszylindrische Bohrung (Durchmesser 10 mm) in einem Kupferblock wird experimentell untersucht. Die Temperaturen im Kupferblock werden während des Kühlprozesses mittels eingebetteter Thermoelemente gemessen. Der Siedeverlauf wird durch Lösen der Wärmeleitgleichung für den Block ermittelt. Es ergibt sich die Schlußfolgerung, daß in einem Siedesystem bei erzwungener Konvektion die Wandüberhitzung zu Beginn des Wiederbenetzens wie auch beim Abschrecken nahezu konstant ist—obwohl sich das Wärmeübergangsverhalten und der Wiederbenetzungsmechanismus abhängig von der Strömungsform, das heißt vom Dampfgehalt, ändern.

ИССЛЕДОВАНИЕ ВТОРИЧНОГО СМАЧИВАНИЯ ПОВЕРХНОСТИ, ВЫЗВАННОГО ОДНОРОДНЫМ ЗАХЛОПЫВАНИЕМ ПУЗЫРЬКОВ ПРИ ТЕЧЕНИИ В УСЛОВИЯХ ПЛЕНОЧНОГО КИПЕНИЯ

Аннотация—Экспериментально исследуется вторичное смачивание сильно нагретой поверхности, вызванное захлопыванием пузырьков при пленочном кипении в потоке R-113, текущего через медный блок по каналу круглого сечения с внутренним диаметром, равным 10 мм. В процессе охлаждения температура в медном блоке измерялась при помощи погруженных в него термопар. Кривые кипения получены решением уравнения теплопроводности в блоке. Делается вывод о том, что в системе кипения в условиях течения, когда характеристики теплопереноса и механизм вторичного смачивания изменяются с изменением режима течения, перегрев стенки при возникновении вторичного смачивания поверхности, а также при подавлении кипения остается почти постоянным.