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Capillary-induced rewetting in a flat porous cover layer

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Abstract—A physical model is developed to investigate the rewetting characteristics of capillary driven liquid flow through the porous layer on a heated vertical plate. Analytical expressions are derived, and experimental investigation is conducted to check the results. The rewetting velocity and maximum heat flux are found to be dependent upon the thermal properties of the liquid and the plate, the liquid rise height, and the physical properties and thickness of the porous layer. As predicted, the maximum heat flux for which rewetting would occur is found to be only 40% of the heat flux required for initial dryout.

INTRODUCTION

FLUID FLOW and heat transfer through porous materials occur in a wide variety of technological applications, including thermal storage, thermal control of liquid-cooled nuclear reactors, heat pipe wicking structures, and heat transfer augmentation devices. Because of the high heat fluxes encountered in these and other applications, the problems associated with fluid flow and heat transfer in porous materials have become significantly more important. This is especially true in applications such as the evaporator wicking structures of heat pipes designed for use in spacecraft thermal control systems, where the dominating gravitational body force is absent.

Several previous experimental and analytical investigations have studied the dryout and rewetting characteristics of liquid flowing over smooth hot surfaces [1–11] and an exact analytical solution for determining the rewetting velocity of thin liquid films on flat heated surfaces has been developed as a function of the mass flux [12], i.e. pressure driven flow. These investigations, however, are limited to the case of pressure-induced rewetting and to a large extent neglect the effect of surface tension and capillary-induced flow. Because the fluid flow and heat transfer in porous media are strongly dependent upon the capillary pressure and permeability, analytical models which describe the behavior for these cases are significantly more complex.

Recently, Peng and Peterson [13] analyzed the rewetting characteristics of thin, surface tension driven liquid films over flat heated plates as a function of the fluid properties, the film thickness, and the applied heat flux. Analytical expressions for the rewetting velocity and maximum permissible heat flux were developed for both flat and grooved plates and were compared with data from previous investigations. Although the results indicated good agreement for low film velocities, at high velocities the experimental data deviated significantly from the theoretical predictions due to sputtering. To compensate for this deviation, the expressions were modified using an empirically derived correction factor. The resulting modified expressions were found to compare very favorably with the available experimental data, over a large range of flow conditions and velocities. However, because these expressions do not include the effects of permeability, they are not applicable for flow through porous materials.

In addition to the aforementioned investigations, others have focused on the capillary penetration, wetting properties, and capillary flow in single or multiple layers of porous materials. Szekely *et al.* [14], Letelier *et al.* [15], Mumley *et al.* [16], Joos *et al.* [17], and Ambrose *et al.* [18, 19] have examined the penetration and flow of liquid in porous media for vertical plates with adiabatic conditions. Pruzan *et al.* [20] investigated dryout in a screen wick and Ambrose *et al.* [21] examined the dryout and rewetting behavior of porous wicking structures similar to those utilized in high capacity heat pipes. Although these investigations have provided considerable insight for specific situations, very little is known about the dryout and the post-dryout re-

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NOMENCLATURE

c	specific heat of plate
c_p	specific heat at constant pressure
g	gravity acceleration
H	maximum height of liquid rise
h	thickness of porous cover layer
h_f	liquid latent heat
K	permeability
K_r	relative permeability
k	conductivity of plate
m_v	vaporization rate of liquid
q''	heat flux
Q	total heat
R	capillary radius
S	saturation
S_i	immobile saturation
s	relative saturation
T	temperature
T_l	liquid temperature
T_w	rewetting temperature
T_∞	temperature of the liquid pool
t	time
U	velocity of liquid flow
U_w	rewetting velocity.

Greek symbols

α	thermal diffusivity
δ	thickness of plate
ε	porosity
μ	absolute viscosity
ρ	density
σ	surface tension.

Subscripts

l	liquid
max	maximum
w	wetting.

wetting that occurs in porous materials. In addition, insufficient and contradictory experimental data compound the problem and make understanding the mechanisms that govern the behavior of this phenomena difficult.

In the following discussion, the capillary flow and rewetting characteristics of one or more layers of screen on a flat plate to which a uniform heat flux was applied were examined in order to develop theoretical expressions for the rewetting velocity and the maximum heat flux for which rewetting would occur.

THEORETICAL ANALYSIS

The liquid penetration and flow in a porous material is the result of the surface tension and the induced capillary pumping forces occurring in the porous material. For a layer of porous material in a vertical orientation these capillary forces counteract the gravitational field and the resulting body force. The physical model for this type of problem is shown in Fig. 1. To achieve an understanding of the liquid behavior in this situation, several problems must be considered. The first involves the problem of how the liquid wets and flows through the porous material when there is no heat addition. The second involves the flow of liquid when a uniform heat flux sufficient to vaporize some or all of the liquid is applied. An extreme example of this arises when the applied heat flux is sufficient to vaporize the liquid faster than it can be supplied to the porous material, resulting in premature dryout.

For the first problem, the liquid rise in the porous layer is governed by a combination of both the capillary and body forces. When first placed in contact with a liquid, the liquid rises in the porous layer and advances at an average velocity, U. This liquid velocity may vary with respect to the liquid rise height due to the gravitational body force. To simplify the problem, assume that the liquid wets the porous layer and that the flow is one-dimensional and laminar. If the porous layer is fully saturated and the thermophysical properties of the liquid, the porous layer, and the plate are all constant, the liquid flow is governed by the Darcy momentum equation,

$$U = -(KK_r/\mu_l)\left[-\frac{dP_c}{dx}+\rho_l g\right] \quad (1)$$

where K_r is the relative permeability (for fully saturated flow $K_r \equiv 1$). The capillary pressure gradient in

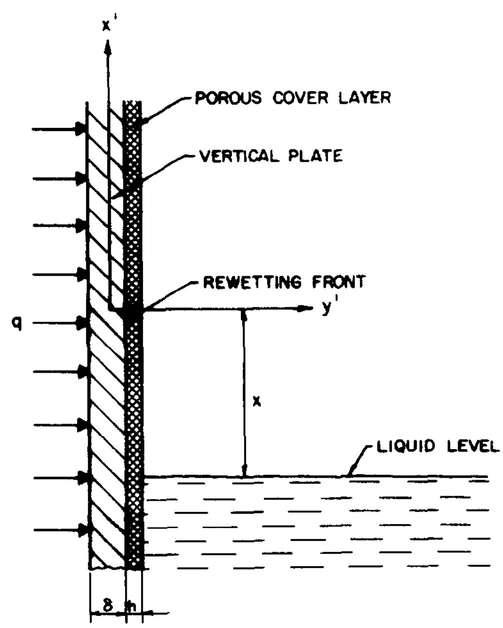

FIG. 1. Description of the problem.

this expression has been studied and found by Letelier *et al.* [15] to be equal to

$$\frac{\mathrm{d}P_c}{\mathrm{d}x} = -\frac{2\sigma}{Rx} \tag{2}$$

over the entire liquid rise height region, where x is the liquid rise height or the distance from the liquid level to the rewetting front, as shown in Fig. 1. Combining equations (1) and (2) yields

$$U = \left(\frac{KK_r}{\mu}\right)\left[\frac{2\sigma}{Rx} - \rho_l g\right] \tag{3}$$

which describes the velocity of the liquid layer flowing in the porous media for the case of a wetting liquid with no heat addition.

If a uniform heat flux sufficient to cause partial vaporization of the liquid is applied to the flat plate, the liquid front is still governed by a combination of capillary and body forces and advances along the porous layer to some maximum height. However, for this case the liquid flow rate is not only a function of the liquid height due to gravity, but is also due to the vaporization of some of the liquid. For the case of uniform heat addition, some of the liquid is vaporized at the leading edge of the advancing liquid front and some from the liquid surface. The heat required to vaporize the liquid is supplied by conduction from the dry hot zone of the plate. The remaining liquid advances with a velocity, U_w, which is different from the velocity for an unheated plate and is known as the wetting or rewetting front velocity.

In comparing these two cases, two things are intuitively apparent: first, the wetting front velocity for an unheated plate is greater than for a heated plate, since during heat addition some of the liquid is vaporized, thereby reducing the liquid mass flow rate in the porous layer; second, when dryout occurs at the leading edge of the wetting front, not all of the heat supplied to the plate is absorbed by the vaporization of the liquid.

To obtain an analytical solution to this problem, the conduction equations for the plate were transformed to a coordinate system moving with the wetting front at a velocity U_w, as shown in Fig. 1. In addition, several other assumptions summarized below were made:

(1) both the conduction heat transfer in the plate and the liquid flow through the plate with the porous cover layer are one-dimensional;

(2) all thermophysical properties are constant;

(3) the liquid temperature at the rewetting front, T_l, which is different from the rewetting temperature, T_w, is assumed to be constant and equal to the saturation temperature, T_s;

(4) the convective heat transfer between the plate (dry hot zone) and air (or vapor for some cases) along with the radiation between the hot surface and surroundings is negligible;

(5) conduction through the porous layer is neglected, since the porous layer is thin and the effective conductivity is small compared with that of the plate.

Utilizing these assumptions and considerations, the one-dimensional conduction equation for the plate yields

$$k\frac{\partial^2 T}{\partial x'^2} - \frac{q''}{\delta} = -\rho c\frac{\partial T}{\partial t}. \tag{4}$$

Since for a moving coordinate system

$$\mathrm{d}t = -\frac{\mathrm{d}x'}{U_w} \tag{5}$$

equation (4) can be simplified to

$$k\frac{\mathrm{d}^2 T}{\mathrm{d}x'^2} - \frac{q''}{\sigma} = \rho c U_w\frac{\mathrm{d}T}{\mathrm{d}x'}. \tag{6}$$

The general solution of equation (6) is

$$T = c_1 + c_2\exp\left[\frac{\rho c U_w x}{k}\right] + \frac{q'' x'}{\rho c U_w \delta}. \tag{7}$$

Because

$$\frac{\mathrm{d}T}{\mathrm{d}x'} = c_2\left[\frac{\rho c U_w}{k}\right]\exp\left[\frac{\rho c U_w}{k}x'\right] + \left[\frac{q}{\rho c U_w \delta}\right]$$

and as $x' \to \infty$, $\mathrm{d}T/\mathrm{d}x' \to \infty$, this is physically impossible which implies that $c_2 = 0$. At the rewetting front, however, the plate temperature can be assumed to be equal to the Leidenfrost or wetting temperature, i.e. $x = 0$, $T = T_w$, and using this condition, a solution can be derived as

$$T = T_w + \frac{q''}{\rho c U_w \delta}x'. \tag{8}$$

From this expression the total heat conduction at $x' = 0$ can be found as

$$Q = \delta k\left.\frac{\mathrm{d}T}{\mathrm{d}x'}\right|_{x'=0} \tag{9}$$

or

$$Q = \frac{q''\alpha}{U_w}. \tag{10}$$

Utilizing an energy balance, the total heat conduction in the region of the wetting front is equal to the energy absorbed by the liquid vaporization, or

$$Q = \dot{m}_v h_f = (U - U_w)\rho_l h h_f \varepsilon \tag{11}$$

where U is the liquid velocity for the unheated plate as determined by equation (3). Combining equations (10) and (11) yields

$$(U - U_w)\rho_l h h_f = \frac{q''\alpha}{U_w} \tag{12}$$

or

$$U_w^2 - U_w U + \frac{q''\alpha}{\rho_l h h_f \varepsilon} = 0. \tag{13}$$

As presented previously [12, 13], the correct solution for equation (13) should be

$$U_w = \frac{1}{2}\left[U + \left(U^2 - \frac{4q''\alpha}{\rho_l h h_f \varepsilon}\right)^{0.5}\right]. \quad (14)$$

Substituting equation (3) into equation (14) yields

$$U_w = \frac{1}{2}\left[\frac{KK_r}{\mu_l}\left(\frac{2\sigma}{Rx} - \rho_l g\right) + \left(\left(\frac{KK_r}{\mu_l}\right)^2\left(\frac{2\sigma}{Rx} - \rho_l g\right)^2 - \frac{4q''\alpha}{\rho_l h h_f \varepsilon}\right)^{0.5}\right]. \quad (15)$$

From this one can conclude that when the surface temperature of a plate with a porous cover layer is higher than the rewetting temperature, T_w, and the heat flux is below the rewetting value, the plate will rewet and the rewetting velocity can be obtained from equation (15). It is clear from this analytical expression that the rewetting velocity is closely related to the heat flux, the porous layer thickness (actually the liquid film thickness), the thermal properties of both the liquid and the plate, and the velocity of the liquid film. In addition, in contrast to the previous cases discussed [12, 13], the rewetting velocity is also dependent upon several properties of the porous layer including the permeability, relative permeability, capillary radius, and porosity. As a result, the rewetting velocity strongly depends not only on the thermal properties of the liquid and the plate, the applied heat flux and the thickness of the porous layer, but also on the properties of the porous layer and the height of the liquid rise. Equation (15) provides theoretical evidence to support the conclusions proposed by several of the experimental investigations discussed previously [1–5, 10, 11]. Furthermore, it reveals some special features associated with the porous layer.

Because the wetting conditions of the heated plate, or the real root of equation (13), should be

$$U^2 = \frac{4q''\alpha}{\rho_l h h_f \varepsilon} \geqslant 0 \quad (16)$$

the limiting condition is

$$U^2 - \frac{4q''\alpha}{\rho_l h h_f \varepsilon} = 0. \quad (17)$$

Therefore, for a given plate with a porous cover layer, the maximum heat flux under which rewetting can occur is

$$q''_{max} = \frac{\rho_l h h_f U^2 \varepsilon}{4\alpha}. \quad (18)$$

Substituting equation (3) into equation (18) yields an expression which describes the maximum heat flux that can be applied to a porous layer and still permit rewetting, i.e.

$$q''_{max} = \left(\frac{KK_r}{\mu_l}\right)^2\left(\frac{2\sigma}{Rx} - \rho_l g\right)^2 \frac{\rho_l h h_f \varepsilon}{4\alpha}. \quad (19)$$

Obviously, the maximum heat flux, q''_{max}, is related to the thermophysical properties, the thickness of the porous layer, the liquid rise height and the properties of the porous layer including permeability, relative permeability, and porosity. The foregoing analysis clearly shows that the applied heat flux is limited to and cannot exceed the specific value predicted by equation (19). Otherwise, the liquid would be unable to provide sufficient cooling to allow the surface to rewet. What is also apparent, and perhaps more significant, is that the maximum permissible heat flux, q''_{max}, corresponds to a maximum liquid rise height, H. This indicates that in a gravity field, the dry hot region may only partially rewet for flows driven by capillary forces alone, and that the rewetting height of vertical plates with a porous layer is limited by and strongly dependent upon the applied heat flux.

EXPERIMENTAL ANALYSIS

To further investigate the rewetting characteristics of this particular situation, and verify the preceding theoretical analyses, an experimental investigation was conducted. A schematic of the experimental apparatus utilized in this investigation is shown in Fig. 2. The test section consisted of a copper wick, a stainless steel heater, and a frame plate made of an insulating machinable ceramic. The height and width of the experimental section were 144 and 37 mm, respectively. The thickness of the stainless steel heater was 0.735 mm. The properties and corresponding physical parameters of the porous layer, which comprised of several layers of copper screen mesh, are listed in Table 1.

Acetone was used as the working fluid for the experimental investigation. Twenty T-type thermocouples (AWG-30) were used to measure the temperature distribution of the plate in the vertical direction. The thermocouples, along with the associated data acquisition system, resulted in an experimental uncertainty of ± 0.5°C. Heat was provided to the porous layer by an alternating current applied directly to the stainless steel heater. The porous layer was electrically insulated from the heater plate by a thin layer of highly conductive thermal epoxy. Measurements of the liquid rise height were made visually by placing a cool stainless steel ruler next to the porous layer and observing where the condensation front occurred. Preliminary tests indicated that this provided a clearly definable wetting front location.

The experiment was conducted for several different levels of applied heat flux. When the wall temperature of the test section was higher than the boiling temperature corresponding to the ambient pressure, approximately 60°C, the test section was lowered into the liquid. After the liquid rise height had reached a maximum steady-state value, the height, heat flux, and wall temperature distribution were measured. No attempt was made to measure the rewetting velocity in the experiment due to the difficulty associated with this measurement.

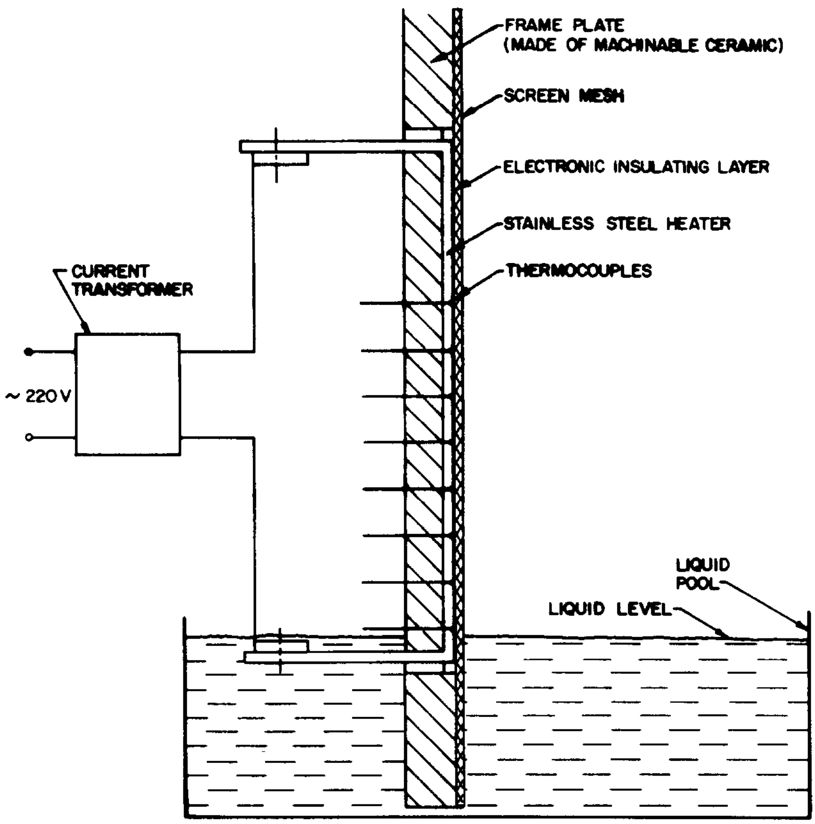

FIG. 2. Schematic of the test facility.

RESULTS AND DISCUSSION

The experimental data are shown in Fig. 3, where the applied heat flux is plotted as a function of the liquid rise height. In addition to the experimental results, the theoretical results predicted by equation (19) for $K_r \equiv 1$ (i.e. the porous layer is fully saturated) are also presented. As shown, the theoretical results are in good agreement with the experimental data, with a relatively constant difference between the predicted and measured values. Because very high heat fluxes resulted in very small liquid rise heights, no data were obtained to verify the theoretical results at these values.

The deviation between the results predicted by equation (19) and the experimental data is the result of several factors. First and foremost was that the screen material was not firmly and uniformly pressed into contact with the stainless steel heater. As a result, the liquid did not rise as high as possible for a given applied heat flux. In addition, as shown by the experiments of Ambrose *et al.* [18, 19], the liquid flow in porous materials is affected by the saturation of the porous layer, S, which varies with the distance from the heated plate. Usually, at the rewetting liquid front the relative saturation

$$s = \frac{S - S_i}{1 - S_i} \tag{20}$$

is less than one. The observations made in this experimental program confirm this. Because the relative permeability can be determined as

$$K_r = f(s) \tag{21}$$

$K_r \equiv 1$ when $s = 1$, and $K_r < 1$ when $s < 1$, the assumption of $K_r \equiv 1$ in equation (19) makes the theoretically predicted values somewhat larger than the values obtained in the experimental tests.

The analysis of Peng and Peterson [13] illustrates the importance of modification due to sputtering. Although sputtering was not observed for lower heat

Table 1. Wick properties, three layers, 80-mesh copper screen

Wick thickness, h (mm)	Permeability, K (m^2)	Capillary radius, R (mm)	Porosity, ε (%)
0.5715	1.11×10^{-10}	0.1397	64

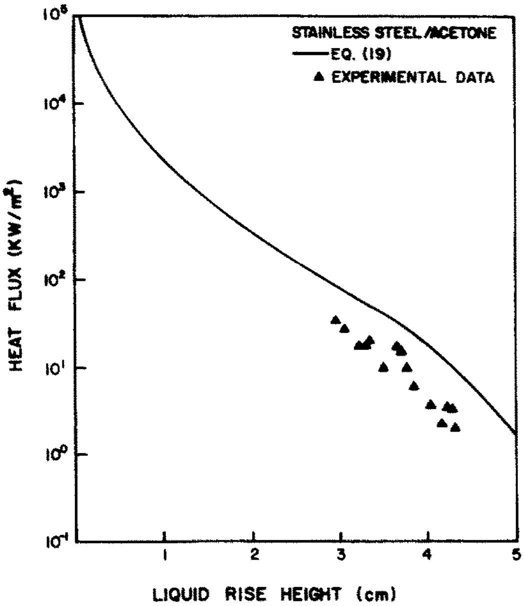

FIG. 3. Comparison of the predicted analytical results and the measured experimental results.

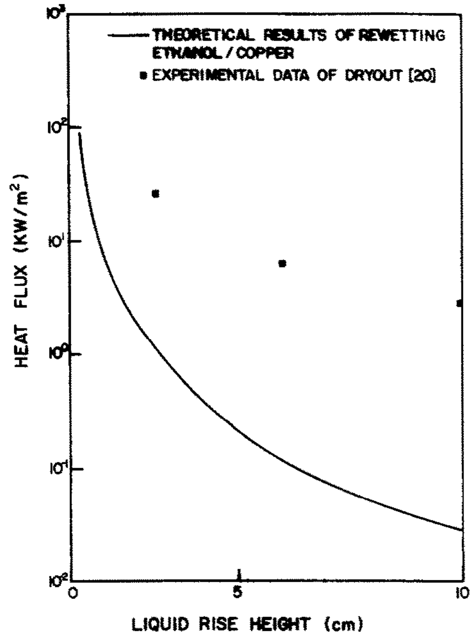

FIG. 4. Comparison of the predicted maximum permissible rewetting heat flux and the dryout heat flux as predicted by Pruzan *et al.* [20] for ethanol/copper.

fluxes, some evidence of sputtering was evident for the higher heat flux values. Because the liquid flows through the hot porous layer and wets the plate surface, the loss of liquid due to sputtering, as described in ref. [13] for flow over a flat plate, is greatly reduced and the liquid is almost all evaporated. As a result, modifications for sputtering are not necessary for the range of heat fluxes evaluated in the present experimental investigation, but may be required for very high heat fluxes.

The theoretical values resulting from equation (19), which predicts the maximum heat flux that can be applied to a porous layer and still permit the liquid to rewet, were compared with the heat flux values required for dryout of a porous layer as measured by Pruzan *et al.* [20]. The results of this comparison are shown in Figs. 4 and 5 for two different liquid/plate material combinations. The properties of the porous layer used in the experimental investigation are listed in Table 2. Although the trend for both is similar, the maximum permissible rewetting heat flux values as predicted by equation (19) were only approximately 40% of the heat fluxes required for dryout. This was anticipated by Bui and Dhir [22], and can be explained by examining a typical boiling curve. Recall that in a typical boiling curve, the critical heat flux (which for this case refers to the heat flux required for dryout) is considerably larger than the heat flux which allows the transition from film to nucleate boiling (or rewetting).

Also of interest are the temperature distributions in the wet, transitional, and dryout regions. Figure 6 illustrates a graphical representation of the wall temperature distribution that occurs when the maximum rewetting height has been reached for a given applied heat flux. The general shape of this curve confirms several things: first, as expected, the temperature change occurring at the rewetting front is very rapid and second the rate of temperature increase occurring in the dry region of the plate is larger than that occurring in the region which has been rewet by the liquid. Although equation (8) predicts that the temperature distribution in the dry region should be linear, there

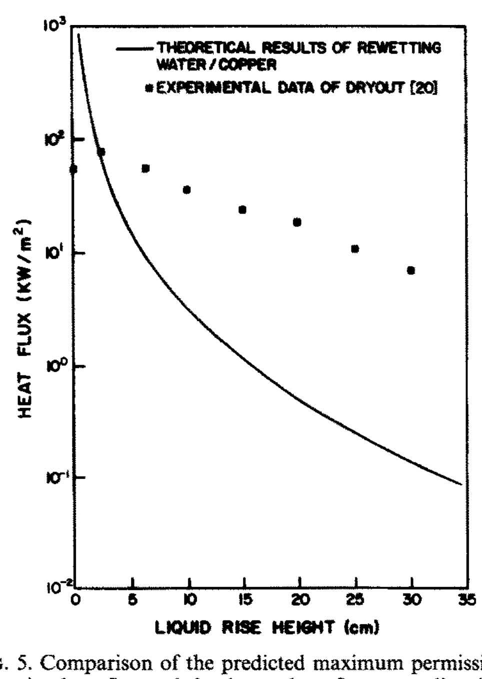

FIG. 5. Comparison of the predicted maximum permissible rewetting heat flux and the dryout heat flux as predicted by Pruzan *et al.* [20] for water/copper.

Table 2. Wick properties, four layers, 325-mesh stainless steel screen

Wick thickness, h (mm)	Permeability, K (m^2)	Capillary radius, R (mm)	Porosity, ε (%)
0.305	4.00×10^{-11}	2.77×10^{-2}	65

is some slight variation believed to be due to a combination of convective and radiative losses. Comparison of the analytical and experimental results, however, demonstrates that equation (8) is sufficiently accurate to be used to determine the conduction at or near the rewetting front.

In the derivation of the theoretical model, the liquid temperature at the rewetting front was assumed to be at saturation conditions. The actual temperature, however, is somewhere between the saturation temperature and the temperature of the liquid pool, i.e.

$$T_\infty < T_1 < T_s. \tag{22}$$

Because the exact temperature at this location is difficult to determine experimentally, the analytical solution was derived for the extreme case $T_1 = T_s$. For the other extreme case, $T_1 = T_\infty$, the energy balance in equation (11) can be expressed as

$$Q = \dot{m}_v h_f \rho c_{pl}(T_s - T_1) = \dot{m}_v[h_f + c_{pl}(T_s - T_1)] \tag{23}$$

or

$$Q = (U - U_w)\rho_1 h\varepsilon[h_f + c_{pl}(T_s - T_1)]. \tag{24}$$

If h'_f is used to replace h_f, i.e.

$$h'_f = h_f + c_{pl}(T_s - T_1) \tag{25}$$

equation (24) can be rewritten as

$$Q = (U - U_w)\rho_1 hh'_f\varepsilon \tag{26}$$

and the rewetting velocity and the maximum heat flux, equations (15) and (19), can be solved to yield

$$U_w = \frac{1}{2}\left[\frac{KK_r}{\mu_1}\left(\frac{2\sigma}{Rx} - \rho_1 g\right) + \left(\left(\frac{KK_r}{\mu_1}\right)^2\left(\frac{2\sigma}{Rx} - \rho_1 g\right)^2 - \frac{4q\alpha}{\rho_1 hh'_f\varepsilon}\right)^{0.5}\right] \tag{27}$$

and

$$q''_{max} = \left(\frac{KK_r}{\mu_1}\right)^2\left(\frac{2\sigma}{Rx} - \rho_1 g\right)^2 \frac{\rho_1 hh'_f\varepsilon}{4\alpha} \tag{28}$$

respectively. It is clear from equations (27) and (28) that the liquid subcooling at the rewetting front will considerably increase the rewetting velocity and the maximum permissible heat flux.

It is worth noting that the conduction through the porous layer was not considered in the model developed here, and that the analytical solution does not include the effects of the thermophysical properties of the porous layer. In some cases, these factors may strongly affect the rewetting and result in some variations from the predicted behavior.

CONCLUSION

A physical model has been developed to investigate the rewetting characteristics of capillary driven liquid flow through a porous layer on a heated vertical plate. From this physical model, analytical expressions have been derived which describe the heat flux-dependent rewetting velocity and the maximum heat flux for

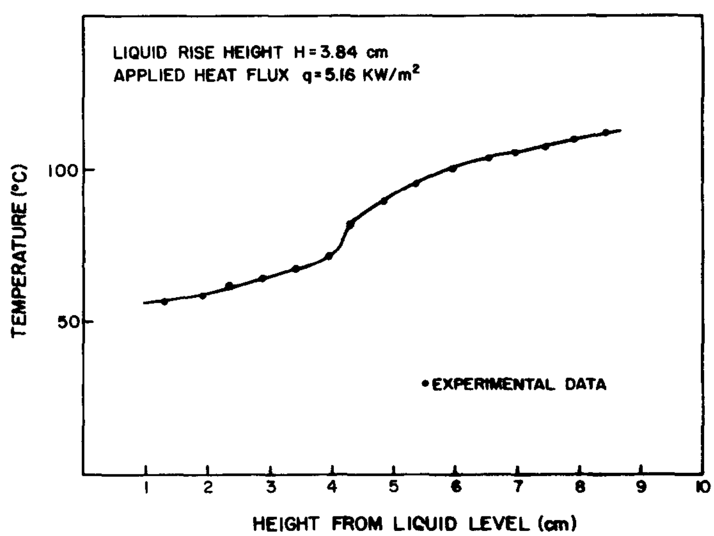

FIG. 6. Longitudinal temperature distribution of the heated surface.

which rewetting can occur. An experimental investigation has been conducted to verify the theoretical results. The rewetting velocity and maximum heat flux have been found to be dependent upon the thermal properties of the liquid and the plate, the liquid rise height, and the physical properties and thickness of the porous layer.

In addition to comparison with the experimental results of this investigation, the theoretical predictions for the maximum rewetting heat flux have been compared with the experimental data obtained by several other investigators. Although the trends for the predicted and measured values were similar, the maximum permissible rewetting heat flux values as predicted by equation (19) were only approximately 40% of the heat fluxes required for dryout.

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REMOUILLAGE INDUIT PAR CAPILLARITE DANS UNE COUCHE PLANE POREUSE

Résumé—On développe un modèle physique pour étudier les caractéristiques du remouillage d'un écoulement liquide mû par capillarité à travers une couche verticale poreuse sur une surface chauffée. On obtient des expressions analytiques et une étude expérimentale pour vérifier les résultats est conduite. La vitesse de remouillage et le flux thermique maximal sont trouvés être dépendants de propriétés du liquide et de la plaque, de la hauteur d'élévation du liquide, des propriétés physiques et de l'épaisseur de la couche poreuse. Comme le calcul le prédit, le flux thermique maximal qui accompagne le remouillage est seulement 40% du flux nécessaire à l'assèchement initial.

WIEDERBENETZUNG IN EINER EBENEN PORÖSEN DECKSCHICHT AUFGRUND VON KAPILLARKRÄFTEN

Zusammenfassung—Es wird ein physikalisches Modell zur Untersuchung der Wiederbenetzung aufgrund von Kapillarströmungen durch die poröse Schicht einer vertikalen beheizten Platte entwickelt. Es werden die analytischen Beziehungen abgeleitet und die Ergebnisse durch experimentelle Untersuchungen überprüft. Es ergibt sich, daß die Geschwindigkeit der Wiederbenetzung und die maximale Wärmestromdichte von den thermischen Eigenschaften des Fluids und der Platte, der Steighöhe der Flüssigkeit sowie von den physikalischen Eigenschaften und der Dicke der porösen Schicht abhängig ist. Die maximale Wärmestromdichte, bei der Wiederbenetzung stattfindet, beträgt nur 40% der Wärmestromdichte, die für die anfängliche Austrocknung benötigt wird.

ПОВТОРНОЕ СМАЧИВАНИЕ ЗА СЧЕТ КАПИЛЛЯРОВ В ПЛОСКОМ ПОРИСТОМ СЛОЕ ПОКРЫТИЯ

Аннотация—Разработана физическая модель для исследования характеристик повторного смачивания в случае течения жидкости в капиллярах пористого слоя на нагретой вертикальной пластине. Получены аналитические выражения и проведена экспериментальная проверка результатов. Найдено, что скорость повторного смачивания и максимальный тепловой поток зависят от тепловых свойств жидкости и пластины, высоты поднятия жидкости, а также от физических свойств и толщины пористого слоя. Кроме того, показано, что максимальный тепловой поток, при котором возможно повторное смачивание, составляет только 40% от необходимого для начального кризиса теплопереноса.