

THE INTERLINE HEAT-TRANSFER COEFFICIENT OF AN EVAPORATING WETTING FILM

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Abstract—The average evaporation heat-transfer coefficient for the interline region of an adsorption controlled wetting film in which the disjoining pressure is approximated by $P_d = -\bar{A}\delta^{-3}$ can be represented by $\bar{h} = h^{id}[1 - 0.5(\eta^{-1} + \eta^{-2})]$. h^{id} is the ideal liquid-vapor interfacial heat-transfer coefficient and η is a function of the physical properties of the system and the extent of the interline region. A simple procedure to obtain the heat-transfer coefficient is presented. The coefficient varies from zero at the interline to a value equal to the liquid-vapor interfacial heat-transfer coefficient over a relatively short distance.

NOMENCLATURE

<p>A, dispersion constant [J];</p> <p>A_{12}, Hamaker constant [J];</p> <p>f, fugacity [$\text{N} \cdot \text{m}^{-2}$];</p> <p>$G$, constant in equation (21) [m^{-2}];</p> <p>H, molar latent heat of vaporization [$\text{J} \cdot \text{mol}^{-1}$];</p> <p>$h$, heat-transfer coefficient [$\text{W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}$];</p> <p>$h_{fg}$, latent heat of vaporization [$\text{J} \cdot \text{kg}^{-1}$];</p> <p>$I$, constant in equation (22) [m];</p> <p>K, curvature [m^{-1}];</p> <p>M, molecular weight [$\text{kg} \cdot \text{mol}^{-1}$];</p> <p>$\dot{m}$, mass flux [$\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$];</p> <p>$P$, pressure [$\text{N} \cdot \text{m}^{-2}$];</p> <p>$\mathcal{R}$, universal gas constant [$\text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$];</p> <p>$T$, temperature [K];</p> <p>u, velocity [$\text{m} \cdot \text{s}^{-1}$];</p> <p>$V$, molar volume [$\text{m}^3 \cdot \text{mol}^{-1}$].</p>	<p>0, evaluated at interline;</p> <p>v, vapor phase;</p> <p>2, substrate (solid);</p> <p>1, fluid.</p> <p>Superscripts</p> <p>$\bar{}$, averaged;</p> <p>id, ideal;</p> <p>$*$, differentiation with respect to ξ.</p>
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Greek symbols

<p>γ, dimensionless heat-transfer coefficient;</p> <p>δ, film thickness [m];</p> <p>Γ, mass flowrate per unit width [$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-1}$];</p> <p>$\epsilon$, dimensionless perturbation in equation (30a);</p> <p>ϵ_0, dielectric constant [dimensionless];</p> <p>η, dimensionless film thickness;</p> <p>μ, absolute viscosity [$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-1}$];</p> <p>$\nu$, kinematic viscosity [$\text{m}^2 \cdot \text{s}^{-1}$];</p> <p>$\nu_v$, characteristic dispersion frequency [s^{-1}];</p> <p>ξ, dimensionless film length coordinate;</p> <p>ρ, density [$\text{kg} \cdot \text{m}^{-3}$];</p> <p>$\sigma$, evaporation coefficient [dimensionless];</p> <p>σ_{lv}, surface tension [$\text{N} \cdot \text{m}^{-1}$].</p>	
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Subscripts

<p>d, disjoining;</p> <p>e, evaporative;</p> <p>l, liquid phase;</p> <p>lv, liquid-vapor interface;</p>	
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1. INTRODUCTION

THE HEAT-TRANSFER coefficient in the interline region (junction of vapor, adsorbed evaporating thin film and adsorbed non-evaporating thin film) is of considerable importance in many change-of-phase heat-transfer processes. For example, analysis of the rewetting of a hot spot and the analysis of evaporation from a stable evaporating meniscus would both be enhanced by a better understanding of the interline heat-transfer coefficient. The present study provides a simple and effective procedure to obtain the interline region heat-transfer coefficient from the physical properties of the system. The present study is limited to wetting, non-polar liquids. The heat-transfer coefficient in the interline region is shown to change from a value of zero at the interline to a value equal to the liquid-vapor interfacial heat-transfer coefficient over a very short distance.

Using adsorption isotherms and the disjoining pressure concept, Deryagin *et al.* have demonstrated that thin film transport is capable of enhancing the evaporation rate from capillaries [1]. The stability of an evaporating meniscus formed on a vertical flat plate immersed in a pool of saturated liquid has been experimentally demonstrated [2]. These studies led to a model of the stable evaporating meniscus which was based on the hypothesis that fluid flow in the evaporating meniscus resulted from a change in the meniscus profile which created the necessary pressure gradient [3]. Experimental data confirming this hypothesis for liquid films with thicknesses greater than

1.2×10^{-7} m have been obtained [4]. Power-law solutions for evaporation from finned surfaces in which fluid flow results from a curvature gradient have also been proposed [5]. In a study of the dynamics of the wetting process, fluid motion resulting from London-van der Waals forces acting between the fluid and solid has been analysed [6]. In this study the intermolecular forces governing the system were related to the disjoining pressure concept and the Hamaker constant. Various theoretical techniques for calculating Hamaker constants are available, e.g. [7]. One of these techniques, which makes use of the optical constants of the fluid and solid is used in the present study. Using this approach the theoretical heat-transfer coefficient is conveniently related to the optical constants of the system.

2. DEVELOPMENT OF THE EQUATIONS

The system to be studied consists of a thin, adsorbed film of pure liquid on a horizontal solid substrate (see Fig. 1). The analysis is restricted to non-polar liquids wetting the solid substrate in which the intermolecular interactions can be predicted from London's theory of dispersion forces. The liquid film and solid substrate are assumed to be at a temperature above the saturation temperature of the liquid. If the film is sufficiently thin it is kept from evaporating by van der Waals dispersion forces between the solid and liquid.

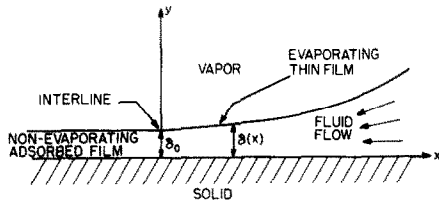


FIG. 1. Interline junction of vapor, adsorbed evaporating thin film and adsorbed non-evaporating thin film.

If a section of the film is slightly tapered, portions of the film may be sufficiently thick to allow evaporation. The junction between the non-evaporating and the evaporating thin films is the interline. Fluid flows in the negative "X" direction in the evaporating thin film as a result of a pressure gradient in the film arising from the film thickness gradient. There is a steady-state source of fluid outside of the analyzed region.

The relationship between the vapor pressure of the thin film and the saturation pressure at the film temperature is given by Deryagin and Zorin [8] as

$$\ln \frac{P_{v|v}}{P_{v|vt}} = \frac{V_l}{\mathcal{R}T_{lv}} P_d \quad (1)$$

In this expression P_d is the "disjoining pressure" and is the "decrease in liquid pressure" resulting from the van der Waals dispersion forces between the adsorbed thin film and the solid substrate. Thus the disjoining pressure represents the reduction in film pressure from the reference vapor pressure:

$$P_d = P_l - P_v \quad (2)$$

Experiments [8] indicate that the relationship between disjoining pressure and film thickness for flat films of non-polar liquids can be represented by

$$P_d = -\bar{A}\delta^{-3} \quad (3)$$

where \bar{A} is related to the Hamaker constant which accounts for the London-van der Waals forces between atoms. Thus

$$P_d \approx -\frac{A_{12}\delta^{-3}}{6\pi} \quad (4)$$

Various authors [1, 3, 6, 9] have suggested that a disjoining pressure gradient is sufficient to support fluid flow. The pressure gradient in the liquid film resulting from the thickness gradient is obtained by differentiating (4):

$$\frac{dP_l}{dx} = 3\bar{A}\delta'\delta^{-4} \quad (5)$$

Under the influence of this pressure gradient, the velocity distribution at any point in the slightly tapered thin film, assuming a continuum, is obtained from the momentum equation:

$$\frac{dP_l}{dx} = \mu \frac{d^2u}{dy^2} \quad (6)$$

The boundary conditions are the traditional no-slip condition at the liquid-solid interface and no-shear conditions at the liquid-vapor interface. For these boundary conditions the velocity distribution in the film is

$$u(y) = \frac{1}{\mu} \left(\frac{dP_l}{dx} \right) \left(\frac{y^2}{2} - \delta y \right) \quad (7)$$

The mass flow rate per unit width of film is obtained from (7) as

$$\Gamma = \rho \int_0^\delta u(y) dy = -\frac{\delta^3}{3\nu} \left(\frac{dP_l}{dx} \right) \quad (8)$$

Combining (5) and (8) gives the mass flow rate in terms of the thickness gradient:

$$\Gamma = -\frac{\bar{A}}{\nu} \frac{\delta'}{\delta} \quad (9)$$

The evaporative mass flux leaving the film surface is obtained from (9) as

$$\dot{m}_e = -\frac{d\Gamma}{dx} = \frac{\bar{A}}{\nu} \left(\frac{\delta'}{\delta} \right)' \quad (10)$$

The evaporative heat flux is then

$$h(T_{lv} - T_v) = h_{fg} \dot{m}_e = \frac{h_{fg} \bar{A}}{\nu} \left(\frac{\delta'}{\delta} \right)' \quad (11)$$

Schrage [10] developed an expression relating the liquid-vapor interfacial conditions to the mass flux of matter crossing the interface which has been used extensively [11-13]. Using this approach the resultant heat flux is expressed as

$$h_{fg} \dot{m}_e = \left(\frac{2\sigma h_{fg}}{2-\sigma} \right) \left(\frac{M}{2\pi \mathcal{R}} \right)^{1/2} \left[\frac{P_{v|v}}{T_{lv}^{1/2}} - \frac{P_v}{T_v^{1/2}} \right] \quad (12)$$

For small liquid superheats $T_{lv}^{1/2} \approx T_v^{1/2} \equiv \bar{T}^{1/2}$ and (11) and (12) combine to give

$$\left(\frac{\delta'}{\delta}\right)' = \frac{v}{\bar{A}} \left(\frac{2\sigma}{2-\sigma}\right) \left(\frac{M}{2\pi\mathcal{R}\bar{T}}\right)^{1/2} (P_{vlv} - P_v). \quad (13)$$

The thermodynamic equation for the change in liquid fugacity with liquid pressure and temperature is

$$d \ln f_l = \frac{V_l}{\mathcal{R}T_l} dP_l + \frac{H^{id}}{\mathcal{R}T_l^2} dT_l \quad (14)$$

where H^{id} is the "ideal" molar heat of vaporization for a liquid expanding into a vacuum. For most normal liquids at moderate temperatures and pressures the ideal heat of vaporization is closely approximated by the ordinary latent heat Mh_{fg} . Since $\ln f$ is an extensive property, (14) may be integrated without regard to the path of integration. Integrating (14) over a range where the fugacity is approximately equal to the vapor pressure of the liquid gives:

$$\begin{aligned} \int d \ln f_l &= \int_{P_{vl} = P_v}^{P_{vl} = P_{vlv}} d \ln P_{vl} \\ &= \int_{\text{const. } P_l = P_v} d \ln P_{vl} + \int_{\text{const. } T_l = T_v} d \ln P_{vl}. \end{aligned} \quad (15)$$

The first integration is along an isobaric path between the vapor phase temperature T_v and the interfacial temperature T_{lv}

$$\int_{P_l = P_v} d \ln P_{vl} = \frac{Mh_{fg}}{\mathcal{R}T_v T_{lv}} (T_{lv} - T_v). \quad (16)$$

The second integration is along an isothermal path between the vapor phase pressure P_v and the liquid phase pressure P_l

$$\int_{T_l = T_v} d \ln P_{vl} = \frac{V_l}{\mathcal{R}T_{lv}} (P_l - P_v). \quad (17)$$

Combining (15), (16) and (17) and making use of (2) gives:

$$\ln \frac{P_{vlv}}{P_v} = \frac{Mh_{fg}}{\mathcal{R}T_v T_{lv}} (T_{lv} - T_v) + \frac{V_l P_d}{\mathcal{R}T_{lv}}. \quad (18)$$

For small changes in vapor pressure the L.H.S. of (18) can be approximated by a truncated Taylor series as:

$$\frac{P_{vlv} - P_v}{P_v} = \frac{Mh_{fg}}{\mathcal{R}T_v T_{lv}} (T_{lv} - T_v) + \frac{V_l P_d}{\mathcal{R}T_{lv}}. \quad (19)$$

Combining (13) and (19) and using (4) gives, after rearranging

$$\left(\frac{\delta'}{\delta}\right)' = -I\delta^{-3} + G \quad (20)$$

where

$$G = \frac{v}{\bar{A}} \left(\frac{2\sigma}{2-\sigma}\right) \left(\frac{M}{2\pi\mathcal{R}\bar{T}}\right)^{1/2} \left(\frac{P_v Mh_{fg}}{R}\right) \left(\frac{T_{lv} - T_v}{T_{lv} T_v}\right) \quad (21)$$

$$I = v \left(\frac{2\sigma}{2-\sigma}\right) \left(\frac{M}{2\pi\mathcal{R}\bar{T}}\right)^{1/2} \left(\frac{V_l P_v}{\mathcal{R}T_{lv}}\right). \quad (22)$$

Equation (20) can now be used with (11) to obtain the local heat-transfer coefficient as

$$h = \frac{h_{fg} \bar{A}}{v(T_{lv} - T_v)} (-I\delta^{-3} + G). \quad (23)$$

The interline film thickness, δ_0 , is found from (23) when $h = 0$ as

$$\delta_0 = \sqrt[3]{\frac{I}{G}} = \sqrt[3]{\left(\frac{\bar{A}V_l T_v}{Mh_{fg}(T_{lv} - T_v)}\right)}. \quad (24)$$

For very thick films $\delta \rightarrow \infty$ and the "ideal" local heat-transfer coefficient which neglects adsorption forces becomes

$$h^{id} = \frac{h_{fg} \bar{A} G}{v(T_{lv} - T_v)}. \quad (25)$$

The ratio of the local to ideal heat-transfer coefficients thus becomes

$$\gamma = \frac{h}{h^{id}} = 1 - \frac{I}{G} \delta^{-3} = 1 - \left(\frac{\delta}{\delta_0}\right)^{-3} = 1 - \eta^{-3}. \quad (26)$$

The term $(\delta_0/\delta)^3$ in (26) represents the ratio of change in vapor pressure resulting from adsorption to the change resulting from the temperature increase. η is also the ratio of the local film thickness to the interline film thickness. For a sufficiently thick film the solid does not affect the heat-transfer coefficient.

The ratio of local to ideal heat-transfer coefficients averaged over the range of applicability of the present study is obtained from (26) as

$$\bar{\gamma} = \frac{\int_{\delta_0}^{\delta} \gamma d\delta}{\int_{\delta_0}^{\delta} d\delta} = 1 - \frac{1}{2}(\eta^{-1} + \eta^{-2}). \quad (27)$$

Equation (20) can be made dimensionless by a simple change of variable. Let

$$\eta = \delta/\delta_0 \quad (28a)$$

$$\xi^2 = Gx^2. \quad (28b)$$

Equation (20) then becomes

$$\left(\frac{\eta^*}{\eta}\right)^* = 1 - \eta^{-3} \quad (29)$$

where the asterisk indicates differentiation with respect to the new independent variable ξ . It should be noted that ξ^2 represents the ratio of the "ideal" evaporation rate from a thin film due to the liquid superheat alone neglecting the effect of adsorption to the actual flow of liquid into the film (real rate of evaporation from the film).

3. NUMERICAL RESULTS AND DISCUSSION

Equation (29) can be solved by a number of numerical techniques to obtain the dimensionless film profile. This equation was solved using the orthogonal collocation method [14, 15] with the following initial conditions:

$$\eta(0) = 1 + \varepsilon \quad (30a)$$

$$\left.\frac{d\eta}{d\xi}\right|_0 = 0 \quad (30b)$$

ε was chosen to be 0.001 which corresponds to a local heat-transfer coefficient equal to approximately 0.3% of the ideal value ($\delta = 1.001 \delta_0$ where δ_0 is usually

Table 1. Calculated Hamaker and dispersion constants for several liquids on various dielectric substrates at 20°C

Liquid		Fused silica	Crown glass	Dense flint glass	ϵ_{10}
CCl ₄ †	A_{12}	6.12×10^{-20}	6.65×10^{-20}	6.82×10^{-20}	2.074
	\bar{A}	3.25×10^{-21}	3.53×10^{-21}	3.62×10^{-21}	
C ₆ H ₆ ‡	A_{12}	6.47×10^{-20}	7.03×10^{-20}	7.23×10^{-20}	2.196
	\bar{A}	3.43×10^{-21}	3.73×10^{-21}	3.84×10^{-21}	
H ₂ O‡	A_{12}	5.41×10^{-20}	5.86×10^{-20}	5.94×10^{-20}	1.77
	\bar{A}	2.87×10^{-21}	3.11×10^{-21}	3.15×10^{-21}	
ϵ_{20}		2.0983	2.2799	2.536	

†Dispersion data of [16, 17].

‡Data of [7] used.

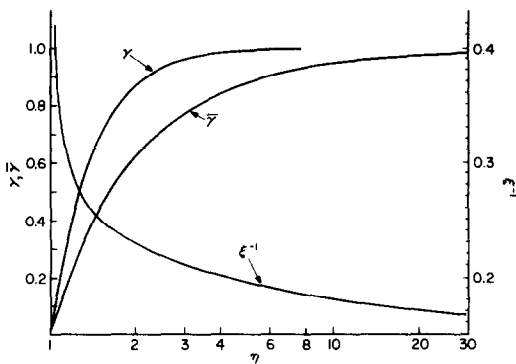


FIG. 2. Dimensionless heat-transfer coefficient profiles and dimensionless film profile.

expected to be less than 50 Å). The combination of (30a) and (25) is equivalent to a heat flux boundary condition.

The dimensionless film profile, η , local heat-transfer coefficient, γ , and average heat-transfer coefficient, $\bar{\gamma}$, are shown in Fig. 2. The right hand ordinate can be conveniently calculated using (28b) and (21). The resulting value of η can be used to obtain the local value of the film thickness or used to obtain the dimensionless heat-transfer coefficient.

Specialization of Fig. 2 to specific liquid/solid systems is achieved through knowledge of the physical properties of the system. In particular the constants I and G are required. In order to calculate G the dispersion constant, \bar{A} , must be obtained. The dispersion constant, \bar{A} , is related to the Hamaker constant, A_{12} , for two dissimilar materials in close proximity by

$$\bar{A} = \frac{A_{12} - A_{11}}{6\pi} \approx \frac{A_{12}}{6\pi}. \quad (31)$$

An interesting approach to the calculation of Hamaker constants is given by Gregory [7]. This approach uses the optical properties of the materials to obtain the Hamaker constant. Gregory obtained the following expression:

$$A_{12} = \frac{37}{32} \frac{h\nu_{1v}\nu_{2v}}{(\nu_{1v} + \nu_{2v})} \frac{(\epsilon_{10} - 1)(\epsilon_{20} - 1)}{(\epsilon_{10} + 2)(\epsilon_{20} + 2)}. \quad (32)$$

In (32) ϵ_{10} is the dielectric constant of material 1 and

ν_{1v} is a characteristic dispersion frequency obtained from the optical properties of the material; h is Planck's constant. Using (32) the Hamaker constants for carbon tetrachloride, benzene and water in contact with several types of glass were calculated. The results are shown in Table 1. Using another approach Lopez, Miller and Ruckenstein [6] estimated the Hamaker constant for CCl₄ to be 6.5×10^{-19} J. Deryagin and Zorin [8] claimed an approximate experimental value of 10^{-19} J. It should be noted that the use of (32) is limited by some of the assumptions used in its derivation, e.g. that the dielectric constant is equal to the square of the limiting refractive in the visible wavelength region [7]. The results for water are included only for comparison since (3) does not apply to a polar liquid. Using (21) for CCl₄ at 293 K and $\Delta T = 0.272$ K with $\bar{A} = 3.25 \times 10^{-21}$ N·m, gives $G = 1.77 \times 10^{14}$ m⁻². Using (25) the ideal heat-transfer coefficient, h^{id} , is found to be 7.39×10^5 Jm⁻²s⁻¹K⁻¹ at 293 K for $\Delta T = 0.272$ K. The ideal heat-transfer coefficient is, of course, a strong function of the temperature.

These results can be analyzed further by evaluating the extent of the interline region described by the model, x , for three arbitrarily chosen limits:

$$\text{I.} \quad \gamma = 0.999, \quad \eta = 10$$

$$\text{II.} \quad \frac{d\delta}{dx} = 0.2, \quad \eta^* = 0.2\delta_0^{-1}G^{-1/2}$$

$$\text{III.} \quad \sigma_w \frac{dK}{dx} = \frac{0.9\bar{A}}{\delta^4} \frac{d\delta}{dx}, \quad \frac{\eta^4 \eta^{***}}{\eta^*} = 0.9\bar{A}/(\delta_0^4 G \sigma_w).$$

The first limit represents the region where the effect of adsorption becomes negligible as a result of the film thickness. The second limit represents the region where the slope becomes appreciable. The third limit represents the region where a possible effect on the pressure gradient due to a curvature gradient is equal to 30% of that due to the disjoining pressure gradient. These two pressure gradients should have opposite signs until the region of curvature control is reached. First, the curvature increases as a result of the disjoining pressure gradient. Then, the curvature decreases as it controls the fluid flow rate. In this latter region (4) is no longer applicable. For CCl₄ on fused silica at 293 K and a

superheat of 0.272 K ($G = 1.77 \times 10^{14} \text{ m}^{-2}$ and $\delta_0 = 21.7 \text{ \AA}$) the values are:

- I. $\eta = 10$, $\delta = 217 \text{ \AA}$, $x = 7.32 \times 10^{-7} \text{ m}$;
- II. $\eta = 4.5$, $\delta = 97.7 \text{ \AA}$, $x = 3.83 \times 10^{-7} \text{ m}$;
- III. $\eta = 1.76$, $\delta = 38.2 \text{ \AA}$, $x = 3.08 \times 10^{-7} \text{ m}$.

For these conditions, it appears that III limits the transport processes in the interline region. The best way to model the combined effects of a pressure gradient resulting from a curvature gradient with one resulting from a thickness gradient is unknown. A linear model has been suggested [18]. If linear, the above results demonstrate that at these heat fluxes with CCl_4 on fused silica an increase in the curvature would tend to restrict the flow of liquid into the evaporating thin film. This could cause the process to become unstable and possibly oscillate or dry out. It could also cause a faster increase in film thickness and a change over to curvature controlled flow. The nature of the transition would depend on the coupled heat flux in the solid. For the above condition the heat flux at $\eta = 1.76$ is $2.01 \times 10^5 \text{ J m}^{-2} \text{ s}^{-1}$. Another interfacial effect, the surface shear stress resulting from a temperature gradient has been shown to have a negligible effect relative to that of the large pressure gradient in the liquid [19].

There are aspects of the above solution which need experimental evaluation and refinement. Because of the microscopic concepts and dimensions of the problem, this will require extensive research which is beyond the scope of this paper. On the other hand, sufficient information is available to develop the above outline of the important characteristics of the interline heat transfer process in useful form. It is expected that this will lead to the design of the proper experiments and better use of the interline heat-transfer process.

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COEFFICIENT DE TRANSFERT THERMIQUE A L'INTERFACE DE CONTACT D'UN FILM MOUILLANT EN EVAPORATION

Résumé—Le coefficient moyen de transfert de chaleur par évaporation d'un film mouillant contrôlé par l'adsorption et dans lequel la pression de séparation est approchée par $P_d = -\bar{A}\delta^{-3}$ peut être représenté par $\bar{h} = h^{id}[1 - 0,5(\eta^{-1} + \eta^{-2})]$; h^{id} représente le coefficient de transfert thermique à l'interface liquide-vapeur dans le cas idéal et η est une fonction des propriétés physiques du système et de l'étendue de la région interfaciale. On présente une procédure simple permettant l'obtention du coefficient de transfert thermique. Le coefficient varie depuis zéro au niveau de l'interface de contact jusqu'à une valeur égale au coefficient de transfert thermique à l'interface liquide-vapeur, cela sur une distance relativement courte.

DER WÄRMEÜBERGANGSKOEFFIZIENT IM RANDBEREICH EINES VERDAMPFENDEN BENETZENDEN FILMES

Zusammenfassung—Der mittlere Wärmeübergangskoeffizient im Randbereich eines adsorptiv kontrollierten, benetzenden Filmes, dessen Trenndruck durch $P_d = -\bar{A} \cdot \delta^{-3}$ angenähert wird, kann durch $\bar{h} = h^{id}[1 - 0,5(\eta^{-1} + \eta^{-2})]$ wiedergegeben werden. h^{id} ist der ideale Wärmeübergangskoeffizient an der

Flüssigkeits-Dampf-Phasengrenzfläche, η ist eine Funktion der physikalischen Eigenschaften des Systems und der Ausdehnung des Randbereiches. Eine einfache Methode zur Ermittlung des Wärmeübergangskoeffizienten wird vorgestellt. Der Koeffizient wächst auf einer relativ kurzen Strecke von Null im Randbereich auf den an der Flüssigkeits-Dampf-Phasengrenzfläche gültigen Wert an.

КОЭФФИЦИЕНТ ТЕПЛОБМЕНА ИСПАРЯЮЩЕЙСЯ ПЛЕНКИ СМАЧИВАЮЩЕЙ ЖИДКОСТИ

Аннотация — Среднее значение коэффициента теплообмена при регулируемой абсорбцией испарения пленки смачивающей жидкости, когда величина расклинивающего давления аппроксимируется выражением $P_d = -A\delta^{-3}$, описывается соотношением $h = h^{id}[1 - 0,5(\eta^{-1} + \eta^{-2})]$, где h^{id} — идеальный коэффициент теплообмена на границе раздела жидкость—пар, а η — функция физических характеристик системы и величины прослойки жидкости. Дается простой метод получения коэффициента теплообмена. На относительно коротком расстоянии значение меняется от нуля на прослойке до величины, равной величине коэффициента теплообмена на границе раздела жидкость—пар.