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The effect of heat convection on drying of porous semi-infinite space

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Abstract—An analytical study is presented for rate processes, including change of phase for a semi-infinite porous substance exposed to a jump in external temperature. The model assumes two distinct regions separated by a moving interface where the change of phase takes place. One region maintains its initial concentration of liquid–solid volatiles while the second is devoid of them. Heat convection by the outflowing gaseous volatiles is accounted for, and its effect on the rate of evaporation and pressure build-up is illustrated for a case of water drying from a porous matrix.

INTRODUCTION

MOVING boiling fronts in porous media have been described by several authors in the past [1–11]. In a recent paper, Haber *et al.* [12] predicted the rate of water evaporation and pressure build-up for various non-dimensional thermophysical parameters of the porous medium. Their analysis relied upon the following basic assumptions: (a) two distinct regions exist which are separated by a moving interface where the change of phase takes place; (b) one region maintains its initial concentration of water while the second is devoid of it; (c) the process occurs at infinite kinetic rate; (d) heat flows through the medium by conduction only; (e) the vapor is compressible and obeys the ideal gas law; (f) Clapeyron equation relates between interface pressures and temperatures; (g) the evaporation–recondensation mechanism described in refs. [8, 9] is neglected; (h) diffusion mass fluxes due to concentration gradients and the Dufour and Soret effects were not accounted for.

It is the objective of this work to relax assumption (d) and to take into consideration the effect of heat convection by the vapor, as well as heat conduction, on the evaporation rate and pressure build-up. This effect was not rigorously solved for by previous authors. It was either avoided or accounted for by assuming an effective conductivity.

STATEMENT OF THE PROBLEM

A semi-infinite porous medium, initially at temperature T_i, is exposed to a high temperature T_0. Liquid starts boiling within the pores whenever the temperature reaches local boiling conditions. Two regions exist, which are separated by a distinct moving interface $s(t)$, where boiling occurs. Region 1 has the original liquid content, while region 2 is devoid of liquid. The gas, generated at the interface, flows through the porous material and convects heat in a direction opposite to the flux of conducted heat. The rate of gas flow is determined, on one hand, through Darcy's law (affected by the pressure gradient, the permeability of the porous material in region 2 and the viscosity of the gas), and on the other hand, through the flux of heat reaching the interface and the latent heat coefficient of the boiling liquid. These two mechanisms govern the sought rate of evaporation and pressure build-up.

MATHEMATICAL PRESENTATION

The governing field equations will be presented for two regions including the convection of heat by gas. For region 1, where no mass flow occurs, the flux of heat is determined by conduction only

$$\rho_1 C_1 \frac{\partial \tilde{T}}{\partial \tilde{t}} = K_1 \frac{\partial^2 \tilde{T}_1}{\partial \tilde{x}^2} \tag{1}$$

where ρ_1, C_1 and K_1 are the density, specific heat and the thermal conductivity, respectively. The tilde indicates henceforth a dimensional variable.

For region 2, heat is conducted from the boundary into the porous material while heat is convected in an opposite direction by the outflowing gas. Thus, the heat transfer equation is

$$\rho_2 C_2 \frac{\partial \tilde{T}_2}{\partial \tilde{t}} + \tilde{\rho}_G C_G \tilde{U}_G \frac{\partial \tilde{T}_2}{\partial \tilde{x}} = K_2 \frac{\partial^2 \tilde{T}_2}{\partial \tilde{x}^2} \tag{2}$$

for gas in local equilibrium with the matrix.

In the previous paper [12], the convection term was neglected. It is the goal of this paper to examine the error introduced by this assumption.

Mass conservation of gas in region 2 is given by

$$\varepsilon \frac{\partial \tilde{\rho}_G}{\partial \tilde{t}} + \frac{\partial (\tilde{\rho}_G \tilde{U}_G)}{\partial \tilde{x}} = 0 \tag{3}$$

where ε, $\tilde{\rho}_G$ and $\tilde{U}_G$ are the porosity of region 2, the gas density and the apparent velocity, respectively.

The momentum equation for gas flow inside porous media is given by Darcy's law, namely

$$\tilde{U}_G = -\frac{\Gamma}{\mu} \frac{\partial \tilde{P}_G}{\partial \tilde{x}} \tag{4}$$

NOMENCLATURE

a_1, a_2, a_3, a_4, a_5	coefficients, equation (13)
B_1, B_2, B_3, B_4	coefficients, equations (32) and (34)
C	specific heat
H	permeability parameter, equation (15b)
K_1, K_2	thermal conductivities
K	thermal conductivity ratio, K_1/K_2
L	latent heat
P	pressure
Q	porosity parameter, equation (15c)
R	gas constant
$s(t)$	instantaneous location of the interface
t	time
T	temperature
U_G	gas apparent velocity
x	coordinate, normal to surface.

Greek symbols

α	$\sqrt{(\alpha_1/\alpha_2)}$
α_1, α_2	thermal diffusivities
Γ	permeability
ε	porosity
γ	convection parameter, equation (15a)
η	similarity parameter, equation (14)
θ	$T_{cr} - T_s$
λ	interface locator parameter, equation (16)
μ	gas viscosity
ρ	density
ω	volume fraction of liquid.

Subscripts

cr	critical point
G	gas
i	initial
L	liquid
s	interface
1	region 1, with initial concentration of volatiles
2	region 2, devoid of volatiles
0	external, ambient.

Superscript

$\tilde{}$	dimensional variable.

where $\tilde{P}_G$, μ and Γ are the local pressure, the gas viscosity and the matrix permeability, respectively.

To complete this set of equations, we assume the gas to behave ideally

$$\tilde{\rho}_G = \frac{\tilde{P}_G}{R\tilde{T}_2}. \tag{5}$$

INITIAL CONDITIONS

Initially, temperature and liquid content are uniform at the entire half space, i.e.

$$\begin{aligned} \tilde{T}_1(\tilde{x}, 0) &= T_i \\ \omega_1(\tilde{x}, 0) &\equiv \omega \end{aligned} \tag{6}$$

where T_i is the initial temperature and ω is the initial volume fraction of the liquid. This volume fraction is assumed to remain constant in region 1 throughout the drying process while region 2 becomes completely devoid of liquid.

BOUNDARY CONDITIONS

The temperature at the boundary of the half space is assumed to equal the external temperature for all times

$$\tilde{T}_2(0, \tilde{t}) = T_0. \tag{7}$$

The temperature profile across the interface $\tilde{x} = \tilde{s}(\tilde{t})$ is continuous

$$\tilde{T}_1(\tilde{s}, \tilde{t}) = \tilde{T}_2(\tilde{s}, \tilde{t}) \triangleq \tilde{T}_s \tag{8}$$

while the fluxes of heat due to conduction differ across the interface

$$-K_1 \frac{\partial \tilde{T}_1}{\partial \tilde{x}} = -K_2 \frac{\partial \tilde{T}_2}{\partial \tilde{x}} + \rho_L \omega L \frac{d\tilde{s}}{d\tilde{t}} \tag{9}$$

due to latent heat of evaporation.

Conservation of mass at $\tilde{x} = \tilde{s}(\tilde{t})$ yields

$$(\rho_L \omega - \tilde{\rho}_G \varepsilon) \frac{d\tilde{s}}{d\tilde{t}} = -\tilde{\rho}_G \tilde{U}_G. \tag{10}$$

A tacit boundary condition for region 1 is that the temperature retains its value far from the boundary, namely

$$\tilde{T}_1(\infty, \tilde{t}) = T_i \qquad \forall \tilde{t} > 0. \tag{11}$$

Two boundary conditions exist for the pressure field. At the porous medium boundary, the pressure is constant

$$\tilde{P}_G(0, \tilde{t}) = P_0 \qquad \forall \tilde{t} > 0. \tag{12}$$

At the moving interface the pressure is related to the temperature by the Clapeyron equation.

Strictly speaking the Clapeyron equation relates the pressure and temperature at equilibrium across a plane interface, where the vapor and the liquid pressures are identical. In capillaries there is a large difference between the pressure of the liquid and that of the vapor, however, the Clapeyron equation deviates only slightly for the vapor pressure. Since the vapor is driven by its pressure at the interface, the Clapeyron equation is suitable to describe the vapor temperature–pressure relation.

As a particular case we examine water evaporation. Integration of the Clapeyron equation for steam yields the following approximate relation [13] between the pressure and temperature at the interface.

$$\log_{10}\frac{P_{\mathrm{cr}}}{\tilde{P}_{\mathrm{s}}}=\frac{\tilde{\theta}}{\tilde{T}_{\mathrm{s}}}\,\frac{a_1+a_2\tilde{\theta}+a_3\tilde{\theta}^3+a_4\tilde{\theta}^4}{1+a_5\tilde{\theta}} \tag{13}$$

where

$$P_{\mathrm{cr}} = 221.1\ \mathrm{bar} = 22.11\ \mathrm{MPa}$$

$$T_{\mathrm{cr}} = 647.4\ \mathrm{K}$$

$$\tilde{\theta} = T_{\mathrm{cr}} - \tilde{T}_{\mathrm{s}}$$

$$a_1 = 3.34613$$

$$a_2 = 4.14113 \times 10^{-2}$$

$$a_3 = 7.515484 \times 10^{-9}$$

$$a_4 = 6.56444 \times 10^{-11}$$

$$a_5 = 1.3794481 \times 10^{-2}.$$

It should be emphasized that, by using an appropriate relation for the saturation pressure, the entire analysis is applicable to substances other than water.

SOLUTION

The partial differential equations, equations (1) and (2), can easily be transformed into ordinary differential equations, since a non-dimensional similarity coordinate η can be found

$$\eta = \frac{\tilde{x}}{2\sqrt{(\alpha_1 \tilde{t})}}$$

where α_1 is the thermal diffusivity of region 1.

Let us define the following non-dimensional variables

$$T_1(\eta) = \tilde{T}_1/T_0 \tag{14a}$$

$$T_2(\eta) = \tilde{T}_2/T_0 \tag{14b}$$

$$P(\eta) = \tilde{P}_{\mathrm{G}}/P_0 \tag{14c}$$

$$\rho(\eta) = \tilde{\rho}_{\mathrm{G}}/\rho_0 \tag{14d}$$

$$u(\eta) = -\tilde{U}_{\mathrm{G}}\sqrt{\tilde{t}}\Bigg/\left(\lambda\omega\frac{\rho_{\mathrm{L}}}{\rho_0}\sqrt{\alpha_1}\right) \tag{14e}$$

and parameters

$$\gamma = \frac{\rho_{\mathrm{L}}}{\rho_2}\frac{C_{\mathrm{G}}}{C_2}\omega \tag{15a}$$

$$H = \frac{2\alpha_1\omega\mu}{\Gamma P_0}\frac{\rho_{\mathrm{L}}}{\rho_0} \tag{15b}$$

$$Q = \sqrt{\pi}\omega\frac{L}{C_1 T_{\mathrm{i}}}\frac{\rho_{\mathrm{L}}}{\rho_1} \tag{15c}$$

$$\alpha = \sqrt{(\alpha_1/\alpha_2)} \tag{15d}$$

$$K = K_1/K_2 \tag{15e}$$

where ρ_0 and P_0 are the ambient gas density and pressure, respectively.

The motion of the interface is taken to be proportional to $\sqrt{(\alpha_1 \tilde{t})}$, namely

$$\tilde{s} = 2\lambda\sqrt{(\alpha_1 \tilde{t})}. \tag{16}$$

This functional form, for the propagation rate, will later be shown to conform with the field equations as well as the boundary conditions. Therefore, this form constitutes an acceptable solution. The parameter λ, named the 'interface locator'—must be solved together with the temperature and pressure fields. It is also introduced in equation (14e) to simplify the following non-dimensional equations.

Substituting equations (14)–(16) into equations (1)–(12), we obtain an equivalent set of five ordinary differential equations, equations (17)–(21), and their corresponding boundary conditions, equations (22)–(27)

$$T_1'' + 2\eta T_1' = 0 \qquad @\ \eta > \lambda \tag{17}$$

$$T_2'' + 2\alpha^2(\eta + \lambda\gamma\rho u)T_2' = 0 \qquad @\ \eta < \lambda \tag{18}$$

$$\left(\frac{\rho_0}{\rho_{\mathrm{L}}}\right)\left(\frac{\eta}{\lambda}\right)\rho' + (\rho u)' = 0 \qquad @\ \eta < \lambda \tag{19}$$

$$P' = \lambda H u \qquad @\ \eta < \lambda \tag{20}$$

$$\rho = \frac{P}{T_2} \qquad @\ \eta < \lambda \tag{21}$$

$$[T_1]_{\eta \to \infty} = \frac{T_{\mathrm{i}}}{T_0} \tag{22}$$

$$[T_2]_{\eta = 0} = 1 \tag{23}$$

$$[T_1]_{\eta = \lambda} = [T_2]_{\eta = \lambda} \tag{24}$$

$$\frac{1}{K}[T_1']_{\eta = \lambda} = [T_2']_{\eta = \lambda} - \frac{2}{\sqrt{\pi}}\frac{T_{\mathrm{i}}}{T_0}\lambda Q \tag{25}$$

$$1 - \left(\frac{\rho_0}{\rho_{\mathrm{L}}}\right)[\rho]_{\eta = \lambda} = [\rho u]_{\eta = \lambda} \tag{26}$$

$$[P]_{\eta = 0} = 1 \tag{27}$$

where primes denote differentiation with respect to η. Since ρ_0/ρ_{L} is of the order of 10^{-3} for a wide range of ambient temperatures and pressures, equations (19) and (26) can further be simplified to

$$[\rho u]' = 0 \qquad @\ \eta < \lambda \tag{28}$$

$$[\rho u]_{\eta = \lambda} = 1. \tag{29}$$

The general solution of equation (28) together with equation (29) yields

$$\rho u = 1 \tag{30}$$

for all $\eta < \lambda$.

Hence, the non-linear equation (18) simplifies to the form

$$T_2'' + 2\alpha^2(\eta + \lambda\gamma)T_2' = 0. \tag{31}$$

It should be noted, that the entire effect of the heat convection term can be attributed to the parameter γ defined in equation (15a). Indeed, the convection of heat by vapor is negligible only for low values of γ. It is also obvious from equation (31) that, by no means, can the convection contribution be lumped into a sort of an 'effective' conductivity coefficient.

The general solution for the temperature field in region 1 is

$$T_1 = B_1 + B_2 \operatorname{erfc}(\eta) \tag{32}$$

where

$$B_1 = T_i/T_0 \tag{33}$$

to satisfy boundary condition (22).

The general solution for the temperature field in region 2 is

$$T_2 = B_3 + B_4 \operatorname{erf}[\alpha(\eta + \lambda\gamma)] \tag{34}$$

where

$$B_3 = 1 - B_4 \operatorname{erf}(\alpha\lambda\gamma) \tag{35}$$

to satisfy boundary condition (23).

Introduction of equations (32) and (34) into equations (24) and (25) provides two additional equations for the unknown coefficients B_2 and B_4. Consequently, B_2 and B_4 can be determined as a function of the yet unknown λ parameter

$$B_2 = \frac{1 - \dfrac{T_i}{T_0}\left\{1 + Q\dfrac{K}{\alpha}\lambda\, e^{\lambda^2\alpha^2(1+\gamma)^2}[\operatorname{erf}(\alpha\lambda(1+\gamma)) - \operatorname{erf}(\alpha\lambda\gamma)]\right\}}{\operatorname{erfc}(\lambda) + \dfrac{K}{\alpha} e^{\lambda^2[\alpha^2(1+\gamma)^2 - 1]}[\operatorname{erf}(\alpha\lambda(1+\gamma)) - \operatorname{erf}(\alpha\lambda\gamma)]} \tag{36}$$

$$B_4 = \frac{1 - \dfrac{T_i}{T_0}[1 - Q\lambda\, e^{\lambda^2} \operatorname{erfc}(\lambda)]}{\dfrac{\alpha}{K}\operatorname{erfc}(\lambda)\, e^{\lambda^2[1-\alpha^2(1+\gamma)^2]} + \operatorname{erf}[\alpha\lambda(1+\gamma)] - \operatorname{erf}(\alpha\lambda\gamma)}. \tag{37}$$

Introduction of equations (21) and (30) into equation (20) results in a first-order differential equation for the pressure in region 2

$$PP' = \lambda H T_2. \tag{38}$$

After integrating equation (38) and utilizing equation (34) we obtain the pressure field in region 2

$$\begin{aligned} P^2 = 1 + 2\lambda H\langle B_3\eta + B_4\{(\eta + \lambda\gamma) \\ \times \operatorname{erf}[\alpha(\eta + \lambda\gamma)] - \lambda\gamma \operatorname{erf}(\alpha\lambda\gamma) \\ - \frac{1}{\sqrt{\pi}}\frac{1}{\alpha}[e^{-\alpha^2\lambda^2\gamma^2} - e^{-\alpha^2(\eta+\lambda\gamma)^2}]\}\rangle. \end{aligned} \tag{39}$$

The pressure at the interface is calculated from equation (39) and has the following form

$$\begin{aligned} P_s^2 = 1 + 2\lambda^2 H\langle 1 + B_4\{(\gamma+1)[\operatorname{erf}(\alpha\lambda(1+\gamma)) \\ - \operatorname{erf}(\alpha\lambda\gamma)] - \frac{1}{\sqrt{\pi}}\frac{1}{\alpha\lambda}[e^{-\alpha^2\lambda^2\gamma^2} \\ - e^{-\alpha^2\lambda^2(1+\gamma)^2}]\}\rangle \end{aligned} \tag{40}$$

where B_4 is given in equation (37). It is seen that the interface pressure remains constant at all times.

The interface temperature is also fixed for all times and can be derived either from equation (32) or equation (34), namely

$$T_s = \frac{T_i}{T_0} + B_2 \operatorname{erfc}(\lambda) \tag{41}$$

where B_2 is given in equation (36).

Hence, both P_s and T_s are determined explicitly as a function of only one unknown parameter λ and the given thermophysical parameters α, K, H, Q and T_i/T_0.

Introducing the expressions for the interface temperature, equation (41), and the interface pressure, equation (40), into the Clapeyron equation (13) we obtain a transcendental algebraic equation for λ. An explicit solution for λ was derived by a bi-section computer program for various values of γ with α_1/α_2, K_1/K_2, Q, H and T_0 as parameters for $T_i = 50°\text{C}$.

Notice, that only at this stage the explicit form of the Clapeyron equation was needed. Since equation (13) cannot be written in a non-dimensional form, no attempt was made to describe results as a function of the non-dimensional temperature ratio T_i/T_0, rather, we preferred to choose a conventional value for T_i and use T_0 as a parameter.

RESULTS AND DISCUSSION

The results presented herein assumed constant thermophysical properties of regions 1 and 2. Even though the properties may actually depend on temperature, the solution can be very useful in three counts:

(a) it provides the correct non-dimensional parameters of the drying problem,

(b) it serves as a first-order approximation for a porous pellet of mean thermophysical properties,

(c) it can be used as a limit case to check out numerical codes of the drying equation which account for temperature varying properties.

The interface pressure and temperature remain fixed through the entire drying process. This result coincides with the one obtained in refs. [7, 8, 12] where no convection effects were accounted for. Bazant *et al.* [11] present a numerical code which considers convection effects in an axisymmetric porous medium. They note that this effect is important for rapid heating, however, a direct comparison with their results cannot be made.

The effect of the convection parameter γ (ranging between 0 and 2) on the interface locator λ and the pressure build-up P_s at the interface for water evaporation, are shown in Figs. 1–10. Values of 0.1, 1.0 and 10 were selected for the parameters α_1/α_2, K_1/K_2, H and Q, and 200, 500 and 900°C for the external temperature T_0. The temperature T_i is fixed at 50°C.

A general trend is found for all figures: an increase in γ causes a decrease in λ and the pressure build-up. Indeed, the amount of heat conducted inward to the interface is reduced because of heat convected outward by vapor, resulting in a reduction of the evaporation rate.

Figures 1 and 2 demonstrate the effect of γ on λ and the pressure build-up for several external temperatures. A comparison of the $\gamma = 2$ case with the no-convection case ($\gamma = 0$) indicate a reduction of 30% in λ when $T_0 = 900°C$ and only 11% when $T_0 = 200°C$. Equivalently, the pressure reduces by 15% when $T_0 = 900°C$ and only by 2% when $T_0 = 200°C$.

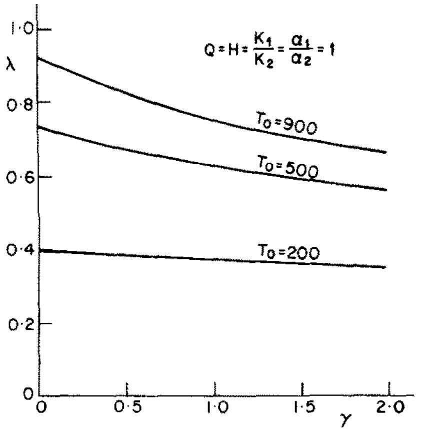

FIG. 1. Interface locator vs convection parameter for $T_0 = 900$, 500 and 200°C.

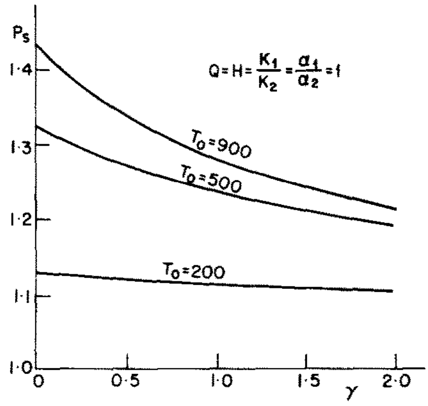

FIG. 2. Interface pressure vs convection parameter for $T_0 = 900$, 500 and 200°C.

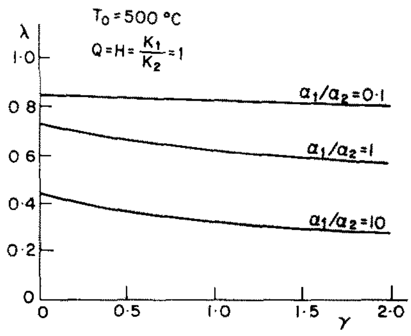

FIG. 3. Interface locator vs convection parameter for $\alpha_1/\alpha_2 = 0.1$, 1.0 and 10.

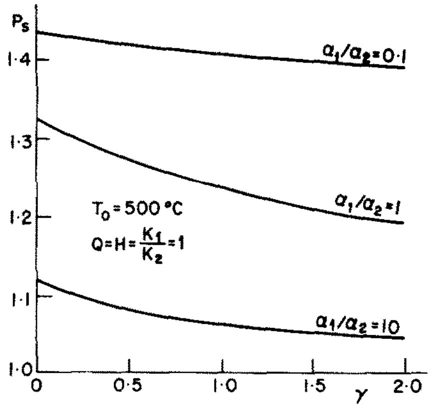

FIG. 4. Interface pressure vs convection parameter for $\alpha_1/\alpha_2 = 0.1$, 1.0 and 10.

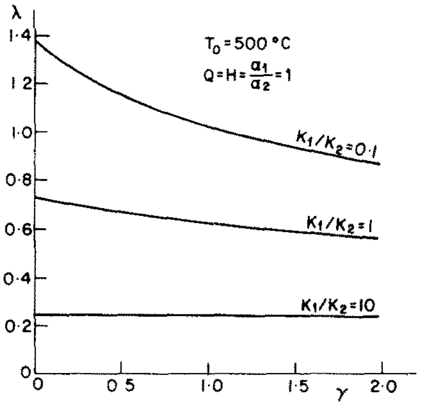

FIG. 5. Interface locator vs convection parameter for $K_1/K_2 = 0.1$, 1.0 and 10.

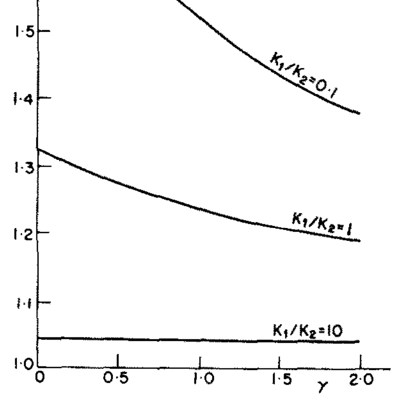

FIG. 6. Interface pressure vs convection parameter for $K_1/K_2 = 0.1$, 1.0 and 10.

Figures 3 and 4 show the effect of γ for various α_1/α_2 ratios. The foregoing comparison indicates a λ reduction of 40% for $\alpha_1/\alpha_2 = 10$ and a reduction of only 6% for $\alpha_1/\alpha_2 = 0.1$. Correspondingly, the pressure is reduced by 7% for $\alpha_1/\alpha_2 = 10$ and 3.5% for $\alpha_1/\alpha_2 = 0.1$.

Figures 5 and 6 illustrate the effect of γ for various K_1/K_2 ratios. They indicate a reduction of 38% in λ and 27% in P_s for $K_1/K_2 = 0.1$ and 6% in λ and only 0.5% in P_s for $K_1/K_2 = 10$.

Figures 7 and 8 depict the effect of γ for various values of the permeability parameter H. The above comparison indicates a reduction of 22% in λ and 20% in P_s for $H = 10$ and 25% in λ and only 2% in P_s for $H = 0.1$.

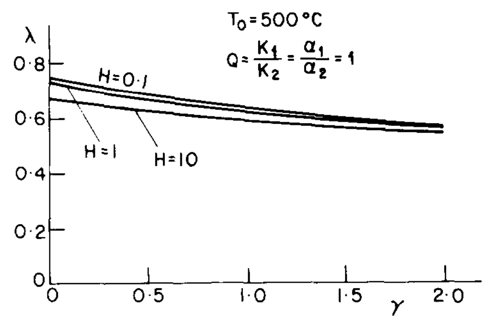

FIG. 7. Interface locator vs convection parameter for $H = 0.1$, 1.0 and 10.

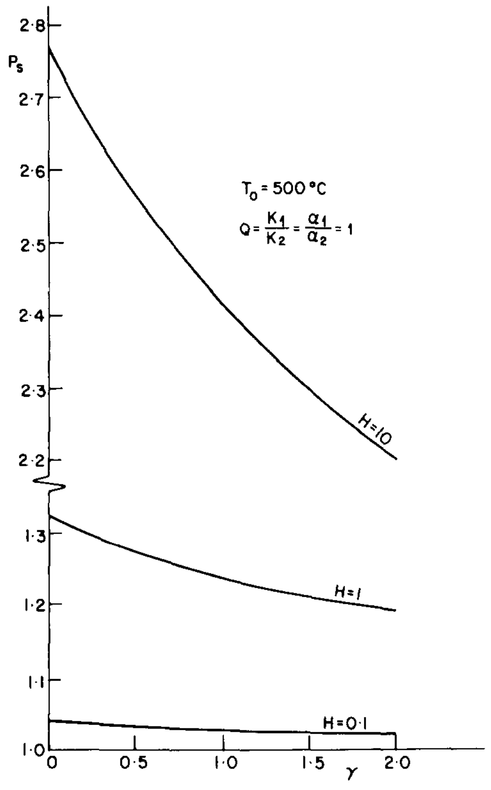

FIG. 8. Interface pressure vs convection parameter for $H = 0.1$, 1.0 and 10.

Figures 9 and 10 show the effect of γ for various values of the porosity parameter Q. The comparison of λ and P_s values at $\gamma = 2$ with the corresponding values at $\gamma = 0$ (no-convection case) manifest that λ is reduced by 32% and P_s by 18% for $Q = 0.1$, while only 8% reduction in λ and 1% in P_s is noticed for $Q = 10$.

The following conclusions may be drawn:

(1) The interface locator λ may be significantly affected by the convection parameter γ. Variation up to 40%, compared with the no-convection solution, can be observed especially for high values of α_1/α_2 and T_0, and for low values of K_1/K_2 and Q.

(2) At the range of low values of α_1/α_2 and T_0 or high values of K_1/K_2 and Q the convection effect may be completely neglected.

(3) Moreover, it can be seen that the effect of convection is insensitive to variation in the permeability parameter H.

(4) The effect of convection on the pressure build-up is less pronounced reaching up to 18% for the studied range of parameters.

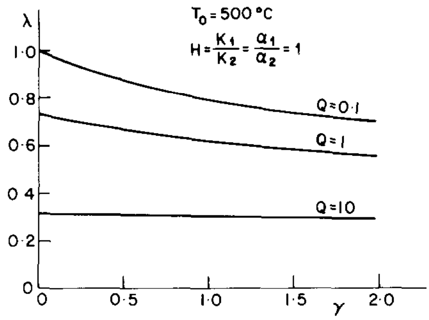

FIG. 9. Interface locator vs convection parameter for $Q = 0.1$, 1.0 and 10.

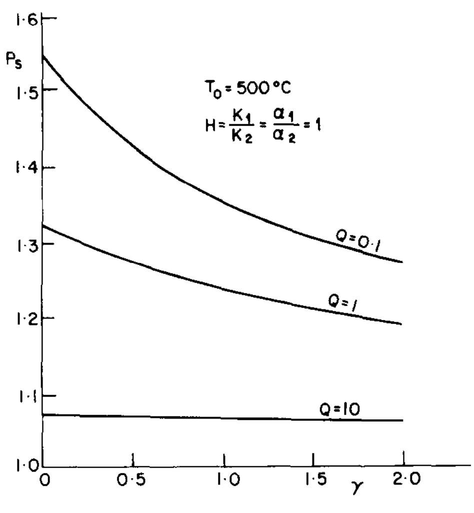

FIG. 10. Interface pressure vs convection parameter for $Q = 0.1$, 1.0 and 10.

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EFFET DE LA CONVECTION THERMIQUE SUR LE SECHAGE D'UN MILIEU POREUX SEMI-INFINI

Résumé—On présente un étude analytique de la vitesse du mécanisme, incluant le changement de phase pour une substance poreuse semi-infinie exposée à un saut de température externe. Le modèle suppose deux régions distinctes séparées par une interface mobile où se fait le changement de phase. Une région conserve sa concentration initiale de liquide tandis que l'autre en dévie. La convection thermique par les vapeurs gazeuses sortantes est prise en compte et son effet sur le taux d'évaporation et la montée de pression est illustré pour un cas d'eau s'évaporant d'une matrice poreuse.

DER KONVEKTIONSEINFLUSS AUF DAS AUSTROCKNEN EINES PORÖSEN HALBUNENDLICHEN RAUMES

Zusammenfassung—Eine analytische Untersuchung über Prozesse wird vorgestellt, bei denen Phasenänderungen in einem halbunendlichen porösen Stoff vorkommen, ausgelöst durch eine sprunghafte Änderung der Umgebungstemperatur. Im Modell werden zwei getrennte Gebiete mit wandernder Grenzfläche betrachtet, in der der Phasenwechsel vonstatten geht. Das eine Gebiet behält seine Anfangskonzentration von verdunstungsfähigen, flüssigen oder festen Bestandteilen bei, während das zweite diese überhaupt nicht enthält. Die Konvektion wird durch das Ausströmen von gasförmigen flüchtigen Bestandteilen erklärt. Ihr Einfluß auf die Verdampfungsrate und den Druckaufbau wird für den Fall gezeigt, daß Wasser aus einer porösen Matrix austrocknet.

ВЛИЯНИЕ ТЕПЛОВОЙ КОНВЕКЦИИ НА СУШКУ ПОРИСТОГО ПОЛУБЕСКОНЕЧНОГО ТЕЛА

Аннотация—Проведено аналитическое исследование быстрых процессов, включающих фазовые превращения в полубесконечном пористом теле при скачкообразном изменении температуры окружающей среды. Модель основана на предположении о существовании двух областей, разделенных подвижной границей, на которой происходит изменение фазы. Концентрация летучих жидкой или твердой фазы в одной области постоянна, а в другой равна нулю. Учитывается тепловая конвекция летучих веществ в газовой фазе и показано ее влияние на скорость испарения воды и рост давления при сушке пористой матрицы.