HEAT AND MASS TRANSFER IN A POROUS PLATE PLACED IN FLUID FLOW

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The transfer of heat and moisture in an infinite porous plate in contact with moving fluid has been investigated in this paper. The equations of internal heat and mass transfer in the porous medium have been solved in conjunction with the flow and energy equations of the fluid taking into account the frictional heating. The fluid has been taken to be incompressible and the motion is assumed to have started impulsively. The problem has been solved with the help of Laplace transform and solutions for small and large values of time have been obtained. The effect of Eckert number and conjugation parameter $k/\sqrt{a}$ has been exhibited graphically.

NOMENCLATURE

t = temperature (°C)

θ = moisture transfer potential (°M)

v = fluid velocity (m/h)

x = length coordinate perpendicular to direction of flow (m)

τ = time (h)

L = width of the porous plate (m)

$Lu = am_2/aq_2$ = Luikov number

$K_0 = \rho \dfrac{cm_2}{cq_2}(\theta_{20}-\theta_p)/(t_{10}-t_{20})$ = Kossovich number

$Pn = \delta_s(t_{10}-t_{20})/(\theta_{20}-\theta_p)$ = Posnov number

$Bim = \alpha_m \,.\, L/\lambda_m$ = Biot number for mass transfer

$Pr = \nu/aq_1$ = Prandtl number

$E = \nu^2/cq_1(t_{10}-t_{20})$ = Eckert number

$F_0 = aq_2 \,.\, \tau/L^2$ = Fourier number (non-dimensional time)

$T = \dfrac{t-t_{20}}{t_{10}-t_{20}}$ = non-dimensional temperature

$\Theta = (\theta_{20}-\theta)/(\theta_{20}-\theta_p)$ = non-dimensional mass transfer potential

λq = thermal conductivity (k cal/m deg ch)

λm = moisture conductivity coefficient (kg$/mhM$)

γ = the density of porous skeleton (kg$/m^3$)

μ = dynamic viscosity (kg$/mh$)

ν = kinematic viscosity (m^2/h)

C_q = specific heat capacity of the moist-porous body (k cal/kg °C)
C_m = specific isothermal mass capacity
a_q = thermal diffusivity coefficient
a_m = moisture diffusivity coefficient
ρ = specific heat of evaporation
δ = thermal gradient coefficient
δ_s = Soret coefficient
α_m = mass transfer coefficient
ϵ = coefficient of moisture internal evaporation
θ_p = equilibrium value of mass transfer potential
$k = \lambda_{q_1}/\lambda_{q_2}$ = ratio of the two conductivities.
$a = aq_1/aq_2$ = ratio of the two diffusivities.
$K_0(x)$ = modified Bessel function of zeroth order and 2nd kind.

Subscripts

1 = fluid
2 = porous plate
0 = initial value

Introduction

Luikov and Mikhailov (1965*a*, *b*) have considered a variety of problems of heat and mass transfer with boundary conditions of first, second and third kind. However, in some cases, for example in problems of heat and mass transfer where the surrounding atmosphere is in motion, the boundary conditions at the interface between the solid and the surrounding fluid are not known *a priori* but depend upon coupled conduction-convection mechanism. In such a case, the flow and energy equations of the fluid have to be solved in conjunction with the heat and mass transfer equations in the porous medium with appropriate matching conditions at the interface.

In the field of simultaneous unsteady heat and mass transfer in capillary-porous bodies Kumar and Narang (1966) introduced this concept in their problem of drying a moist capillary-porous body in moving air. In that problem of idealized nature they took the porous medium as semi-infinite. In practical cases, however, the case of infinite geometry is less realistic and so we have in our present problem treated the case of heat and mass transfer in a porous plate (finite width) (Fig. 1), surrounded by infinitely extended fluid, geometry being complementary to that considered by Kumar and Balkrishan (1966). Problem like this, find wide applications in the process of drying in chemical technology.

The flow and energy equations of the fluid, taking into account the frictional heating, have been solved in conjunction with heat and mass transfer equations in the porous body with continuity conditions at the interface.

The problem has been solved with the help of Laplace transform and asymptotic solutions have been presented as the exact solution is quite complicated to obtain. Some numerical results showing the effect of Eckert number and conjugation parameter $k/\sqrt{a}$ have been exhibited graphically.

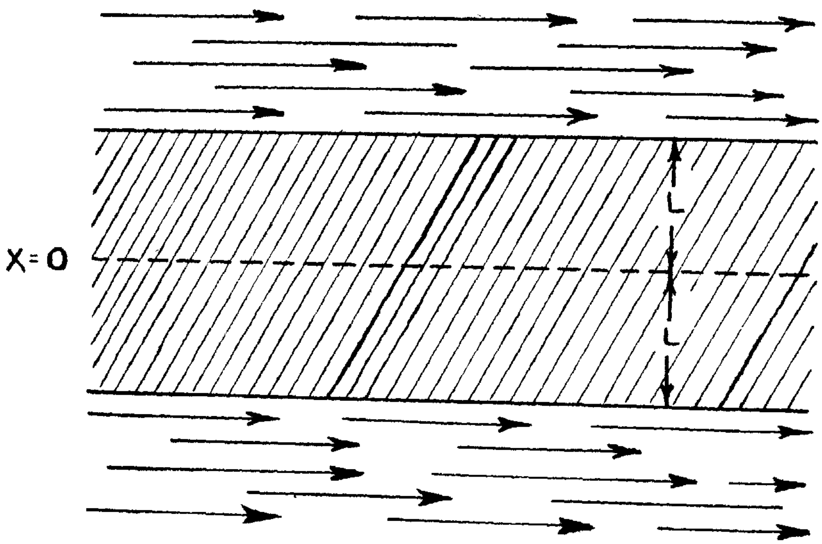

FIG. 1. Sketch of the geometry analysed in this problem.

THE PROBLEM

Taking into account the symmetry, the problem may be mathematically formulated in the non-dimensional form as

$$\frac{\partial T_2}{\partial F_0} = \frac{\partial^2 T_2}{\partial X^2} - \epsilon K_0 \frac{\partial \Theta_2}{\partial F_0}$$

$$\frac{\partial \Theta_2}{\partial F_0} = Lu \frac{\partial^2 \Theta_2}{\partial X^2} - Lu\, Pn \frac{\partial^2 T_2}{\partial X^2}, \quad (0 < X < 1,\, F_0 > 0)$$

$$\frac{\partial V}{\partial F_0} = a \,.\, Pr \,.\, \frac{\partial^2 V}{\partial X^2}$$

$$\frac{\partial T_1}{\partial F_0} = a \frac{\partial^2 T_1}{\partial X^2} + Pr \,.\, E \,.\, a \,.\left(\frac{\partial V}{\partial X}\right)^2, \quad (X > 1,\, F_0 > 0).$$

[F_0 is the Fourier number (non-dimensional time)].

Initially

$$\left.\begin{array}{l} T_2 = 0 \\ \Theta_2 = 0 \end{array}\right\} \quad 0 < X < 1$$

$$\left.\begin{array}{l} T_1 = 1 \\ V = 1 \end{array}\right\} \quad X > 1.$$

Boundary conditions at $X = 1$,

$$T_1 = T_2$$

$$\frac{\partial T_2}{\partial X}+(1-\epsilon)\, Lu\, K_0\, Bim\, (1-\Theta_2) = k\frac{\partial T_1}{\partial X}$$

$$-\frac{\partial \Theta_2}{\partial X}+Pn\frac{\partial T_2}{\partial X}+Bim\,(1-\Theta_2) = 0$$

$$V = 0.$$

Symmetry conditions at $X = 0$,

$$\frac{\partial T_2}{\partial X} = 0$$

$$\frac{\partial \Theta_2}{\partial X} = 0.$$

Solution of the Problem

Applying Laplace transform (Carslaw and Jaeger 1959), taking into account initial conditions, solving the resulting equations, taking into account the transformed boundary conditions, we get the transformed non-dimensional temperature $\overline{T}_2$, mass transfer potential $\overline{\Theta}_2$, in the porous plate and non-dimensional transformed temperature $\overline{T}_1$, in the fluid. The expressions of these quantities are quite lengthy and involve the hyperbolic sine and cosine functions. Though, in principle, there is no difficulty in finding the exact inversion of these expressions but practically it is extremely difficult and cumbersome to go in for it and hence we have resorted here to finding the asymptotic solutions for large and small values of time (Carslaw and Jaeger 1948) which are given below.

Solution for Large Values of Time

Expanding in power series, the various hyperbolic functions involved, resorting to some algebraic manipulations, keeping the terms only up to $p^{3/2}$ and inverting term by term thereafter, we get

$$T_2 = H_1+\frac{H_2}{\sqrt{\pi}F_0}-\frac{H_4}{2\sqrt{\pi}F_0^{3/2}}+\frac{3H6}{4\sqrt{\pi}F_0^{5/2}}$$

where H_1, H_2, etc., are given by the following expressions:

$$H_n = \frac{1}{c_1}\left[r_n-\frac{c_2}{c_1}r_{n-1}+\left\{\left(\frac{c_2}{c_1}\right)^2-\left(\frac{c_3}{c_1}\right)\right\}r_{n-2}+\dots\right]$$

$$(n = 1, 2, 4, 6)$$

where

$$r_n = a_n + b_n + \frac{X^2}{2!}(a_{n-2}\nu_1^2 + b_{n-2}\nu_2^2) + \frac{X^4}{4!}(a_{n-4}\nu_1^4 + b_{n-4}\nu_2^4),$$

$$(n = 1, 2, 3, \ldots 6)$$

$$a_1 = -K[(1+2M')Z_2 + Bim]$$

$$a_2 = \nu_2^2[Y_2 - Bim]$$

$$a_3 = -\nu_2^2[K(1+2M')X_2 - \tfrac{1}{2}a_1]$$

$$a_4 = \frac{\nu_2^2}{3!}[a_2]$$

$$a_5 = -\frac{\nu_2^4}{3!}[K(1+2M')X_2 - \tfrac{1}{4}a_1]$$

$$a_6 = \frac{\nu_2^4}{5!}[a_2]$$

and b_i can be obtained from a_i by taking first the negative sign and then by changing ν_1 to ν_2 wherever it occurs.

c_i are composed of two terms, namely

$$c_i = c_{i1} - c_{i2},$$

where c_{i2} is nothing but c_{i1} with v_1 and v_2 interchanged and

$$c_{11} = -KZ\nu_1^2$$

$$c_{21} = \nu_1^2 X_{12}$$

$$c_{31} = K\nu_1^2\left[X_1 - \frac{\nu_1^2}{2!}Z\right]$$

$$c_{41} = \nu_1^2\left[\frac{-\nu_1^2\nu_2^2}{\epsilon X_0} + \left(\frac{\nu_2^2}{2!} + \frac{\nu_1^2}{3!}\right)(X_{12} - Z_2)\right]$$

$$c_{51} = K\nu_1^2\left[\frac{-\nu_1^2\nu_2^2}{2!\,\epsilon K_0} + \frac{1}{3!}\nu_1^2 X_1 - \frac{1}{4}Z\left(\frac{\nu_1^4+\nu_2^4}{3!} + \nu_1^2\nu_2^2\right)\right]$$

$$c_{61} = \nu_1^2\left[\frac{-\nu_1^4\nu_2^2}{3!\,\epsilon K_0} + \frac{1}{3!}\cdot\frac{1}{2!}\left(\frac{\nu_1^4}{10} + \frac{\nu_2^4}{2} + \nu_1^2\nu_2^2\right)(X_{12} - Z_2)\right]$$

$$t_{11} = M'c_{11}$$

$$t_{21} = \nu_1^2[(Z_2 - X_{12})(1+M') - Y_1 + Bim]$$

$$t_{31} = \nu_1^2\left[KM'X_1 + \frac{t_{11}}{2!}\right]$$

$$t_{41} = \left[(1+M')\frac{\nu_1^4\nu_2^2}{\epsilon K_0} + \left(\frac{\nu_2^2}{2!} + \frac{\nu_1^2}{3!}\right)t_{21}\right]$$

$$t_{51} = \left[KM'\nu_1^2 X_1\left(\frac{\nu_2^2}{2!} + \frac{\nu_1^2}{3!}\right) + \left(\frac{\nu_1^4+\nu_2^4}{4!} + \frac{\nu_1^2\nu_2^2}{2!\,.\,2!}\right)t_{11}\right]$$

$$t_{61} = \left[(1+M')\frac{\nu_1^6\nu_2^2}{\epsilon K_0} + \left(\frac{\nu_2^4}{4!} + \frac{\nu_1^2\nu_2^2}{3!\,.\,2!} + \frac{\nu_1^4}{5!}\right)t_{21}\right].$$

The quantities X_i, Y_i, Z_i, Z, M', K, X_{ij}, etc., ($i = 1, 2$; $j = 1, 2$) introduced above are given by the following expressions:

$$X_i = \left[\frac{(1-\nu_i^2)}{\epsilon K_0}+Pn\right]$$

$$X_{ij} = Lu\ Bim\ (1-\nu_i^2)\left(\frac{1-\epsilon}{\epsilon}\right)X_i$$

$$Y_i = Lu\ K_0\ Bim\ (1-\epsilon)X_i$$

$$M' = EM/\pi$$

$$K = k/\sqrt{a}$$

$$Z = Bim/\epsilon K_0$$

$$Z_i = Z(1-\nu_i^2)$$

$$M = \frac{1}{\sqrt{1-2/Pr}} \log\left\{\frac{1+\sqrt{1-2/Pr}}{\sqrt{2/Pr}}\right\} \qquad (Pr > 2)$$

$$= \frac{1}{\sqrt{2/Pr-1}} \cos^{-1}\left(\sqrt{Pr/2}\right) \qquad (Pr < 2).$$

Similarly

$$\Theta_2 = I_1+\frac{I_2}{\sqrt{\pi}F_0}-\frac{I_4}{2\sqrt{\pi}F_0^{3/2}}+\frac{3I_6}{4\sqrt{\pi}F_0^{5/2}}$$

where I_i ($i = 1, 2, \ldots, 6$) can be obtained from the expressions of H_i ($i = 1, 2, \ldots, 6$) by replacing r_1 with S_1, r_2 with S_2, ..., r_6 with S_6 respectively. Also S_i can be obtained from the expressions of r_i ($i = 1, 2, \ldots, 6$) by replacing a_i with $-a_i\left(\frac{1-\nu_1^2}{\epsilon K_0}\right)$ and b_i with $-b_i\left(\frac{1-\nu_2^2}{\epsilon K_0}\right)$ respectively wherever they occur.
And

$$T_1 = J_1+\frac{J_2}{\sqrt{\pi}F_0}-\frac{J_4}{2\sqrt{\pi}F_0^{3/2}}+\frac{3J_6}{4\sqrt{\pi}F_0^{5/2}}+G$$

where J_i ($i = 1, 2, \ldots, 6$) can be obtained from H_i ($i = 1, 2, \ldots, 6$) by replacing r_1 with w_1, r_2 with w_2, ... and r_6 with w_6 respectively and where

$$w_n = t_n+\left(1+\frac{EM}{\pi}\right)c_n+\sum_{m=1}^{5}\left\{-\frac{X-1}{\sqrt{a}}\right\}^m\frac{t^{n-m}}{m!}$$

where t_i involved in the above expressions have already been defined.
Also

$$G = \frac{E\,.\,Pr^{1/2}}{2\pi}\int_0^{F_0}\frac{e^{-\frac{(X-1)^2}{2a\{Pr(F_0-\tau)+2\tau\}}}}{\sqrt{(F_0-\tau)\{Pr(F_0-\tau)+2\tau\}}}\,\text{erfc}\left(\frac{-(X-1)\sqrt{Pr(F_0-\tau)}}{2\sqrt{a\tau\{Pr(F_0-\tau)+2\tau\}}}\right)d\tau.$$

Solution for Small Values of Times

The non-dimensional temperature T_2 and mass transfer potential Θ_2, for small values of time F_0, are given as

$$T_2 = \frac{A_1}{r} P_1 - \frac{A_2}{r} P'_1 + \frac{B_1}{r} P_2 - \frac{B_2}{r} P'_2 - \frac{C_1}{r} P_3 + \frac{C_2}{r} P'_3$$

where

$$P_1 = \begin{bmatrix} e^{\nu_2(1-X)\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{\nu_2(1-X)}{2\sqrt{F_0}} + \alpha\sqrt{F_0}\right\} \\ -e^{\{2\nu_1+\nu_2(1-X)\}\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{2\nu_1+\nu_2(1-X)}{2\sqrt{F_0}} + \alpha\sqrt{F_0}\right\} \\ +e^{\nu_2(1+X)\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{\nu_2(1+X)}{2\sqrt{F_0}} + \alpha\sqrt{F_0}\right\} \\ -e^{\{2\nu_1+\nu_2(1+X)\}\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{2\nu_1+\nu_2(1+X)}{2\sqrt{F_0}} + \alpha\sqrt{F_0}\right\} \end{bmatrix}$$

$$P_2 = \begin{bmatrix} \frac{1}{\alpha} \operatorname{erfc}\left\{\frac{\nu_2(1-X)}{2\sqrt{F_0}}\right\} - \frac{1}{\alpha} e^{\nu_2(1-X)\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{\nu_2(1-X)}{2\sqrt{F_0}} + \alpha\sqrt{F_0}\right\} \\ +\frac{1}{\alpha} \operatorname{erfc}\left\{\frac{\nu_2(1+X)}{2\sqrt{F_0}}\right\} - \frac{1}{\alpha} e^{\nu_2(1+X)\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{\nu_2(1+X)}{2\sqrt{F_0}} + \alpha\sqrt{F_0}\right\} \end{bmatrix}$$

$$P_3 = \begin{bmatrix} \frac{1}{\alpha} \operatorname{erfc}\left\{\frac{2\nu_1+\nu_2(1-X)}{2\sqrt{F_0}}\right\} - \frac{1}{\alpha} e^{\{2\nu_1+\nu_2(1-X)\}\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{2\nu_1+\nu_2(1-X)}{2\sqrt{F_0}}\right\} \\ +\frac{1}{\alpha} \operatorname{erfc}\left\{\frac{2\nu_1+\nu_2(1+X)}{2\sqrt{F_0}}\right\} - \frac{1}{\alpha} e^{\{2\nu_1+\nu_2(1+X)\}\alpha+\alpha^2 F_0} . \operatorname{erfc}\left\{\frac{2\nu_1+\nu_2(1+X)}{2\sqrt{F_0}}\right\} \end{bmatrix}$$

and P'_1, P'_2, P'_3 can be obtained from P_1, P_2, P_3 respectively by interchanging ν_1 and ν_2.

Also

$$A_i = K(1+2M')\nu_i X_i$$

$$B_i = K[(1+2M')Z_i + Bim] - \nu_i Y_i + \nu_i \, Bim$$

$$C_i = -K[(1+2M')Z_i + Bim] - \nu_i Y_i + \nu_i \, Bim$$

$$S = \nu_1 X_{12} - \nu_2 X_{21} + \nu_2 Z_1 - \nu_1 Z_2$$

$$r = K[\nu_1 X_1 - \nu_2 X_2] + \frac{\nu_1 \nu_2}{\epsilon K_0}(\nu_2^2 - \nu_1^2)$$

$$\alpha = S/r.$$

The expression for Θ_2 is similar to T_2 except that we have to replace in T_2, the coefficients A_1/r, B_1/r, C_1/r by $-A_1/r . \left(\frac{1-\nu_2^2}{\epsilon K_0}\right)$, $-B_1/r . \left(\frac{1-\nu_2^2}{\epsilon K_0}\right)$, $-C_1/r . \left(\frac{1-\nu_2^2}{\epsilon K_0}\right)$ and A_2/r, B_2/r, C_2/r by $-A_2/r . \left(\frac{1-\nu_1^2}{\epsilon K_0}\right)$, $-B_2/r . \left(\frac{1-\nu_1^2}{\epsilon K_0}\right)$, $-C_2/r . \left(\frac{1-\nu_1^2}{\epsilon K_0}\right)$ respectively.

The non-dimensional fluid temperature T_1, for small values of time, is given by the expression:

$$T_1 = 1+\frac{M_1}{r}\cdot\frac{1}{\alpha}\cdot\text{erfc}\left\{\frac{X-1}{2\sqrt{aF_0}}\right\}$$
$$+\frac{1}{r}\left(L_1-\frac{1}{\alpha}M_1\right)e^{\frac{X-1}{\sqrt{a}}\cdot\alpha+\alpha^2F_0}\cdot\text{erfc}\left(\frac{X-1}{2\sqrt{aF_0}}+\alpha\sqrt{F_0}\right)$$
$$+\frac{M_2}{r}\cdot\frac{1}{\alpha}\cdot\text{erfc}\left(\frac{X-1}{2\sqrt{aF_0}}+\frac{\nu_1}{\sqrt{F_0}}\right)$$
$$+\left(\frac{L_2}{r}-\frac{1}{\alpha}\frac{M_2}{r}\right)e^{\left(2\nu_1+\frac{X-1}{\sqrt{a}}\right)\alpha+\alpha^2F_0}\cdot\text{erfc}\left(\frac{\nu_1}{\sqrt{F_0}}+\frac{X-1}{2\sqrt{aF_0}}+\alpha\sqrt{F_0}\right)$$
$$+\frac{M_3}{r}\cdot\frac{1}{\alpha}\cdot\text{erfc}\left(\frac{\nu_2}{\sqrt{F_0}}+\frac{X-1}{2\sqrt{aF_0}}\right)$$
$$+\left(\frac{L_3}{r}-\frac{1}{\alpha}\frac{M_3}{r}\right)e^{\left(2\nu_2+\frac{X-1}{\sqrt{a}}\right)\alpha+\alpha^2F_0}\cdot\text{erfc}\left(\frac{\nu_2}{\sqrt{F_0}}+\frac{X-1}{2\sqrt{aF_0}}+\alpha\sqrt{F_0}\right)$$
$$+\frac{M_4}{r}\cdot\frac{1}{\alpha}\cdot\text{erfc}\left(\frac{\nu_1+\nu_2}{\sqrt{F_0}}+\frac{X-1}{2\sqrt{aF_0}}\right)$$
$$+\left(\frac{L_4}{r}-\frac{1}{\alpha}\frac{M_4}{r}\right)e^{\left(2\nu_1+2\nu_2+\frac{X-1}{\sqrt{a}}\right)\alpha+\alpha^2F_0}\cdot\text{erfc}\left(\frac{\nu_1+\nu_2}{\sqrt{F_0}}+\frac{X-1}{2\sqrt{aF_0}}\right)+G$$

where

$$L_1 = K_1-K_2+K_3$$
$$L_2 = -[K_1+K_2+K_3]$$
$$L_3 = K_1+K_2-K_3$$
$$L_4 = -K_1+K_2+K_3$$
$$M_1 = -K'_1+K'_2+K'_3-K'_4+K'_5$$
$$M_2 = K'_1+K'_2-K'_3-K'_4+K'_5$$
$$M_3 = -K'_1-K'_2+K'_3+K'_4+K'_5$$
$$M_4 = -K'_1+K'_2+K'_3-K'_4+K'_5$$

and where

$$K_i = KM'\nu_iX_i, \quad \text{where } i = 1, 2$$
$$K_3 = (1+M')\frac{\nu_1\nu_2}{\epsilon K_0}(\nu_1^2-\nu_2^2)$$
$$K'_i = \nu_i[Y_i-Bim], \quad \text{where } i = 1, 2$$
$$K'_3 = \nu_1(1+M')[Z_2-X_{12}]$$

K'_4 is obtained by interchanging ν_1 and ν_2

$$K'_5 = KM'Z(\nu_2^2-\nu_1^2)$$

and the other quantities like α and G involved have already been defined.

Numerical Results and Discussion

The non-dimensional temperature T_2 and mass transfer potential Θ_2, at the interface ($X = 1$), have been graphically exhibited at Figs. 2 to 7 for

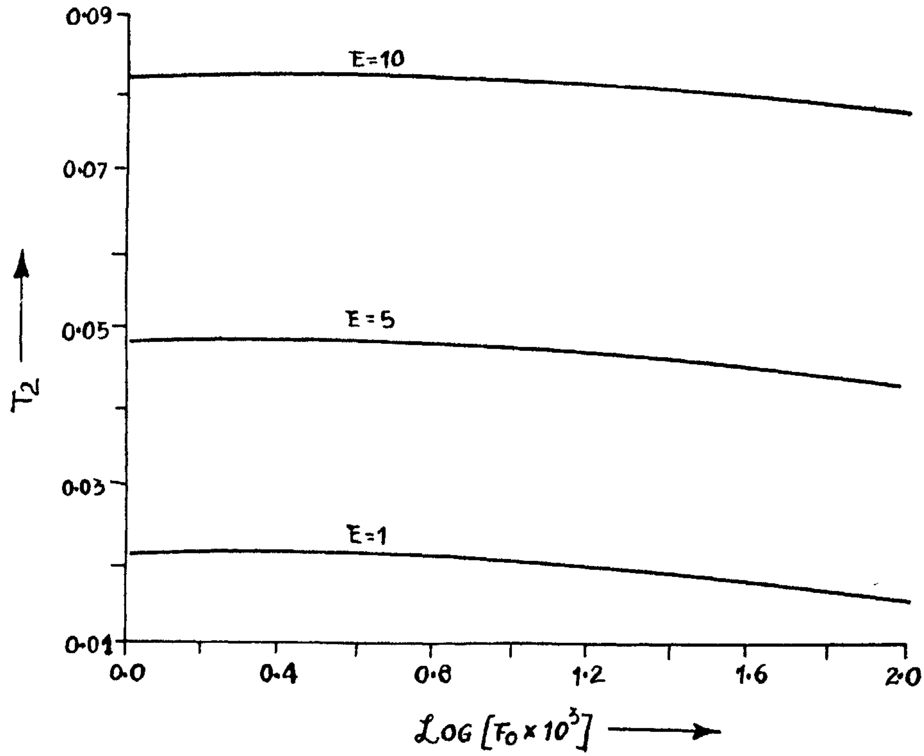

Fig. 2. Variation of non-dimensional interface temperature with non-dimensional time (small values of time) for various values of Eckert number.

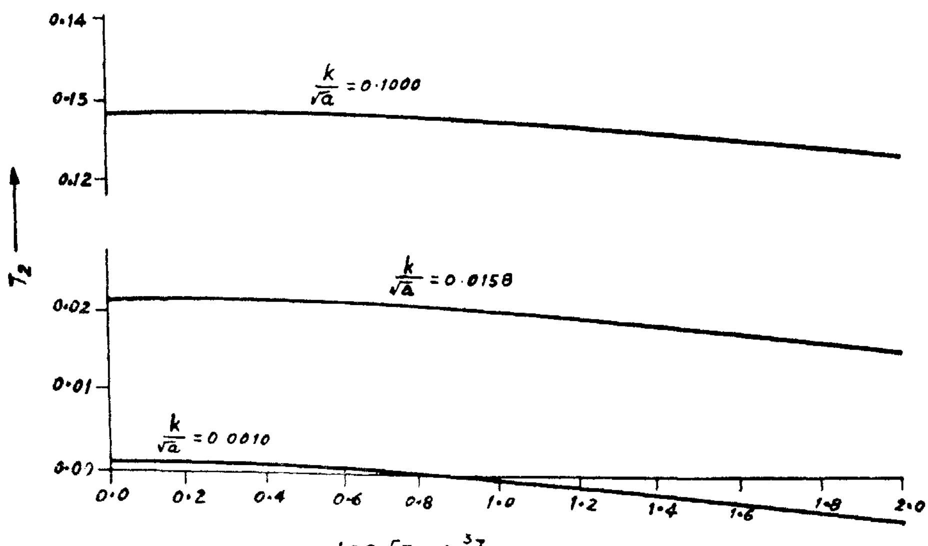

Fig. 3. Variation of non-dimensional interface temperature with non-dimensional time (small values of time) for various values of $k/\sqrt{a}$.

various values of the Eckert number E and conjugation parameter $k/\sqrt{a}$. This we have done for both small and large values of time and the following set of values of non-dimensional parameters were chosen for numerical work.

$$Lu = 0{\cdot}2, \quad K_0 = 1{\cdot}2, \quad Pn = 0{\cdot}5$$
$$Pr = 0{\cdot}7, \quad Bim = 0{\cdot}1, \quad \epsilon = 0{\cdot}5.$$

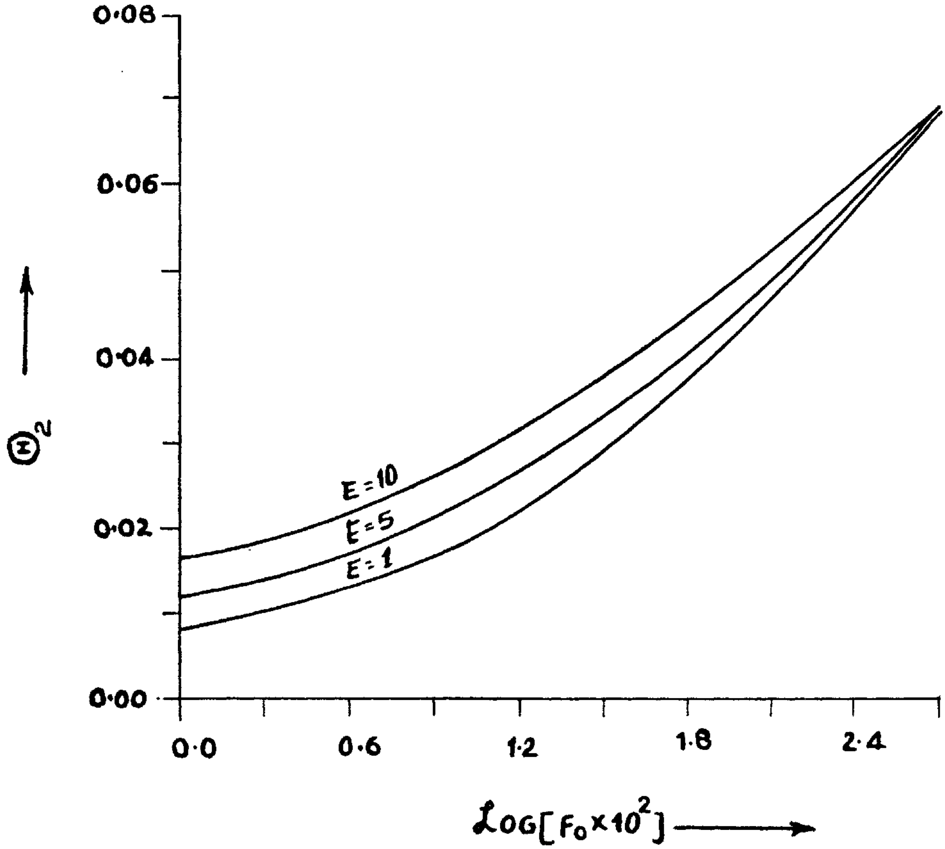

FIG. 4. Variation of non-dimensional interface mass transfer potential with non-dimensional time (for small values of time) for various values of Eckert number.

Figures 2 and 3 exhibit the variation of non-dimensional temperature T_2 at the interface ($X = 1$) with non-dimensional time F_0 (small values of time) for various values of Eckert number E and conjugation parameter $k/\sqrt{a}$ respectively. In Fig. 2 it can be seen that for a fixed value of E, T_2 decreases with F_0. This can be explained on account of the fact that in the initial stages, some heat is conducted in the porous body and also some amount is used up for evaporation of incoming liquid at the interface and as the heat source (frictional heating) in the fluid is fixed, therefore, the heat content of the porous body decreases with the result the temperature at the interface decreases. Also it is seen that for a fixed F_0, T_2 increases with E. This can be interpreted by the fact that E being the measure of heat source (heat produced due to frictional heating to the heat conducted in the fluid), the increase in the value of this number would naturally raise the interface temperature.

In Fig. 3, it is seen that T_2, for a fixed $k/\sqrt{a}$, decreases with F_0. Also for a fixed F_0, T_2 increases with $k/\sqrt{a}$. This can be explained on account of the fact that for a fixed ratio of the heat diffusivities of the fluid and the porous plate (i.e. fixed a), the increase in $k/\sqrt{a}$ means that more of heat is transferred per unit time to the porous body from the fluid, resulting thus in the increase of the porous body temperature and hence that of the interface.

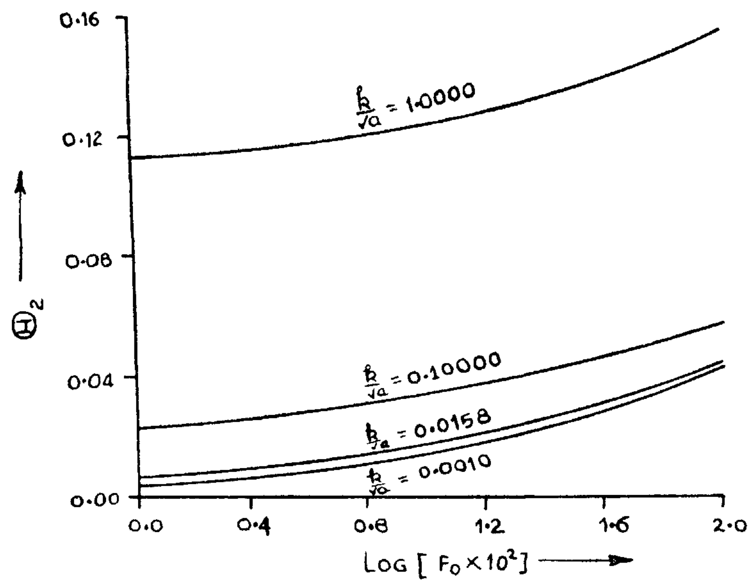

FIG. 5. Variation of non-dimensional interface mass transfer potential with non-dimensional time (small values of time) for various values of $k/\sqrt{a}$.

Figures 4 and 5, similarly show the variation of non-dimensional mass transfer potential Θ_2 with non-dimensional time F_0 (small values of time) for various values of E and $k/\sqrt{a}$ respectively. In Fig. 4, it can be seen that Θ_2 increases with F_0 and with E. The increase of Θ_2 with F_0 means the decrease in the actual interface mass transfer potential Θ_2' with time. This can also be explained by the fact that as time passes the moisture in the porous plate decreases and hence the moisture or mass transfer potential at the interface also decreases. The same type of trend can be seen in Fig. 5 also. The difference lies in the fact that the increase in Θ_2 with F_0 (for fixed $k/\sqrt{a}$) is not that sharp as was in the previous case and also the increase in Θ_2 with

$k/\sqrt{a}$ (for fixed F_0) is more pronounced as compared to the increase of Θ_2 with E in the previous case.

Figures 6 and 7 show the variation of interface non-dimensional temperature T_2 with time F_0 (for large values of time) for various values of E and $k/\sqrt{a}$ respectively. In Fig. 6, as can be seen, T_2 increases both with

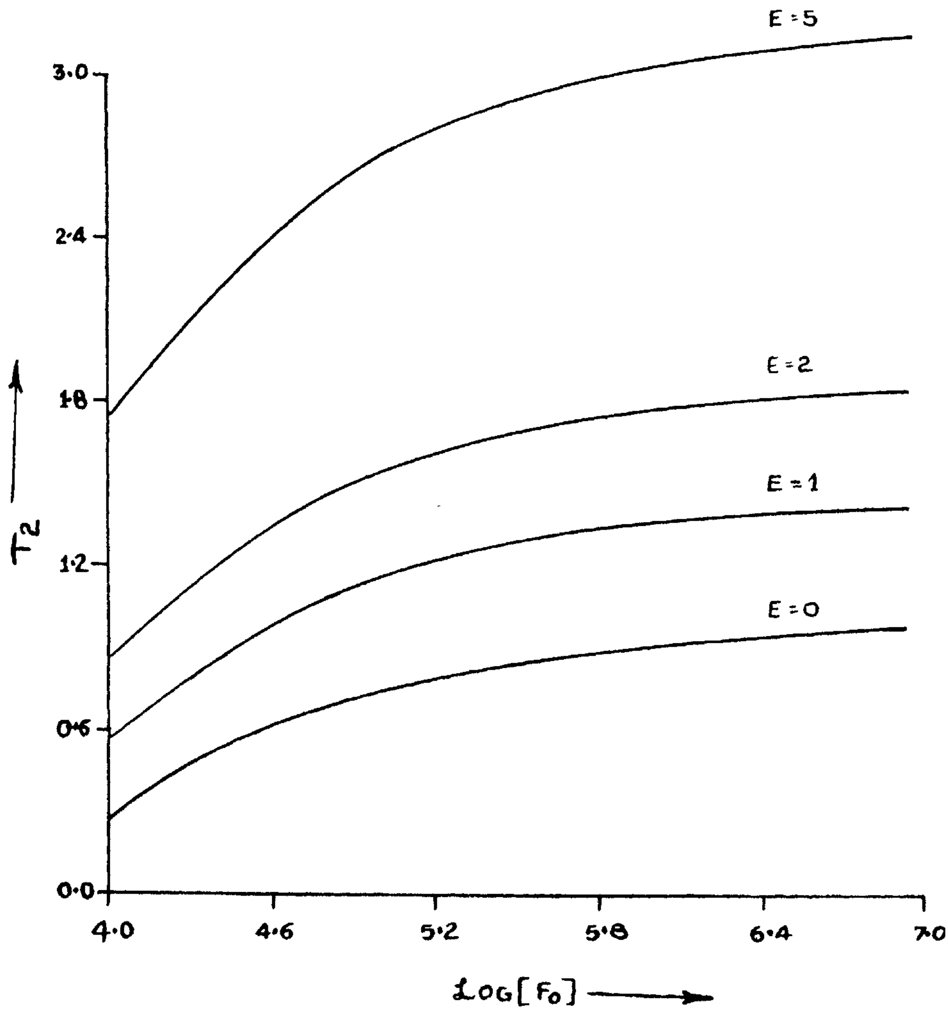

FIG. 6. Variation of non-dimensional interface temperature with non-dimensional time (large values of time) for various values of Eckert number.

F_0 and E till a steady state is reached. A similar type of behaviour is indicated in Fig. 7 except that the increase in T_2 for a fixed $k/\sqrt{a}$ is quite sharp with time. The graph for the variation of Θ_2 against time F_0 at the interface (for large values of time) for various values of E or $k/\sqrt{a}$ has not been given here as it comes out from the calculations that Θ_2 reaches the equilibrium value very quickly and in fact much earlier than the temperature does so.

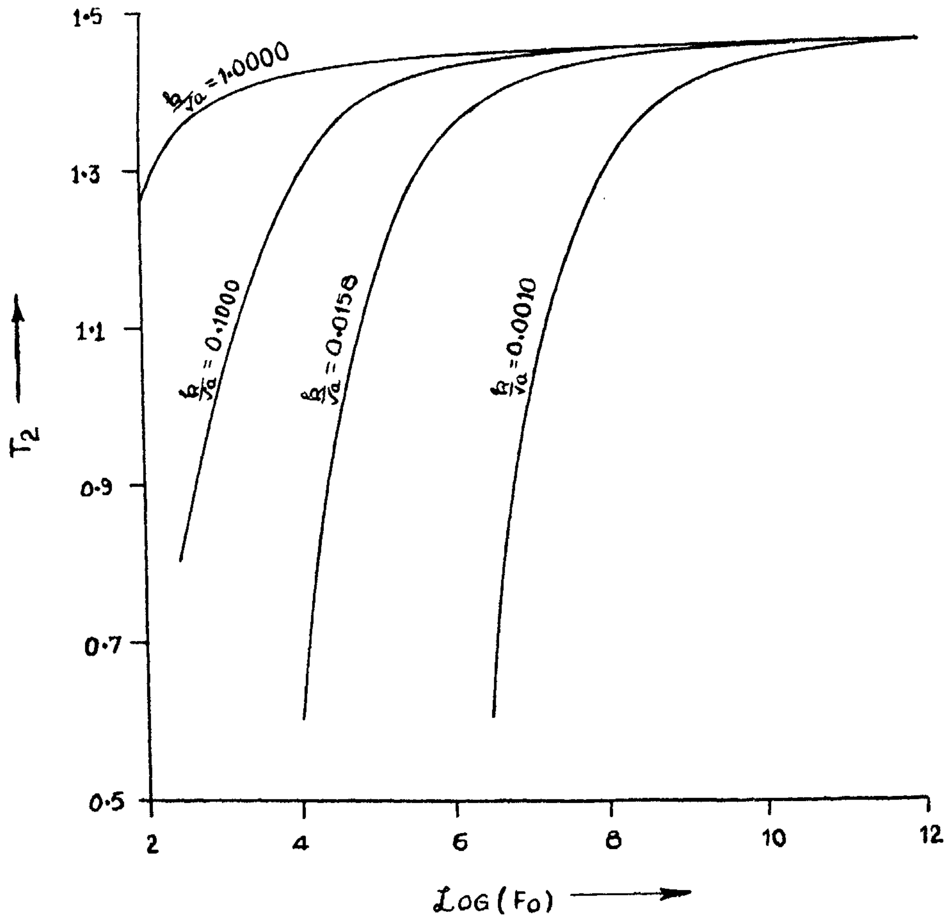

FIG. 7. Variation of non-dimensional interface temperature with non-dimensional time (large values of time) for various values of $k/\sqrt{a}$.

Comparison with the Previous Results

The present results have been compared with the results of Kumar and Narang (1966) who discussed a similar problem for the semi-infinite Geometry of the porous body. Results for small values of time both in case of T_2 and Θ_2 (Figs. 2, 4) have the same behaviour. However, there is found to be a marked difference for large values of time. In their case the temperature T_2 at the interface ultimately approaches a negative value but in our case the ultimate (steady value) is positive, i.e. in their case the interface was ultimately cooled whereas in our case it gets ultimately heated up. This can be explained on account of the fact that in their case the porous body being of a semi-infinite shape, a continuous flow of moisture was present even for large values of time. The evaporation at the surface produced, therefore, the observed cooling at the interface. In the case of finite thickness of the porous body discussed here the moisture flow is present only for a short time, therefore, the body and hence the interface gets heated up once again (Fig. 6) after the initial cooling (Fig. 2).

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