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AUTHORITY

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AUTHOR: Zadikoy, I. N.

TITLE: Some exact solutions of the energy equation for a plane parallel flow of a viscous incompressible fluid

PERIODICAL: Inzhenerno-fizicheskiy zhurnal, v. 5, no. 10, 1962, 3 - 8

TEXT: The boundary value problem

$$\frac{1}{a}\frac{\partial T}{\partial t} = \frac{\partial^2 T}{\partial y^2} + \frac{\mu}{\lambda}\frac{U_0^2}{h^2},$$

$$T(y, 0) = T_0 + \frac{\mu U_0^2}{2\lambda}\frac{y}{h}\left(1 - \frac{y}{h}\right), \qquad (3)$$

$$T(0, t) = T_0, \quad T(h, t) = T_1.$$

is solved by the expression

$$\Theta = \eta + S\eta(1-\eta) + \frac{2}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^n}{n}\sin(\pi n\eta)\exp(-\pi^2 n^2\beta),$$

Card 1/3 (4),

where $\Theta = (T - T_0)/(T_1 - T_0)$, $\beta = at/h^2$, $\eta = y/h$, and $S = (PrE)/2 = \mu U_0^2/2\lambda(T_1 - T_0)$. It is shown that for $S > 1$ the cooling of the wall ceases at $\beta_{cr} = vt_{cr}/h^2$ and that its heating is due to the dissipation energy of the fluid. The figure illustrates the dependence of β_{cr} on S (the indices 1 and 2 refer to the steady and to the unsteady flow, respectively). For an unsteady flow, the temperature distribution is obtained only for $Pr \gg 1$,

$$\Theta = \eta + S\eta(1-\eta) + (2/\pi)\sum_{n=1}^{\infty}(-1)^n\sin(\pi n\eta)\exp(-\pi^2 n^2\beta)/n -$$

$$(8/\pi^3)S\sum_{n=1}^{\infty}(2n-1)^{-3}\sin\left[(2n-1)\pi\eta\right]\exp\left[-\pi^2(2n-1)^2\beta\right], \qquad (6)$$

and for $Pr \ll 1$,

Card 2/3

$$\Theta = \eta + \frac{2}{\pi}\sum_{k=1}^{\infty}\frac{(-1)^k}{k}\sin(\pi k\eta)\exp(-\pi^2 k^2\beta) +$$

$$+ S\left\{(\eta - \eta^2)\left[1 + 2\exp(-2\pi^2\alpha)\right] + \frac{8}{\pi^2}\exp(-\pi^2\alpha)(1 - \cos\pi\eta) - \right. \qquad (7).$$

$$\left. \frac{16}{\pi^2}\eta\exp(-\pi^2\alpha) + \frac{1}{\pi^2}(\cos 2\pi\eta - 1)\exp(-2\pi^2\alpha)\right\}.$$

Equation (6) can be used to calculate the temperature distribution in a lubricant ($Pr \gg 1$) which takes up the play between the crank journal and the bearing when rapid changes occur in the rpm of the shaft. There are 3 figures.

ASSOCIATION: Gosudarstvennyy universitet imeni M. V. Lomonosova, g. Moskva (Moscow State University imeni M. V. Lomonosov)

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Card 3/3