HEAT FLOW IN A MOVING SOLID CYLINDER

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A transient state problem of heat transfer in a solid cylinder moving with a uniform speed in the direction of its length is considered mathematically. The cylinder is taken to be of infinite length and is maintained initially at a constant temperature θ_o. The method of Laplace and the finite Hankel transform has been used to obtain the solution. Numerical results for the solution in the positive region are exhibited graphically for two different values of the velocity.

A steady state problem of heat transfer in a cylinder moving along its axis with a constant velocity has been considered by Carslaw and Jaegar[1] under simple boundary conditions of constant temperature. Other problems on heat conduction in a moving medium have been dealt with by Owen[2], Somers[3] and Benfield[4]. The object of the present investigation is to study a corresponding transient state problem of a moving cylinder by considering the radiation boundary conditions at the surface. The cylinder is considered to be of infinite length to ignore the end effects. It has been assumed to be initially at a constant temperature θ_o. In the region $z<0$, radiation is taking place into a medium at constant temperature θ_o, while in the positive region it is radiating heat into an atmosphere of zero temperature. Such a boundary condition is suggested by some metallurgical problems relating to manufacture of metallic bars. The solution of the problem for both the regions has been obtained by the application of the Laplace transform and the finite Hankel transform. Numerical results for the temperature distribution in the positive region are obtained for two different values of the velocity and are exhibited graphically for various values of r. As should be expected the results for the region $z<0$ are of interest only for very small values of z.

STATEMENT OF THE PROBLEM

Let us consider the heat flow in a cylinder moving with a uniform velocity u and initially held at a constant temperature θ_o. Let the cylinder be radiating heat into the surrounding media at temperature θ_o and zero, in the regions $z<0$ and $z>0$ respectively.

The equation of heat flow appropriate to the problem is

$$\frac{\partial \theta}{\partial t} + u \frac{\partial \theta}{\partial z} = k \left[\frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial \theta}{\partial r} \right) + \frac{\partial^2 \theta}{\partial z^2} \right], \qquad 0<r<a; \; -\infty<z<\infty; \; t>0 \tag{1}$$

The initial and the boundary conditions are

$$\theta = \theta_o, \; t = 0 \tag{2}$$

$$K \frac{\partial \theta}{\partial r} + H(\theta - \theta_o) = 0, \qquad r = a; \; z<0; \; t>0 \tag{3}$$

$$K \frac{\partial \theta}{\partial r} + H\theta = 0, \qquad r = a; \; z>0; \; t>0 \tag{4}$$