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THE RATE OF HEAT TRANSFER COEFFICIENT AT THE LOWER AND UPPER WALLS

S. SREEDHAR*

**Asst. Professor, Dept. of Applied Mathematics,
GITAM Institute of Science, GITAM University, Visakhapatnam. (A.P.), India.**

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ABSTRACT

This theoretical study of the rate of Heat transfer coefficient at the lower and upper walls have some practical applications to many diversified areas like geophysical flows, aero-space science, in particular aero-dynamic heating and in the problems of engineering applications such as MHD generators, Hall accelerators and in thermo-nuclear power reactors etc. The governing differential equations are solved analytically, using the prescribed boundary conditions in both phases and obtained exact solutions. Numerical calculations of the resulting solutions are performed and by varying the various physical parameters Hartmann number Ha, Hall parameter m, viscosity ratio , height ratio h, thermal conductivity ratio on the behavior of heat transfer when all the remaining governing parameters are held fixed.

INTRODUCTION

The current interest in using Magnetohydrodynamic principle to analyses the effects of influence of the uniform magnetic field on the motion of an electrically conducting fluid (liquid and gas) and its associated heat transfer aspects in two-fluid flow system with varied conditions and of different geometrical situations is an active area of research in many diversified fields; in view of its geophysical, astrophysical, astronautically, also various engineering and technological importance. The theory of heat transfer plays an important role in many design problems in aeronautical, chemical, civil, electrical, and metallurgical and mechanical engineering. Typical applications include design of thermal and nuclear power plants, heat engines, catalytic converters, heat shields for space vehicles, furnaces, electronic components (against overheating), etc.

FORMULATION OF THE BASIC ENERGY EQUATIONS WITH BOUNDARY CONDITIONS

Using the fully developed two-fluid flow as already obtained in chapter 2, the effect of the flow parameters on the fluid's temperature and the heat transferred between the fluid and the walls has been considered here. Further, assuming that the thermal boundary conditions apply everywhere on the infinite channel walls and neglecting the thermal conduction in the flow direction, the governing energy equation in two regions (that is, for the fluids in upper and lower regions) becomes

Region-I:

$$\rho_1 u_1 c_{p_1}\frac{\partial T_1}{\partial x}+\rho_1 w_1 c_{p_1}\frac{\partial T_1}{\partial z}=\frac{c_{p_1}\mu_1}{P_r}\frac{\partial^2 T_1}{\partial y^2}+\mu_1\left[\left(\frac{\partial u_1}{\partial y}\right)^2+\left(\frac{\partial w_1}{\partial y}\right)^2\right]+\frac{J_1^2}{\sigma},$$

Region-II:

$$\rho_2 u_2 c_{p_2}\frac{\partial T_2}{\partial x}+\rho_2 w_2 c_{p_2}\frac{\partial T_2}{\partial z}=\frac{c_{p_2}\mu_2}{P_r}\frac{\partial^2 T_2}{\partial y^2}+\mu_2\left[\left(\frac{\partial u_2}{\partial y}\right)^2+\left(\frac{\partial w_2}{\partial y}\right)^2\right]+\frac{J_2^2}{\sigma},$$

Corresponding Author: S. Sreedhar*
Asst. Professor, Dept. of Applied Mathematics,
GITAM Institute of Science, GITAM University, Visakhapatnam. (A.P), India.

The isothermal boundary and interface conditions on temperature for both fluids are given

$$T_1(h_1) = T_{w_1},$$
$$T_2(-h_2) = T_{w_2},$$
$$T_1(0) = T_2(0),$$

The rate of heat transfer coefficient at the upper wall $(Nu_1) = -\left(\frac{d\theta_1}{dy}\right)$ at y = 1.

The rate of heat transfer coefficient at the lower wall $(Nu_2) = \frac{1}{\beta h}\left(\frac{d\theta_2}{dy}\right)$ at y = -1.

Solutions of the Problem:

Exact solutions of the governing differential equations with the help of boundary and interface conditions for the primary and secondary velocities u_1, u_2, w_1 and w_2 respectively.

The numerical values of the expressions given at equations and computed for different sets of values of the governing parameters involved in the study and these results are presented graphically from figures 1 and 2, also discussed in detail.

RESULTS AND DISCUSSION

The problem of two-fluid heat transfer flow of electrically conducting fluids in channels under the influence of an applied transverse magnetic field with consideration of Hall Effect between two parallel walls is investigated analytically, in two cases. Rate of heat transfer $Nu_1$and Nu_2 for both fluids in two cases i.e. when the walls are made up of non-conducting and conducting materials. Corresponding computational values for various sets of values of the governing parameters involved are determined to represent them graphically and are as shown in figs.1 to 2.

The rate of heat transfer coefficients at both the walls against the Hartmann number are shown in figs.1 and 2. It is concluded that, an increase in Hartmann number is to increase the rate of heat transfer coefficients, when all the remaining governing parameters are held fixed.

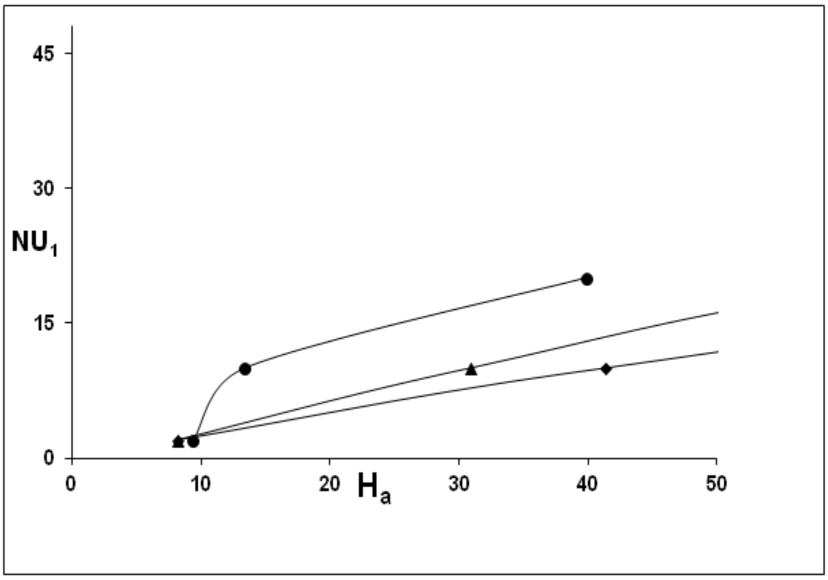

Figure-1: Nusselt Number (Nu_1) for different H_a and α = 0.333, $\sigma_0 = 2$, $\sigma_1 = 1.2$, $\sigma_2 = 1.5$, β = 1, h = 0.8, s = 0.5.

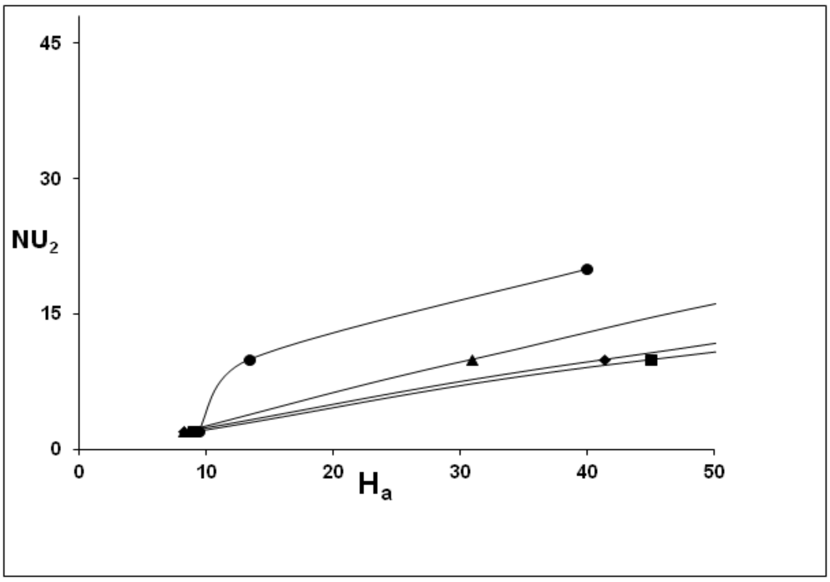

Figure-2: Nusselt Number (Nu_2) for different H_a and a $\alpha = 0.333$, $\sigma_0=2$, $\sigma_1=1.2$, $\sigma_2 = 1.5$, $\beta = 1$, $h = 0.8$, s = 0.5.

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