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OPTIMIZATION OF HEAT TRANSFER IN TWO AND THREE-DIMENSIONAL MFD BOUNDARY LAYERS

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ABSTRACT

This research study is concerned with the optimization of heat transport in the boundary layers of two-dimensional (2D) and three-dimensional (3D) multi-function displays, also known as MFDs. The ability of MFDs to dissipate heat is an important design consideration because excessive heat can cause a decline in performance as well as a shorter lifespan. This work will evaluate several heat transfer enhancement techniques, such as surface modifications, flow control strategies, and cooling mechanisms, for both 2D and 3D MFD boundary layers through a mix of numerical simulations and experimental observations. These techniques include: surface modifications; flow control strategies; and cooling mechanisms. The findings will help in the development of effective thermal management systems, which will ensure maximum MFD performance and longevity.

Keywords: *three-dimensional MFD, heat transfer*

INTRODUCTION

There are currents in the natural world that are brought by not only by differences in temperature but also by variances in concentration. These changes in the rate of mass transfer do have an effect on the rate of heat transmission. The combined buoyancy effect of thermal diffusion and diffusion through chemical species is responsible for many of the many transport processes that take place in industrial settings. These processes include the simultaneous transfer of heat and mass. In businesses that rely heavily on chemical processing, such as food processing and polymer synthesis, the phenomena of heat and mass transfer occurs quite frequently. The process of free convection flow, which involves the coupled transport of heat and mass, occurs frequently in nature. The fluctuations in temperature and concentration that occur inside the fluid serve as the source of the driving forces that cause this movement. For instance, variations in the concentration of water vapour can have an effect on thermal convection in the atmosphere, which occurs when the sun warms the earth and causes the surface temperature to rise. Because of its wide range of potential applications, magnetohydrodynamics has captured the interest of a significant number of academics in recent years. It has applications in the fields of astrophysics and geophysics, such as the study of stellar and solar structures, interstellar matter, radio propagation through the ionosphere, and other topics. In the field of engineering, it is used in things like MHD pumps and MHD bearings, among other things. In liquid-metals, electrolytes, and ionized gases, the study of the effects of magnetic field on free convection flow is an important research topic. Power engineering and metallurgy are two fields that find the thermal physics of hydromagnetic problems with mass transport to be interesting. In addition, there are a variety of engineering applications that call for combined heat and mass movement, such as humidifiers, dehumidifiers, desert coolers, chemical reactors, and other similar devices. Consideration of a typical moving continuous surface is the approach taken in the majority of investigations into these phenomena.

Numerous writers, including Vedhanayagam et al., Martynenko et al., Kolar et al., Ramanaiah et al., and Camargo et al., have conducted substantial research on the topic of free convection flow in the vicinity of a vertical plate or surface under a variety of situations. Researchers Soundalgeker, Revankar, Soundalgeker et al., Das et al., Muthukumaraswamy et al., and Panda et al. have investigated free convection flow with mass transfer that occurs past a vertically moving plate. There have been a lot of people working on hydromagnetic natural convection flow across a vertical surface under a variety of situations. Some of these people include Revankar, Anwar, Sahoo, and others.In-depth research into the effects of heat and mass transfer on a free convection flow near an infinite vertical porous plate has been conducted by Takhar et al., Hossain et al., Israel et al., Sahoo et al., Ali, Chaudhary, and Jain. Their findings have been published in a number of scholarly journals. However, the majority of them approached the problem using numerical solutions. As a result, it would appear that the solution to this problem that is based on analysis will be of more interest.Das refined the problem further recently by thinking about how the magnetic effect affects free convection flow when there is heat radiation present.

The purpose of the current investigation is to analyze the effect of heat and mass transfer on the unsteady free convection flow of a viscous, electrically conducting, incompressible fluid near an infinite vertical plate embedded in porous medium that moves with time dependent velocity under the influence of a uniform magnetic field that is applied normal to the plate. Through the application of the Laplace transform technique, one can obtain a general precise solution to the governing partial differential equation. In addition to that, this general solution is used to take into consideration several significant exceptions to the flow: (i) motion of the plate with a constant velocity; (ii) motion of the plate with a single acceleration; and (iii) motion of the plate with periodic acceleration.

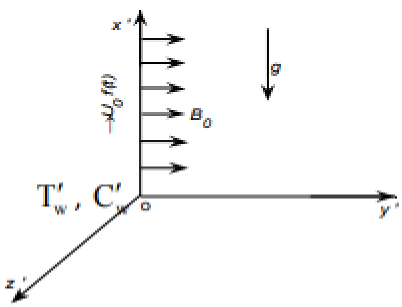

Fig.1 A diagrammatic representation of the issue together with the coordinate system

Formulation of the problem

Let us analyze the unsteady free convection and mass transfer flow of a viscous incompressible and electrically conducting fluid over an infinite non-conducting vertical flat plate (or surface) via a porous material in the presence of a uniform transverse magnetic field B0 put on this plate. The fluid in question is electrically conducting, and it is incompressible and viscous. On this plate, an arbitrary location has been chosen as the origin of a Cartesian coordinate system, with the -axis running along the plate in the direction that is upward and the -axis being normal to the plate (Fig.1).

At first, and for a period of time $t' \le 0$ Both the plate and the fluid are kept at the same temperature during the entire process T'_∞ under conditions where there is no change to the concentration of the species C'_∞ at all points. Subsequently $(t' > 0)$. It is assumed that the plate has a velocity and is moving at an increasing rate. $U_0 f(t')$ Instantaneously, both the temperature of the plate and the concentration are elevated to their respective maximums along the x′-axis in their own plane. x'-axis, Both the temperature of the plate and the concentration shoot up to in a millisecond. T'_w and C'_w respectively, which are going to be treated as constants from here on out.

In addition, for the free convection flow, we presume the following things to be true: (i) All the physical parameters of the fluid, including its coefficient of viscosity (μ),viscosity as measured by the kinematic coefficient (ν), temperature at a pressure that is held constant (C_P), conductance to heat or cold (κ), coefficient of volumetric expansion due to thermal volume (β^*_T), the ratio of the volumetric expansion coefficient to the concentration (β^*_C),The chemical molecule diffusivity (D), as well as other properties, do not change. (ii) The influence that differences in density have (ρ) according to the conventional Boussinesq approximation ([6],[11]), temperature) and species concentration are only included on the body force term of the equation.(iii) In the energy equation, the term owing to viscous dissipation can be omitted in comparison to the conducting term ([4], [6]). This is because the viscous dissipation term is smaller than the conducting term.(iv) The thermal-diffusion (Soret) and diffusion thermal (Dufour) effects in the energy equation and in the concentration equation can be omitted because it is often assumed that the level of concentration in free convection flows is relatively low ([6]). These effects are part of the energy equation and the concentration equation, respectively. (v) Since it is assumed that the flow of the fluid is in the direction of the x-axis, the physical quantities are functions solely of the space coordinate y' and time t'alone.

The governing equations for the flow in two dimensions can be stated as follows, assuming the conditions outlined above are met.

$$\frac{\partial u'}{\partial t'} = \nu \frac{\partial^2 u}{\partial y'} + g\beta_T (T' - T'_\infty) + g\beta_c (C' - C'_\infty) - \frac{\sigma B_0^2 u'}{\rho} - \frac{\nu u'}{K'}, \quad \ldots\ldots.1.$$

The equation for energy::

$$\frac{\partial T'}{\partial t'} = \frac{\kappa}{\rho C_p} \frac{\partial^2 T'}{\partial y'^2}, \quad \ldots\ldots.2$$

Concentration equation:

$$\frac{\partial C'}{\partial t'} = D \frac{\partial^2 C'}{\partial y'^2}, \quad \ldots\ldots\ldots3$$

where u′ denotes the velocity, T′ denotes the temperature, C′ denotes the concentration of the species, and g is the acceleration caused by gravity.

The initial conditions and boundary conditions that correspond to the current problem are as follows:

$$u'(y',t') = 0, T'(y',t') = T'_\infty, C'(y',t') = C'_\infty \text{ for } y' \ge 0 \text{ and } t' \le 0, \quad \ldots\ldots 4$$

$$u'(0,t') = U_0 f(t'), T'(0,t') = T'_w, C'(0,t') = C'_w \text{ for } t' > 0$$
$$u'(\infty,t') \to 0, T'(\infty,t') \to T'_\infty, C'(\infty,t') \to C'_\infty \text{ for } t' > 0 \quad \ldots\ldots 5$$

For the sake of convenience, let us simplify the preceding equations into a form that does not require dimensions by introducing the dimensionless variables and parameters shown below:

$$u = \frac{u'}{U'_0},\ t = \frac{t'U_0^2}{\nu},\ y = \frac{Uy'}{\nu},\ K = \frac{K'U_0^2}{\nu^2},\ M = \frac{\sigma B_0^2 \nu}{\rho U_0^2},\ Pr = \frac{\mu C_p}{\kappa},\ \omega = \frac{\omega'\nu}{U_0^2},$$
$$Gr = \frac{\nu g \beta_T (T'_w - T'_\infty)}{U_0^3},\ Gm = \frac{\nu g \beta_C (C'_w - C'_\infty)}{U_0^3},$$
$$S_c = \frac{\nu}{D},\ \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty},\ C = \frac{C' - C'_\infty}{C'_w - C'_\infty}, \quad \ldots.6$$

where Gr represents the thermal Grashof number, Gm represents the mass Grashof number, K represents the permeability parameter, M represents the magnetic parameter, Pr represents the Prandtl number, and Sc represents the Schmidt number. β_T represents the coefficient of thermal expansion, β_C is concentration expansion coefficient and ω is the rate at which something oscillates. The other physical variables have the meanings that are typically associated with them. The governing equations (2.1) to (2.3) can be reduced with the assistance of (2.6), which is as follows:

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial y^2} + Gr\theta + Gm\phi - (M + \frac{1}{K})u, \quad \ldots\ldots 7$$

$$Pr\frac{\partial \theta}{\partial t} = \frac{\partial^2 \theta}{\partial y^2}, \quad \ldots\ldots 8$$

$$Sc\frac{\partial C}{\partial t} = \frac{\partial^2 C}{\partial y^2}, \quad \ldots.9$$

The beginning and boundary conditions that correspond to them in non-dimensional form are as follows:

$$\begin{array}{llll} u(y,t) = 0, & \theta(y,t) = 0, & C(y,t) = 0, & \text{for } y \ge 0, \text{ and } t \le 0, \\ u(0,t) = f(t), & \theta(0,t) = 1, & C(0,t) = 1, & \text{for } t > 0, \quad (2.10) \\ u(\infty,t) \to 0, & \theta(\infty,t) \to 0, & C(\infty,t) \to 0, & \text{for } t > 0, \end{array}$$

CONCLUSION

In order to increase the effectiveness and functionality of heat transfer systems, research has been conducted on the optimization of heat transfer in two-dimensional (2D) and three-dimensional (3D) MFD (Mean Flow Deflection) boundary layers. The conclusion that can be derived from this comparative research shows the major findings and implications for maximizing heat transfer in both two-dimensional and three-dimensional boundary layers. In the context of two-dimensional boundary layers, numerous approaches have been investigated in order to improve the effectiveness of heat transfer. These include the utilization of passive approaches such as the alteration of the surface through the use of riblets, dimples, and surface roughness, all of which produce favourable flow conditions and promote convective heat transfer. Active approaches such as flow control technologies, including vortex generators, jets, and microscale actuators have also been used to promote heat transmission. These techniques work by boosting mixing and promoting turbulence in the fluid. In addition, it has been discovered that the adjustment of geometric parameters, such as channel height and aspect ratio, can have an effect on the performance of heat transmission in two-dimensional boundary layers. Due to the increased complexity brought about by the inclusion of a third dimension, optimizing heat transfer in 3D boundary layers presents new obstacles. These challenges must be overcome in order to achieve optimal results. Despite this, a number of different approaches have been looked into in order to improve the efficiency of heat transfer in 3D boundary layers. These include the implementation of three-dimensional surface changes, such as riblets, turbulators, and vortex generators, which improve mixing and disrupt the boundary layer in order to boost heat transmission. Active methods, such as pulsed or oscillating flow control, have also been investigated as a means of boosting turbulence and generating unstable flow patterns in order to facilitate improved heat transfer. In addition, it has been discovered that the optimization of geometric parameters and flow topologies, such as channel geometry and curvature, can have an effect on the performance of heat transfer in three-dimensional boundary layers. A multidisciplinary approach is required for the optimization of heat transfer in both two-dimensional and three-dimensional MFD boundary layers. This approach must include an understanding of fluid dynamics, heat transfer mechanisms, and optimization techniques. The findings highlight how important it is, when developing heat transfer systems, to take into consideration the dimensionality of the boundary layer as well as the unique flow characteristics. In order to reach the desired level of heat transfer enhancement through the creation of effective solutions for heat transfer, it is necessary to combine both passive and active methods of heat transfer, as well as to optimize the parameters of the geometry involved. In order to improve the rate at which heat is transferred in 2D and 3D MFD boundary layers, there is a need for more investigation into novel methods, materials, and configurations. The research of more advanced numerical simulations and experimental approaches can provide beneficial insights into the complicated flow phenomena and direct the creation of heat transfer devices that are more effective. Ultimately, the optimization of heat transfer in both two-dimensional and three-dimensional boundary layers has major consequences for a variety of applications. These applications include thermal management, energy conversion, and the design of heat exchangers, and they make it possible for performance to be improved, energy consumption to be lowered, and efficiency to be increased.

REFERENCES

[1]. Ali. et al., 2000, Hydromagnetic combined heat and Mass Transfer by natural convection from a permeable surface embedded in a fluid saturated porous medium, International Journal of Numerical Methods for Heat & Fluid flow 10(5) ,455-476.

[2]. Anwar 1998,.MHD unsteady free convection flow past a vertical porous plate., ZAMM 78, 255-270.

[3]. Camargo . et al. 1996, Numerical study of the natural convective cooling of a vertical plate., Heat and Mass Transfer 32, 89-95.

[4]. Chaudhary &Jain 2006., Combined heat and mass transfer effects on MHD free convection flow past an oscillating plate embedded in porous medium,.Rom. Jour. Phys. 52(5-7), 505-524.

[5]. Das et al.1996 , Mass transfer effects on flow past an impulsively started infinite vertical plate with constant mass flux – an exact solution. ,Heat and mass transfer 31, 163-167.

[6]. Gebhart et al 1988., Buoyancy induced flow and transport,hemisphere., New York,Chaps. 3, 6, 8, 10, 12.

[7]. Hossain &Mondal .1985, Mass transfer effects on the unsteady hydromagnetic free convection flow past an accelerated vertical porous plate,. J. Phys. D: Appl. Phys 18,163-169.

[8]. Israel-Cookey .& Sigalo .2003, Unsteady MHD free convection and Mass Transfer flow past an infinite heated porous vertical plate with time suction., ASME Modelling B 72(3), 25.

[9]. Kolar &.Sastri 1988,.Free convective transpiration over a vertical plate: a numerical study. , Heat and Mass Transfer 23(6), 327-336.

[10]. Martynenko et al. 1984, Laminar free convection flow from a vertical plate. , Int. J. Heat Mass Transfer 27, 869-881

[11]. Muthukumaraswamy 2003, Effects of chemical reaction on moving isothermal plate with variable mass diffusion., Theor Appl. Mech. 30(3), 209-220. 12. Panda et al. 2003, Unsteady Free convection flow and Mass Transfer past a vertical porous plate., AMSE Modelling B 72(3), 47-58.

[12]. Ramanaiah &.Malarvizhi 1992, Unified treatment of free convection adjacent to a vertical plate with three thermal boundary conditions,.Heat and Mass Transfer. 27(6), 393-396.

[13]. Revankar 1983, Natural convection effects on MHD flow past an impulsively started permeable plate,. Indian J. Pure and Appl. Math. 14, 530-539.

[14]. Revankar .2000, Free convection effect on the flow past an impulsively started or oscillating infinite vertical plate., Mechanics Research Comm.27, 241-246.