Aydın, Orhan; **Kaya, Ahmet**

MHD mixed convection of a viscous dissipating fluid about a permeable vertical flat plate.

(English) Zbl 1205.76292
Appl. Math. Modelling 33, No. 11, 4086-4096 (2009).

Summary: The problem of steady laminar magnetohydrodynamic (MHD) mixed convection heat transfer about a vertical plate is studied numerically, taking into account the effects of Ohmic heating and viscous dissipation. A uniform magnetic field is applied perpendicular to the plate. The resulting governing equations are transformed into the non-similar boundary layer equations and solved using the Keller box method. Both the aiding-buoyancy mode and the opposing-buoyancy mode of the mixed convection are examined. The velocity and temperature profiles as well as the local skin friction and local heat transfer parameters are determined for different values of the governing parameters, mainly the magnetic parameter, the Richardson number, the Eckert number and the suction/injection parameter, f_w. For some specific values of the governing parameters, the results agree very well with those available in the literature. Generally, it is determined that the local skin friction coefficient and the local heat transfer coefficient increase owing to suction of fluid, increasing the Richardson number, R_i (i.e. the mixed convection parameter) or decreasing the Eckert number. This trend reverses for blowing of fluid and decreasing the Richardson number or decreasing the Eckert number. It is disclosed that the value of Ri determines the effect of the magnetic parameter on the momentum and heat transfer.

MSC:

76W05 Magnetohydrodynamics and electrohydrodynamics
76E06 Convection in hydrodynamic stability
74K20 Plates

Keywords:

MHD flow; mixed convection; vertical plate; viscous dissipation; suction/injection effect

Full Text: DOI

References:

[1] Chen, C.H., Combined heat and mass transfer MHD free convection from a vertical surface with ohmic heating and viscous dissipation, Int. J. eng. sci., 42, 699-713, (2004) · Zbl 1211.76141

[2] Chen, C.H., Heat and mass transfer in MHD flow by natural convection from a permeable, inclined surface with variable wall temperature and concentration, Acta mech., 172, 219-235, (2004) · Zbl 1178.76321

[3] Yıh, K.A., Heat source/sink effect on MHD mixed convection in stagnation flow on a vertical permeable plate in porous media, Int. commun. heat mass, 25, 3, 427-442, (1998)

[4] Chamkha, A.J.; Takhar, H.S.; Nat, G., Mixed convection flow over a vertical plate with localized heating (cooling), magnetic field and suction (injection), Heat mass transfer, 40, 835-841, (2004)

[5] Abo-Eldahab, E.M.; Azzam, G.E.A., Thermal radiation effects on MHD flow past a semi-infinite inclined plate in the presence of mass diffusion, Heat mass transfer, 41, 12, 1056-1065, (2005)

[6] Abo-Eldahab, E.M.; Azzam, G.E.A., Thermal radiation effects on magnetohydrodynamic flow past a semi-infinite vertical plate in the presence of mass diffusion, Can. J. phys., 83, 3, 243-256, (2005)

[7] Abdelkhalek, M.M., The skin friction in the MHD mixed convection stagnation point with mass transfer, Int. commun. heat mass, 33, 249-258, (2006)

[8] Aydin, O.; Kaya, A., Mixed convection of a viscous dissipating fluid about a vertical flat plate, Appl. math. model, 31, 843-853, (2007) · Zbl 1210.76067

[9] T. Cebeci, P. Bradshaw, Momentum Transfer in Boundary layers, Hemisphere, Washington D.C., USA, 1977. · Zbl 0424.76023

[10] Takhar, H.S.; Beg, O.A., Effects of transverse magnetic field, Prandtl number and Reynolds number on non-Darcy mixed convective flow of an incompressible viscous fluid past a porous vertical flat plate in a saturated porous medium, Int. J. energy res., 21, 87-100, (1997)

[11] Lin, H.T.; Lin, L.K., Similarity solutions for laminar forced convection heat transfer from wedges to fluids of any Prandtl number, Int. J. heat mass transfer, 30, 1111-1118, (1987)

[12] Yih, K.A., MHD forced convection flow adjacent to a non-isothermal wedge, Int. commun. heat mass, 26, 819-827, (1999)

[13] Chamkha, A.J.; Mujtaba, M.; Quadri, A.; Issa, C., Thermal radiation effects on MHD forced convection flow adjacent to a non-isothermal wedge in the presence of heat source or sink, Heat mass transfer, 39, 305-312, (2003)

[14] Nield, D.A.; Kuznetsov, A.V., Boundary layer analysis of forced convection with a plate and porous substrate, Acta mech., 166, 141-148, (2003) · Zbl 1064.76098

[15] Kuznetsov, A.V.; Nield, D.A., Boundary layer treatment of forced convection over a wedge with an attached porous substrate, J. porous media, 9, 7, 683-694, (2006)

[16] Saeid, N.W., Mixed convection flow along a vertical plate subjected to time-periodic surface temperature oscillations, Int. J. therm. sci., 44, 531-539, (2005)

[17] Watanabe, T.; Pop, I., Thermal boundary layers in magnetohydrodynamic flow over a flat plate in the presence of a transverse magnetic field, Acta mech., 105, 233-238, (1994) · Zbl 0814.76093