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Effect of nonlinear radiation on entropy optimised MHD fluid flow

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ABSTRACT

Here we investigate the irreversible aspects of 2D, steady, incompressible natural convection magnetohydrodynamic flow of electrically conducting fluid through the convective surface. Energy equation is mathematically modelled subject to viscous dissipation, joule heating effect, heat generation/absorption and nonlinear radiation. The investigation of irreversibility is also examined. Similarity transformations are used to translate the system of partial differential equations into ordinary one. Homotopy analysis method is used to solve the obtained system of nonlinear ordinary differential equations. Flow characteristics are discussed and interpreted graphically with respect to influential parameters. Velocity profile increases for magnetic parameter, first-order velocity slip parameter and suction parameter. Temperature rises for the large amount of radiation parameter, magnetic parameter, temperature ratio parameter, and Brinkman number while behaves opposite for Prandtl number. Concentration profile declines for higher values of Schmidt number and suction parameter.

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KEYWORDS
Entropy generation; Bejan number; viscous dissipation; joule heating; stretching surface; nonlinear radiation

Nomenclature

x, y	Cartesian coordinates (m)
u, v	velocity components ($\mathrm{m\,s^{-1}}$)
a	dimensionless constant ($\mathrm{s^{-1}}$)
B_0	magnetic field strength ($\mathrm{kg\,s^{-2}\,A^{-1}}$)
T	fluid temperature (K)
T_∞	ambient temperature (K)
T_w	temperature at the wall (K)
C	fluid concentration ($\mathrm{kg\,m^{-3}}$)
C_w	concentration at the wall ($\mathrm{kg\,m^{-3}}$)
C_∞	ambient concentration ($\mathrm{kg\,m^{-3}}$)
g	gravitational acceleration ($\mathrm{m\,s^{-2}}$)
C_p	specific heat ($\mathrm{J\,kg^{-1}\,K^{-1}}$)
C_{fx}	skin friction coefficient
J_w	mass flux
Re_x	Reynolds number
k	thermal conductivity ($\mathrm{W\,m^{-1}\,K^{-1}}$)
Q	heat generation/absorption coefficient
q_w	heat flux
q_r	radiative heat flux ($\mathrm{W\,m^{-2}}$)
D	mass diffusion coefficient ($\mathrm{m^2\,s^{-1}}$)
u_w	velocity at the stretching surface
v_w	suction/injection velocity
l	molecular free mean path
h_f	convective heat transport
Rd	radiation parameter
M	magnetic parameter
Pr	Prandtl number
Br	Brinkman number
Sc	Schmidt number
S	suction/injection parameter
Bi	Biot number
Ec	Eckert number
Gr_T	thermal Grashof number
Gr_C	solutal Grashof number
Nu_x	Nusselt number
Sh_x	Sherwood number

Greek Symbols

μ	dynamic viscosity ($\mathrm{kg\,m^{-1}\,s^{-1}}$)
ν	kinematic viscosity ($\mathrm{m^2\,s^{-1}}$)
σ	electrical conductivity ($\mathrm{kg^{-1}\,m^{-3}\,s^3\,A^2}$)
ρ	fluid density
β	heat generation/absorption parameter
ϕ	dimensionless concentration
θ	dimensionless temperature
ψ	stream function
τ_w	shear stress ($\mathrm{N\,m^{-2}}$)
γ	first-order velocity slip parameter
θ_w	temperature ratio parameter
β_T	volumetric thermal expansion coefficient $\mathrm{K^{-1}}$
β_C	volumetric solutal expansion coefficient

1. Introduction

One of the main concerns of engineers and researchers today is to develop procedures that control the consumption of efficient energy. The primary goal of thermal engineering is to achieve maximum device efficiency while minimising heat loss, friction and dissipation during mechanical processes. It is a well-known fact that all thermal devices operate on the thermodynamic prin-

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