Radiation Absorption with a MHD Heat Source/Sink Fluid Past on a Vertical Porous Media

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Abstract

The impacts of radiation absorption on a mhd Flow heat source/sink fluid moving through a vertical porous media have been studied. The dimensionless governing equations are coupled and linear. The perturbation technique is used to solve these equations analytically. The expressions for velocity, temperature, and concentration are obtained and their variations under different parameters are mentioned employing graphs.

Keywords : Radiation absorption, Chemical reaction, MHD, Heat source/sink, Porous plate.

Introduction

The MHD generation process is based on Faraday's electro-magnetic induction law. The Magneto-hydrodynamic generator generates thermal energy or kinetic energy of a moving conducting fluid into directly electrical energy. Examples of such kind of fluids are ionized gas, plasma, liquid metals, and seawater. It's a plasma technology. The gas is continuously seeded with potassium nitrate, making the gas electrically conductive at lower temperatures. The alkali metal ionizes easily at lower temperatures. MHD generators are different from conventional electric generators in that they can operate at high temperatures without moving parts.

Veerasankar et al. [1] investigated unsteady MHD convective flow of rivlin-ericksen fluid over an infinite porous vertical plate with permeability effect and variable suction. AnuradhaPunithavalli [2] investigated the MHD boundary layer flow of a steady micro polar fluid along a stretching sheet undergoing a binary chemical reaction. Rama Krishna Reddy and colleagues [3] investigated the MHD free convective flow past a porous plate. KarunaDwivedi et al. [4] investigated the MHD flow through a horizontal channel filled with porous medium and placed in an inclined magnetic field. Using an accurate solutions, Chandra Reddy et al.[5] investigated the Magnetohydrodynamic natural convective heat Fluid formation and radiation past a horizontal plate embedded in a porous medium.

Chemical Reaction Effects on Mhd Flow Casson Balakrishna et al. [6] investigated fluid flow well beyond a moving infinitely inclined plate through a porous medium. Rama Mohan et al. [7] investigated the effects of chemical reactions and thermal radiation on jittery free convection flow of MHD past an oriented moving plate using TGHS. Reactive chemical and inevitably convection cooling fast speed Magnetohydrodynamic fluid flow through with a wavelike porous plate vertically with heat and radioactivity absorption effect was discussed by Arifuzzaman et al. [8]. Eid [9] discussed the chemical process effect on MHD bounding flow of a two-phase nano - fluids model over a sheet exponentially stretching with heat generation. Muthurajet al.[10] investigated the effects of chemical reactions and wall properties on

Formulation of the Problem

Continuity equation:

$$\frac{\partial v^*}{\partial y^*} = 0 \tag{1}$$

Momentum equation:

$$\frac{\partial u^*}{\partial t^*} + V^* \frac{\partial u^*}{\partial y^*} = \vartheta \frac{\partial^2 u^*}{\partial y^{*2}} + g\beta\ (T^* - T_\infty) + gB^*(C^* - C_\infty) - \frac{\sigma B_0^2}{\rho} u^* - \frac{\vartheta}{K^*} u^* \tag{2}$$

Energy equation:

$$\frac{\partial T^*}{\partial t^*} + V^* \frac{\partial T^*}{\partial y^*} = \frac{K}{\rho C_p} \frac{\partial^2 T^*}{\partial y^{*2}} + \frac{1}{\rho C_p} \frac{\partial q_r}{\partial y^*} - \frac{Q_0}{\rho C_p}(T^* - T_\infty) - \frac{L_1}{\rho C_p}(C^* - C_\infty) \tag{3}$$

Concentration equation:

$$\frac{\partial C^*}{\partial t^*} + V^* \frac{\partial C^*}{\partial y^*} = D \frac{\partial^2 C^*}{\partial y^{*2}} - K^*(C^* - C_\infty) \tag{4}$$

The relevant boundary conditions are given as follows

$$u^* = L^*\left(\frac{\partial u^*}{\partial y^*}\right), \quad T^* = T_w^* + (T_w^* - T_\infty^*)e^{i\omega^* t^*}, \ C^* = C_w^* + (C_w^* - C_\infty^*)e^{i\omega^* t^*} \ \text{ at } \ y^* = 0 \tag{5}$$

$$u^* \to 0, \qquad T^* \to T_\infty^*, \qquad C^* \to C_\infty^* \qquad \text{as} \quad y^* \to \infty$$

Where T_w^* and T_∞^* is the temperature at the wall and infinity, C_w^* and C_∞^* is the species

Eq.(1) gives that V* = Constant = - V_0 (6)

Where V_0 is the constant suction velocity normal to the plate.

The governing equations (2) to (4) can be rewritten in the non-dimensional form as follows

$$\frac{1}{4}\frac{\partial u}{\partial t} - (1 + \varepsilon A e^{i\omega t})\frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + Gr\theta + GcC - M_1 u \tag{7}$$

$$\frac{1}{4}\frac{\partial \theta}{\partial t} - (1 + \varepsilon A e^{i\omega t})\frac{\partial \theta}{\partial y} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} + F_1\theta + LC \tag{8}$$

$$\frac{Sc}{4}\frac{\partial C}{\partial t} - Sc(1 + \varepsilon A e^{i\omega t})\frac{\partial C}{\partial y} = \frac{\partial^2 C}{\partial y^2} - Sc\gamma C \tag{9}$$

The corresponding boundary conditions are given by

$$u = h(\frac{\partial u}{\partial y}),\ \theta = 1 + \varepsilon e^{i\omega t}, C = 1 + \varepsilon e^{i\omega t}, \quad at \quad y = 0$$
$$u \to 0, \quad \theta \to 0, \quad C \to 0 \quad as \quad y \to \infty \tag{10}$$

Solution Of The Problem

Equations (8) through (10) are combined,

$$u(y,t) = u_0(y) + \varepsilon e^{i\omega t} u_1(y)$$
$$\theta(y,t) = \theta_0(y) + \varepsilon e^{i\omega t} \theta_1(y) \tag{11}$$
$$C(y,t) = C_0(y) + \varepsilon e^{i\omega t} C_1(y)$$

by replacing equations (12) into equations (8)-(10)

$$u_0'' + u_0' - \mathrm{M_1 u_0} = -\mathrm{Gr}\,\theta_0 - \mathrm{Gc}\,C_0 \tag{12}$$

$$\theta_0'' + \mathrm{Pr}\,\theta_0' + \mathrm{PrF_1Q}\,\theta_0 = -\mathrm{PrLC_0} \ (14) \quad C_0'' + Sc\ C_0' - \mathrm{Sc}\gamma C_0 = 0 \tag{13}$$

First order terms:

$$u_1'' + u_1' - (\mathrm{M_1} + \frac{i\omega}{4})\mathrm{u_1} = -\mathrm{Gr}\,\theta_1 - \mathrm{Gc}\,C_1 - \mathrm{A}u_0' \tag{14}$$

$$\theta_1'' + \mathrm{Pr}\,\theta_1' + \mathrm{Pr(F_1 - i\omega/4)Q}\,\theta_1 = -\mathrm{PrA}\theta_0' - \mathrm{PrLC_1} \tag{15}$$

$$C_1'' + ScC_1' - Sc(\gamma + \frac{i\omega}{4})C_1 = -\mathrm{ScA}C_0' \tag{16}$$

The corresponding boundary conditions are

$$u_0 = h(\frac{\partial u_0}{\partial y}), u_1 = h(\frac{\partial u_1}{\partial y}),\ \theta_0 = 1, \theta_1 = 1, C_0 = 1, C_1 = 1 \quad at \quad y = 0$$

(17) The

$$u_0 \to 0, u_1 \to 0, \theta_0 \to 0, \theta_1 \to 0, C_0 \to 0, C_1 \to 0 \quad as \quad y \to \infty$$

by solving(14-16)

$$u = B_3 \exp(-m_1 y) + B_4 \exp(-m_2 y) + B_5 \exp(-m_3 y)$$

(19).

$$+ \varepsilon(B_{12}\exp(-m_1 y) + B_{13}\exp(-m_2 y) + B_{14}\exp(-m_3 y) + B_{15}\exp(-m_4 y) + B_{16}\exp(-m_5 y) + B_{17}\exp(-m_6 y))e^{i\omega t} \tag{18}$$

$$\theta = B_1 \exp(-m_1 y) + B_2 \exp(-m_2 y) + \varepsilon(B_8 \exp(-m_1 y) + B_9 \exp(-m_2 y) + B_{10}\exp(-m_4 y) + B_{11}\exp(-m_5 y))e^{i\omega t}$$

(19)
$$C = \exp(-m_1 y) + \varepsilon(B_6 \exp(-m_1 y) + B_7 \exp(-m_4 y))e^{i\omega t} \tag{20}$$

The rate of heat transfer in terms of the Nusselt number is given by

$$Nu = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0}$$

$$Nu = m_1 B_1 + m_2 B_2 + \varepsilon(m_1 B_8 + m_2 B_9 + m_4 B_{10} + m_5 B_{11})e^{i\omega t} \tag{21}$$

Sherwood Number :

The rate of mass transfer on the wall in terms of Sherwood number is given by

$$Sh = -\left(\frac{\partial \phi}{\partial y}\right)_{y=0}$$

$$Sh = m_1 + \varepsilon(m_1 B_6 + m_4 B_7)e^{i\omega t} \quad (22)$$

Results And Discussion

, numerical calculations for the velocity, temp, and effectively measure are performed, and the discussion that follows is laid out. Throughout the calculations we use, Sc=0.22,Pr=0.71,Gr=5,Gc=1,γ=2,K=3,F=**0.**1,M=3, E=0.01,t=1,R=0.1,**ω=π/3,** **L**=0.02. h=0.5,A=1.

To expose the effects of process factors on the non - dimensional velocity profiles, heat flux, intensity field, frictional forces, Nusselt number, and Sherwood number, as well as the effect of various physicochemical characteristics such as the Grashof number (Gr), the altered Grashof number (Gc), the magnetic parameter (M), the porosity parameter (K), the Prandtl number (Pr), the heat absorption parameter (F), the radiation parameter (R), the radiation permeation parameter (L), Tables 1–3 show the impact of these variables on friction factor, Nusselt number, and Sherwood number.Figure 1: Effect ofThermalGrashof number on Velocity

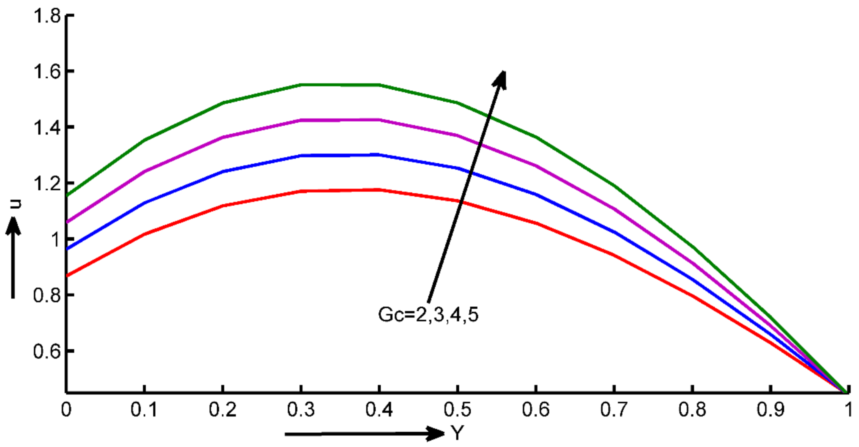

Figure 2: Effect of Modified Grashof numberon Velocity

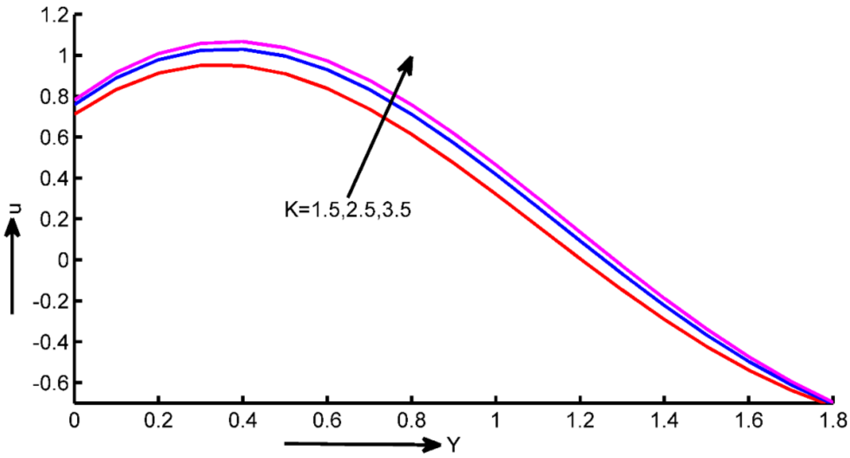

Figure 3: Effect of Porosity parameter on Velocity

Table-1: Variations in Skin Friction

Gr	Gc	M	K	T
4				1.4843
5				1.7346
6				1.9520
7				2.2264
	3			1.7635
	4			1.8427
	4			2.2011
	6			2.5595
		0.1		5.4359
		0.2		4.9710
		0.3		4.5041
			0.6	1.0426
			0.7	1.205
			0.8	1.2139

Table – 2

Table-2: Variations in Nusselt Number

Pr	R	F	L	Nu
0.3				0.1502
0.5				0.2505
0.71				0.3543
	0.1			0.1197
	0.5			0.5476
	0.7			0.6617
		0.4		0.4772
		0.6		0.6153
		0.8		0.7245
			0.1	0.0562
			0.2	-0.0231
			0.3	-0.1124
			0.4	-0.1815

Table – 3

Table-3: Variations in Sherwood Number

Sc	Γ	Sh
0.2		0.6409
0.4		0.9088
0.6		1.1127
0.8		1.2823
	2	0.6725
	3	0.8319

	4	0.9672
	5	1.0873

Conclusions

We investigated the radiofrequency permeability and chemical reaction effects on an unsteady thermal radiation heat source/sink fluid passing through an embedded in a porous medium in this problem. The conclusions that can be drawn from the analysis procedure:

1. The flow rate increased as the Grashof number, altered Grashof number, and conductivity parameter of the poroelastic raise, while it reduces as the metallic speed increase.

2. The temperature goes up in the appearance of the Radiationabsorption variable, while it falls in the existence of the Heat flux, the Heat flux parameter, and the Prandtl.

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