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**Effect of Radiation on Dusty Viscous Fluid through Porous Medium overa Moving Infinite Vertical Plate with Heat Source**

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**ABSTRACT**

*Aim of this paper is investigate to effects of radiation and heat source on MHD free convection flow of viscous fluid through porous medium over an impulsively started infinite vertical plate with uniform heat flux is studied here. Radiationand heat source effects are taken into account and the dimensionless governing equation are solved using the finite difference technique. The numerical results are presented graphically for different values of the parameters entering into the problem on the velocity profiles of fluid and particles of dust, temperature and concentration profile and skin friction.*

***Key words:*** *impulsively started vertical plate,radiation,heat flux, porous medium, MHD, Heat source.*

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**Nomenclature:**

*A* : Constant

*B* : Dusty Particle parameter

*B*1 : Dusty fluids parameter

*B*0 : The magnetic induction

*C* : Concentration of the fluid near the plate

 : Concentration of the plate

 : Concentration of the fluid far away from the plate

*Cp* : Specific heat at constant pressure

*D* : The chemical molecular diffusivity

*g* : Acceleration due to gravity

*Gr* : ThermalGrashoff number

*Gm* : Modified thermal Grashoff number

*k* : Thermal conductivity of the fluid

*K* : The Stoke’s resistance coefficient

*K*0 : The porosity of the porous medium

Pr : Prandtl number

*qr* : Radiative heat flux in the *y*- direction

*m*1 : The mass of dust particles

*N* : Radiation parameter

*N*0 : The number density of the dust particles (constant)

*S* : Heat source parameter

*Sc* : Schmidt number

*T* : Temperature of the fluid near the plate

 : Temperature of the plate

 : Temperature of the fluid far away from the plate

*t* : Time

*u* : Velocity of the fluid in the *x*- direction

*v* : Velocity of the dust particle in the *x*- direction

*u*0 : Velocity of the plate

*U* : Dimensionless velocity

**Sinha *et al***

*y* : Coordinate axis normal to the plate

 : Dimensionless coordinate axis normal to the plate

 : Mean absorption coefficient

**Greek symbols**

** :** Thermal diffusivity

** : Volumetric coefficient of thermal expansion

 : Volumetric coefficient of concentration expansion

 : Coefficient of viscosity

 : Kinematic viscosity

*ρ* : Density

 : Stefan-Boltzmann constant

 : Dimensionless skin-friction

 : Dimensionless temperature

**INTRODUCTION**

Magneto convection plays an important role in various industrial applications. Examples include magnetic control of molten iron flow in the steel industry, liquid metal cooling in nuclear reactors and magnetic suppression of molten semi conducting materials. It is of importance in connection with many engineering problems, such as sustained plasma confinement for controlled thermonuclear fusion, liquid-metal cooling of nuclear reactors, and electromagnetic casting of metals. In the field of power generation, MHD is receiving considerable attention due to the possibilities it offers for much higher thermal efficiencies in power of plants. MHD finds applications in electromagnetic pumps, controlled fusion research, crystal growing, plasma jets, chemical synthesis, etc.

Radiative convective flows are encountered in countless industrial and environment process e.g. heating and cooling chambers, fossil fuel combustion energy processes , evaporation from large open water reservoirs, astrophysical flows, solar power technology and space vehicle re-entry. Radiative heat transfer play an important role in manufacturing industries for the design of reliable equipment .nuclear power plants , gas turbines and various propulsion device for aircraft, missiles, satellite and space vehicles are examples of such engineering applications.

England and emery [1] have studied the thermal radiation effects of an optically thin gray gas bounded by a stationary vertical plate. Soundalgekar and Takhar [2] have considered the radiative free convective flow of an optically thin gray-gas past a semi-infinite vertical plate were studied by Hossain and Takhar [3] in all above studies, the stationary vertical plate is considered. Rapits and Perdikis [4] have studied the effects of thermal radiation and free convection flow past a moving infinite vertical plate, radiation effects on moving infinite vertical plate. Radiation effects on moving infinite vertical plate with variable temperature were studied by Muthucumaraswamy and Ganesan [5]. The governingequations were solved by the Laplace transform technique. Chandrakala and Antony [6] studied the effects of thermal radiation on the flow past a semi-infinite vertical isothermal plate with uniform heat flux in the presence of transversely applied magnetic field. Recently, Chandrakala [7] has studied on thermal radiation effects on moving infinite vertical plate with uniform heat flux.

Our aim of this study to investigate the effect of radiation and heat source on unsteady natural convection flow of dusty viscous fluid through over an impulsively started infinite verticalPlate with uniform heat flux in the presence of magnetic field has not received much attention from contemporaryresearchers. The governing equations are solved by the finite difference technique.The velocity of fluid of dust particle, temperature, concentration profile and skin friction profiles for different parameters entering into the problem are analyzed graphically.

**MATHEMATICAL FORMULATIONS**

Here the flow of an incompressible dusty viscous radiating fluid through porous medium over an impulsively started infinite vertical plate with uniform heat flux in the presence of magnetic field and heat sourceis considered. A transverse constant magnetic field is applied *i.e.* in the direction of *y* - axis. The *x*- axis is taken along the plate in the vertical direction and the *y*-axis is taken normal to the plate. Initially,the plate and fluid are at the same temperature in a stationary condition. At time the plate is given an impulsive motion in the vertical direction against the gravitational field with constant velocity. At the same time, the heat is supplied from the plate to the fluid at uniform rate. The fluid considered here is a gray, absorbing-emitting radiation but a non-scattering porous medium. Then by usual Boussinesq’s approximation, the unsteady magneto hydrodynamic flow is governed by the following equation.

**Sinha *et al***

…(3.1)

 …(3.2)

…(3.3)

 …(3.4)

Where the rosseland approximation (Brewster (1992)) is used, which leads to

…(3.5)

The initial and boundary conditions are as follows

…(3.6)

Where 

We assume that the temperature differences within the flow are sufficiently small such that  may be expressed as a linear function of the temperature. This is accomplished by expending in a Taylor series about and neglecting higher –order terms, thus

 …(3.7)

By using equation (3.5) and (3.7), equation (3.3)reduces to

 …(3.8)

On introducing the following non-dimensional quantities



**Sinha *et al***

…(3.9)

In Eqs. (3.1) to (3.8) leads to

 …(3.10)

 …(3.11)

 …(3.12)

 …(3.13)

The initial and boundary conditions in non-dimensionless form are

 …(3.14)

**Solution of the problem:**

The governing Equations (3.10) to (3.13) are to be solved under the initial and boundary conditions of equation (3.14). The finite difference method is applied to solve these equations.

The equivalent finite difference scheme of equations (3.10) to (3.13) are given by

 ...(4.2)

**Sinha *et al***

 ...(4.3)

 …(4.4)

Here, index *i* refers to *y* and *j* to time. The mesh system is divided by taking,

From the boundary conditions in Equation (3.14), we have the following equivalent.

...(4.5)

The boundary conditions from equation (3.14) are expressed in finite difference form are as follows:

 ...(4.6)

Here, infinity is taken as *y* = 6. First, the velocity of dusty fluid at the end of time step namely  to 10 is computed from equation (4.1), the velocity of dust particle at the end of time step namely  to 10 is computed from equation (4.2) and temperature to 10 from equation (4.3) and concentration to 10 from equation (4.4). The procedure is repeated until *t* = 1 (i.e., *j* = 800). During computation, was chosen to be 0.00125. These computations are carried out for different values of parameters *Gr*, *Gm*, Pr, *Sc*, *M*, *K*0, *N*, *S*(heat source parameter), *B* (dust particle parameter), *B*1 (dusty fluid parameter) and *t* (time). To judge the accuracy of the convergence of the finite difference scheme, the same program was run with smaller values of, i.e., = 0.0009, 0.001 and no significant change was observed. Hence, we conclude that the finite difference scheme is stable and convergent.

**RESULTS AND DISCUSSION**

Numerical calculations have been carried out for dimensionless velocity of dusty fluid, temperature and concentration profiles for different values of parameters and are displayed in Figures-(6.1) to (6.15).

Figures-(6.1) to (6.11) represent the velocity profiles of dusty fluid for different parameters. Figure-(6.1) shows the variation of velocity *U* with magnetic parameter *M*. It is observed that the velocity decreases as *M* increases. Figure-(6.2) shows that an increase in permeability parameter *K*0 causes an increase in velocity profile of dusty fluid. From Figure-(6.3), it is observed that the velocity of dusty fluid increases as the Grashoff number *Gr* increase. The variation of *U* with modified Grashoff number *Gm* is shown in Figure-(6.4). It is noticed that increase in *Gm* leads to increase in velocity of dusty fluid. From Figure-(6.5) shows the variation of velocity *U* with Prandtl number Pr. It is observed that the velocity of dusty fluid decreases as Pr increases. The velocity profile of dusty fluid for Schmidt number *Sc* is shown in Figure-(6.6). It is clear that velocity of dusty fluid *U* decreases with increasing in *Sc*. In figure-(6.7), the velocity profile of dusty fluid decreases due to increasing thermal radiation parameter*N*. From Figure-(6.8) shows the variation of velocity profile of dusty fluid *U* with dust particle parameter*B*. It is observed that the velocity of dusty fluid decreases as *B* increases. The velocity profile of dusty fluid for *B*1 (dusty fluid parameter) is shown in Figure-(6.9). It is clear that velocity of dusty fluid *U* decreases with increasing in *B*1. The velocity profile for time variable *t* is shown in Figure-(6.10). It is clear that an increase in *t* leads to an increase in *U*. In figure-(6.11), the velocity profile of dusty fluid increases due to increasing heat source parameter *S*. From Figure-(6.12), it is observed that increase in Prandtl number Pr causes decrease in temperature profile of dusty fluid. Figure-(6.13) shows that an increase in thermal radiation parameter *N* causes a decrease in temperature profile of dusty fluid. In figure-(6.14), the temperature profile of dusty fluid increases due to increasing heat source parameter *S*.From Figure-(6.15), it is noticed that an increase in Schmidt number *Sc* leads to decrease in concentration profile of dusty fluid.

Figure-(6.16) shows the skin friction. Knowing the velocity field, the skin friction is evaluated in non-dimensional form using,. The numerical values of are calculated by applying Newton’s interpolation formula for 11 points and are presented. From figure-(6.16), it is observed that an increase in Grashoff number *Gr*, Modified Grashoff number *Gm,* porosity parameter *K*0 and thermal radiation parameter *N* causes decrease in skin friction, and an increase in magnetic parameter *M* leads an increase in skin friction.

**Sinha *et al***

**Figures:**

**Sinha *et al***

**Sinha *et al***

**Sinha *et al***

**Sinha *et al***

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