An Unsteady Magnetohydrodynamics Flow of Bingham Fluid with Hall Effect of Heat Transfer

Pudhari Srilatha, J. Suresh Goud, B. Raju, S. Devaraj

Abstract: In this paper we investigated an unsteady magnetohydrodynamics flow of Bingham fluid with Hall Effect of heat transfer. Partial differential equations are simplified to higher order differential equations. MATLAB integrated bvp4c digital solver for velocity and temperature solves a set of nonlinear ordinary differential equations. The graphs show the effect of different parameters of velocity and temperature.

Keywords: Bingham fluid, Magnetohydrodynamics, Hall Effect, Heat Transfer.

I. INTRODUCTION

Bingham fluid is a viscous fluid and non-Newtonian fluid that meets the flow limit and must exceed this flow limit before the fluid flows. The name was created by E. C. Bingham after the introduction of his mathematical model in 1916. Toothpaste jumps into the tube only after some pressure. Bingham fluids are used in various geological and mathematical materials for engineering, aerospace engineering and chemical technology. For example: mud, mud, cement, mud, grease, chocolate etc. Nigam, singh [1] investigated the thermal displacement between parallel plates is affected by the transverse magnetic field. R. Alpher [2] examined magnetic fluid flow between parallel plates in heat transfer. Walters K.[3] studied the development of non-Newtonian fluid mechanics. Astarita G.[4] studied three alternative approaches to developing governance equations. Walton Bittleston [5] studied Articulation of Bingham’s plastic flow from a small eccentric circle. Attia, Kotb [6] examined heat wave occurring between two parallel lines in magnetic field. Attia, Transient [7] studied the heat transfer between the MHD flow and the two parallel plates depend on temperature and viscosity. Chamkha [8] investigated the unstable layer of particles is a circular magnetic flux for the transfer of fluid and heat in these channels and channels. Attia [9] studied the unstable flow of HMD and heat transfer between the powders in parallel plates with different physical properties. Hazem Ali Attia and sayed ahmed [10] examined hall effect on the flow and heat transfer of transient particles of MHD, the aspiration and injection of bingham fluid.

II. MATHEMATICAL FORMULATION

Study of viscous uncompressed conductive Bingham fluid in parallel plate channels defined by the original porous medium. The fluid moves with a uniform pressure gradient parallel to the channel plate, and a magnetic field with a uniform intensity gradient Ho, inclined at an angle oblique to the normal to the xz- plane, acts throughout the flow field. The fluid undergoes a constant change of pressure in the X direction at t=0 and has a uniform suction up and a semi perpendicular mobile plate. Ogulu, Amakiri and Mbeledogu [12] investigated the radiation heat transfer process, no instability wave convey or compressible fluid to flow into the plate to move vertically. Ramchandra Prasad, and Bhaskar Reddy [13] studied the effect of radiation convective heat and mass transfer by the HMD unstable semi-infinite vertical plate embedded in a porous medium for transmitting. Dass, Satapathy, Panda [14] considered under the influence of suction, the vibratory and thermal transmission energy as a result of heat transfer and mass transfer from the mass flow source is transmitted through a porous medium that is rare along the plate vertical. Ahmed S, Khaut H [15] studied flow of the oscillating magnetic fluid in the porous blood vessels of flat suction and injection. Makinde, Chinyoka , Rundora [16] investigated the transient of a non-newtonian variable viscosity fluid undergoes an asymmetric porous saturated medium under the conditions of a convection profile. Rundora, Makinde [17] examined a porous channel filled with a medium is introduced by a flow of non-newtoinan non-reactive liquid under stationary and convective condition. Chuo-Jeng Huang [18] studied the effect of a uniform bladder/absorption on non-Newtonian convection without fluid in a vertical cone in porous media with thermal radiation and Soret/Dufour effects.

In view of the above discussion, the main objective of this work is to solve the unsteady flow of fluid to heat soil magnetohydrodynamics Bingham hall transfer. The effects can be extracted from the non-linear differential equation, which can be solved using MATLAB bvp4c with an integrated digital solver.

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A uniform magnetic field is ignored due to the assumption of a very small Reynolds number; therefore, it is assumed that this does not affect the magnetic field. Due to the Hall Effect, The z component of the speed is constant. Therefore, the fluid velocity vector is defined as

\[ v'(y,t) = v'(y,t)\hat{t} + v'y\hat{j} + w'(y,t)\hat{k} \]

\[ \rho \frac{Dv'}{Dt} = \nabla.(\mu \nabla v') - \nabla p + J \times B_0 \]  
---(1)

\[ \rho \frac{\partial u'}{\partial t} + \rho v_0' \frac{\partial u'}{\partial y} = -\frac{dp}{dx} + \frac{\partial}{\partial y} \left( \mu \frac{\partial u'}{\partial y} \right) \]

\[ -\frac{\sigma B_0^2 \sin^2 \alpha}{1 + m^2 \sin^2 \alpha} (u + m \sin \alpha w') - \frac{v'}{k} \]
---(2)

\[ \rho \frac{\partial u'}{\partial t} + \rho v_0' \frac{\partial u'}{\partial y} = \frac{\partial}{\partial y} \left( \mu \frac{\partial u'}{\partial y} \right) \]

\[ -\frac{\sigma B_0^2 \sin^2 \alpha}{1 + m^2 \sin^2 \alpha} (-w' - m \sin \alpha u') \]

\[ \frac{v' w'}{k} \]
---(3)

\[ \rho c_p \frac{\partial T}{\partial t} + \rho c_p v_0' \frac{\partial T}{\partial y} = k \frac{\partial^2 T}{\partial y^2} \]

\[ + \mu \left[ \left( \frac{\partial u'}{\partial y} \right)^2 + \left( \frac{\partial u'}{\partial y} \right)^2 \right] \]

\[ + \frac{\sigma B_0^2 \sin^2 \alpha}{1 + m^2 \sin^2 \alpha} \left( \frac{v'}{k} \right) (u'^2 + w'^2) \]
---(4)

Dimensionless quantities

\[ x = -\frac{x}{h}, y = -\frac{y}{h}, z = -\frac{z}{t}, t = \frac{t U_0}{h}, \]

\[ w = \frac{w}{U_0}, \mu = \frac{\mu}{\sigma B_0^2 \sin^2 \alpha} \]

By using non-dimensional quantities, equations (2), (3) and (4) reduced to

\[ \frac{\partial u'}{\partial t} + \frac{S \partial u'}{\partial y} = -\frac{dp}{dx} + \]

\[ \frac{1}{Re} \left[ \frac{\partial}{\partial y} \left( \frac{\partial u'}{\partial y} \right) - \frac{M^2 \sin^2 \alpha}{1 + m^2 \sin^2 \alpha} \right] \]

\[ \frac{1}{Re} \left( \frac{v' u'}{k} - \frac{v' w'}{k} \right) \]
---(5)

Corresponding the initial and boundary conditions are

\[ u' = w' = 0 \text{ at } t \leq 0, \]

\[ u' = w' = 0 \text{ at } y = -1 \]

\[ u' = 1, w' = 0 \text{ at } y = 1 \text{ for } t > 0, \]

\[ \theta = 0 \text{ for } t \leq 0, \text{ and } \theta = 0 \text{ at } y = -1 \text{, } \theta = 1 \text{ at } y = 1 \text{ for } t > 0 \]

III. NUMERICAL PROCEDURE

Using a similar transformation, the differential equation is reduced to a common differential equation of higher order. In addition, these differential equations of higher order are solved numerically with integrated digital solver bvp4c from MATLAB.

IV. RESULTS AND DISCUSSION

To find a numerical interpretation of a particular problem, a parametric study was conducted to demonstrate the effects of its control parameters: Bingham number, Reynolds number, Hartmann number, Prandtl number and Eckert number. Figure (1-12) shows the velocity component and temperature profile for a fixed time value or a Bingham number. In Figure (1-3) that increasing the elastic limit of the Bingham number lowers the velocity component and increases the viscosity as the time they reach the stable valve increases. These figures also show that the speed component does not reach its equilibrium state monotonously. This behavior is more pronounced for Bingham numbers of smaller parameters and for velocity components. Figure(3) shows that the monotonic temperature curve reaches a stable it increase temperature. Figure (4-6) describes the velocity components and temperature changes for different values of Hartmann parameters in the middle of the channel.
In these figures, the velocity and temperature component decrease with increasing magnetic field strength throughout the fluid area.

Figures (10-12) illustrate the components of velocity and temperature changes over time in each of the Hall parameters. Figure (10) shows that as the Hall coefficient increases, the effective conductivity decreases and the velocity component increases, reducing the magnetic damping force of the velocity component. The time in the velocity component reaches its stable increases as the Hall parameter increases and decreases as the Bingham number increases.

In Figure (11), the velocity component increases as the reverb parameter increases because the velocity component is the result of the reverb effect. Figure (10-12) shows that the effect of Hall parameters on temperature depends on time. The increase of the Hall parameter decreases the temperature in a short time and increases the temperature when it is high. This shows the temperature history as a function of time for Bingham numbers. It was also observed that for all values of the Hall parameter, increasing the Bingham number would reduce the temperature. In fact, increasing the Bingham number reduces the velocity component and its gradient, thereby reducing Joule and viscous entire range of fluids, the speed and temperature components are displayed over time for the control parameters. In order to examine the accuracy and correctness of the solutions, the results of the time development of the velocity components $u'$ and $w'$ at the centre of the channel for the Newtonian case is compared and shown, as depicted Table 1, to have complete agreement with those reported by Attia. This ensures the satisfaction of all the governing equations; mass continuity, momentum and energy equations.

### Table 1

<table>
<thead>
<tr>
<th>$t$</th>
<th>Present Result</th>
<th>Attia</th>
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</thead>
<tbody>
<tr>
<td>$u'$</td>
<td>$w'$</td>
<td>$u'$</td>
</tr>
<tr>
<td>$\text{Present Result}$</td>
<td>$\text{Attia}$</td>
<td>$\text{Attia}$</td>
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<tr>
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### V. CONCLUSION

An unsteady magnetohydrodynamics flow of Bingham fluid with Permeable walls of Heat Transfer has studied in the current paper. The resulting higher order differential equations are solved using MATLAB with the integrated bvp4c digital solver for a given boundary condition. Here are some important conclusions from this review.

- Bingham number increases velocity components decreases at increasing the time.
- The velocity and temperature components decrease with increasing magnetic field strength.
- The Hall parameter increases and the temperature drop rapidly and increase rapidly.
- Bingham number increases temperature decreases for all values of hall parameter.

![Figure 1](image1.png)

![Figure 2](image2.png)
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Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

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