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FINITE ELEMENT APPROACH ON MHD FLOW THROUGH POROUS MEDIA PAST AN ACCELERATED VERTICAL PLATE IN A THERMALLY STRATIFIED FLUID

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ABSTRACT:
The current examination manages the investigation of unsteady MHD over permeable earlier media an enhancedvertical plate in a thermally stratified fluid. The principal equations are resolved by Galerkin finite-element schemewith help of Crank-Nicolson techniqueby running MATLAB Program. The impacts of the flow factors on velocity and temperature profiles are discussed with the help of graphs and table**.**

Key Words: MHD, Unsteady flow, FEM, Stratified fluid.

I. INTRODUCTION

Study of MHD flow with heat and mass transmission play avitalpartengineering & Sciences. It has many imperative applications, Ex.power generation system,cooling the nuclear reactors, liquid metal's fluid , &geothermal energy. Some of the investigators are studied on these like,Basant Kumar [1] has contemplated MHD free convection & mass transform flow throughpermeable medium.Singh.A.K [2] has considered transient natural convection between two vertical walls heated/cooled unevenly. MHD & Radiation effects on moving isothermal vertical plate by variable mass diffusionwas studied byMuthucumaraswamyandJanakiraman[3].Rajput and S.Kumar [4] have studiedunsteady MHD normal convection flow earlier an enhancedvertical plate a thermally stratified fluid through porous media.ShankarGoud and Raja Shekar[6] have discussed finite element solution of viscous dissipative,Variable temperature and mass diffusion influences unsteady MHD flow past a parabolic happening vertical plate. Jaiswal&Soundalgekar [6] investigated special effects on flow previous an infinite permeableoscillating plate throughcontinuouspressure and embedded in permeable medium.

Hence, this paper investigates unsteady MHDnatural convection flow of stratified fluid through permeable media past an accelerated vertical plate. The nondimensional governing equations are resolved using the efficient finite process.

II. MATHEMATICAL FORMULATION

In this studynatural convective flow ofgelatinous incompressible,electricaldirecting fluid is considered. The x - axis and the plate is taken along same direction i.eupword and the plate is taken perpendicular to y - axis. Fluid & plate are rest initially the time $t \le 0$, and the fixed temperature T'_∞. At the T $t' > 0$, Temp of plate increased or decreased T'_W & the concentration level nearby the plateincreasing linearly with time.That The following set of equations is the flow modal:

$$\upsilon \frac{\partial^2 u'}{\partial y'^2} - \frac{\partial u'}{\partial t'} + g\beta\left(T' - T'_\infty\right) - \left(\frac{\sigma B_0^2}{\rho} + \frac{\upsilon}{K'}\right) u' = 0 \qquad \dots (1)$$

$$\frac{\partial T'}{\partial t'} = \alpha \frac{\partial^2 T'}{\partial y'^2} - \gamma u' \qquad \dots (2)$$

Where $\gamma = \frac{dT_\infty}{dz} + \frac{g}{C_p}$

Here $\frac{dT_\infty}{dz}$ is thermal stratification and $\frac{g}{C_p}$ is pressure work term.

The B.C's are:

$$\left.\begin{array}{ll} t' \le 0 : u' = 0, T' = T'_\infty & \forall y' \\ t' > 0 : u' = At', T' = T'_W \quad , & at \quad y' = 0 \\ u' \to 0, \quad T' \to T'_\infty, & y' \to \infty \end{array}\right\} \quad \dots (3)$$

Where $A(>0)$ is the constant acceleration, T'_W are the temperature & concentration of wall respectively, t^* the time.

Introducing the following dimensionless quantities,

$$y = \left(\frac{A}{\upsilon}\right)^{\frac{1}{2}} y', \theta = \frac{T' - T'_\infty,}{T'_W - T'_\infty}, \Pr = \frac{\mu C_p}{k}, K = \frac{K'A}{\upsilon}, t = t'A, \quad \dots (4)$$

$$S = \frac{\gamma}{A(T'_W - T'_\infty)}, Gr = \frac{g\beta(T'_W - T'_\infty)}{A}, M = \frac{\sigma B_0^2}{\rho A}, \mu = \rho\upsilon$$

With the help of dimensionless quantities, equations (1) and (2) becomes

$$\frac{\partial^2 u}{\partial y^2} - \frac{\partial u}{\partial t} - \left(M + \frac{1}{K}\right)u + Gr\theta = 0 \quad \dots (5)$$

$$\frac{\partial^2 \theta}{\partial y^2} - \Pr\frac{\partial \theta}{\partial t} + S\Pr u = 0 \quad \dots (6)$$

And nondimensional boundary conditions are

$$\{u = 0, \ \theta = 0 \qquad forall\, y\}_{t \le 0}$$

$$\left.\begin{array}{ll} u = t, \theta = 1 & at \ \ y = 0 \\ u \to 0, \ \theta \to 0 & as \ \ y \to \infty \end{array}\right\}_{t>0} \quad \dots (7)$$

III. METHOD OF SOLUTION

The determinateelement strategy has been applied, get the mathematicalresults of equation(5) and (6) under margincircumstances (7). Given method is particularly effective & permits vigorous resultsoffnonlinear differential equationsystem. The following steps are:

Step 1: Discretization of the condition into components

Step 2: Derivation of the component conditions

The Derivation of constrained component conditions i.e., logarithmic conditions among the not known parameters of the limited component estimation, includes the accompanying 3 steps.

- Create the variational definition of the distinction condition.
- Suppose the inexact arrangement over distinctive finite component.
- Derive the determinate component conditions by replacing the estimated arrangement into the variational detailing.

Step 3: Get together of component conditions.

Step 4: Impositions of Boundary Conditions.

Step 5: Solution of the assembled equations.

By implementing the step (1-3) to the nonlinear differential equation(5), the assembled element conditions for 2 consecutive elements $y_{i-1} < y < y_i$ & $y_i < y < y_i + 1$ put row consistent to the node 'i' to '0', with the variance schemes by taking $h = l^{(e)}$ the following obtained

$$\frac{1}{6}\left[\dot{u}_{i-1} + 4\dot{u}_i + \dot{u}_{i+1}\right] + \frac{1}{h^2}\left[-u_{i-1} + 2u_i + u_{i+1}\right] + \frac{N}{6}\left[u_{i-1} + 4u_i + u_{i+1}\right] = P \quad \dots (8)$$

Implemetingthe trapezoidal law, the givenset of Equ's in Crank-Nicholson method are achieved

$$A_1 u_{i-1}^{j+1} + A_2 u_i^{j+1} + A_3 u_{i+1}^{j+1} = A_4 u_{i-1}^{j} + A_5 u_i^{j} + A_6 u_{i+1}^{j} + P^* \quad \dots (9)$$

$$A_1 = A_3 = 2 - 6r - kN,\quad A_4 = A_6 = 2 + 6r - kN, A_2 = 4(2 + 3r + kN),$$

$$A_5 = 8 - 4kN - 12r, P^* = 12kP = 12kGr\theta_i^j,\ N = \left(M + \frac{1}{K}\right)$$

Apply the same strategy, the following is obtained

$$B_1\theta_{i-1}^{j+1} + B_2\theta_i^{j+1} + B_3\theta_{i+1}^{j+1} - P^{**} = B_4\theta_{i-1}^{j} + B_5\theta_i^{j} + B_6\theta_{i+1}^{j} \quad \ldots (10)$$

where

$$B_1 = B_3 = \Pr - 3r \quad B_4 = B_6 = \Pr + 3r$$

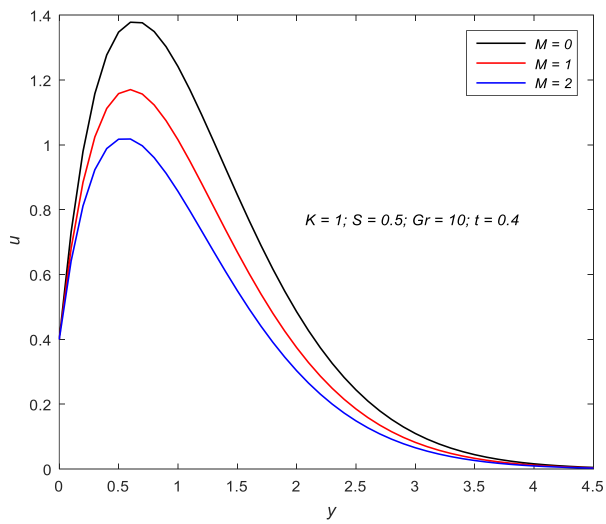
$$B_2 = 4\Pr + 6r,\quad B_5 = 4\Pr - 6r, P^{**} = -6k\Pr Su_i^j$$

Here, $r = k/h^2$, time and y direction the mesh size are k & h correspondingly. The given (i, j) indicates space & time. In the Equ's (9) – (10), taking $i = 1\ldots,n$ &utilizing boundary circumstances (7), the givenequ'sareattained:

$$A_i X_i = B_i\ i = 1\ldots,n \quad \ldots (11)$$

Where the order matrix and thematrices of the columns have elements.Thomas algorithm method using for velocity , concentration &tempthe results of the equations systems above are obtained.The mathematical solutions often attained by runningthis MATLAB software with reduced values of end.There was not a bigimprovement in u, and θ then the Galerkin finite element method is constant&convergent . Then the dimensionless skin friction is given by $\tau = \left(\frac{\partial u}{\partial y}\right)_{y=0}$.

The dimensionless Nusselt number is given by $\tau = \left(\frac{\partial \theta}{\partial y}\right)_{y=0}$



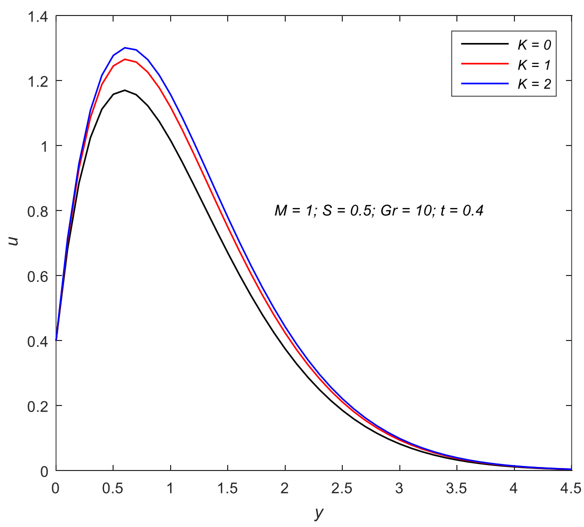
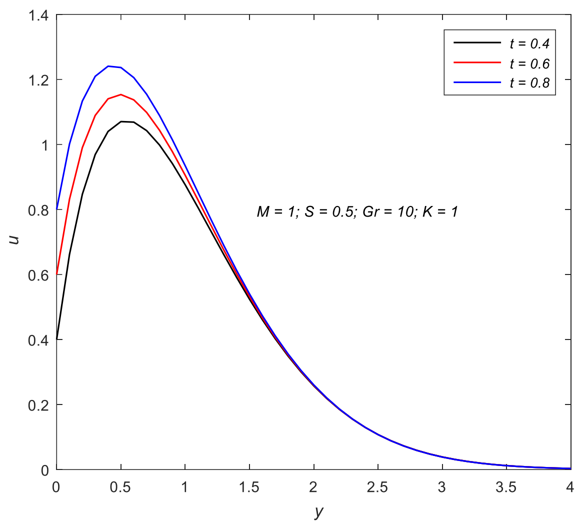


Fig.1: velocity v/s magnetic field parameter Fig.2: velocity v/s permeability parameter



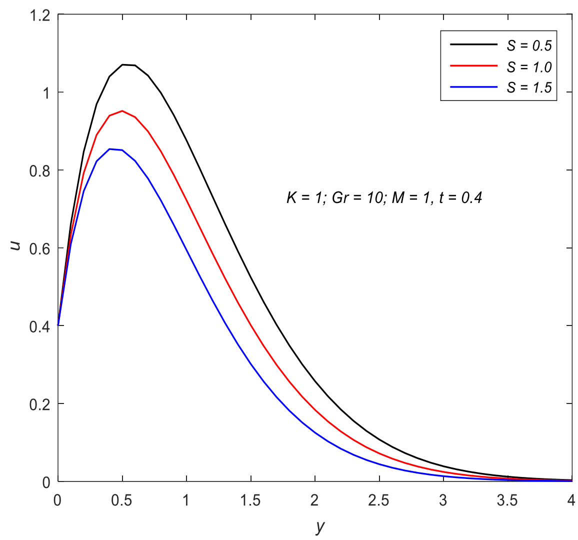
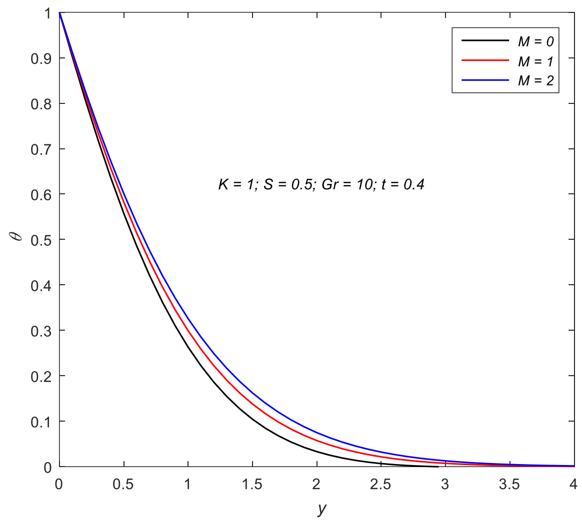


Fig.3: velocity v/s tFig.4: Velocity v/s stratification parameter



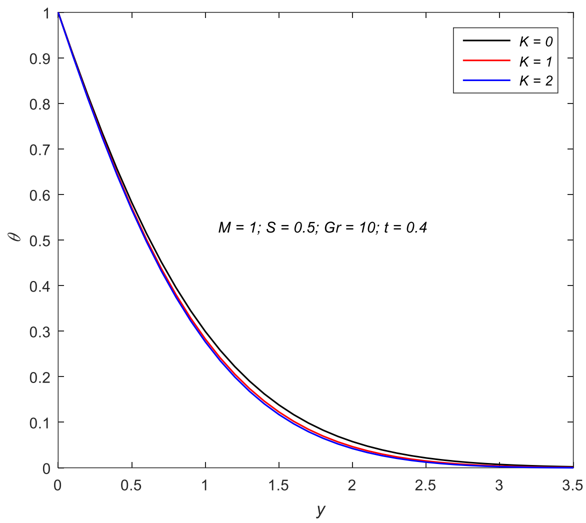
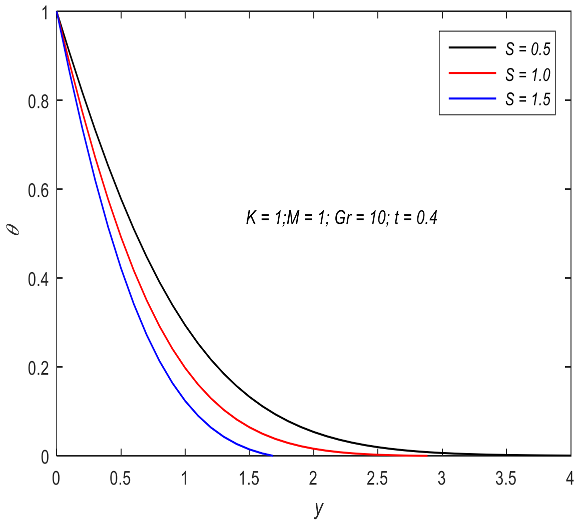


Fig.5:TemperatureV/s magnetic field Fig.6: Temperature v/s permeability parameter parameter



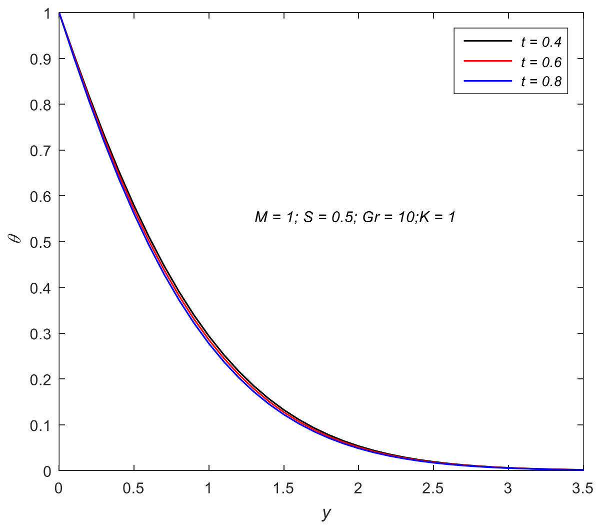


Fig.7: Temperature v/s stratification parameterFig.8: Temperature v/s time

Table-1: Differences in Skin friction and Nusselt number for distinct parameters

M	K	Gr	S	t	τ	Nu
0	1	10	0.5	0.4	-2.22203	1.761921
1	1	10	0.5	0.4	-2.00916	1.759671
1	1	10	1.0	0.4	-1.98028	1.867796
2	1	10	1.0	0.4	-1.77553	1.861046
2	1	5.0	1.0	0.4	-0.39091	1.810796
2	1	5.0	0.5	0.4	-0.40466	1.729921
1	1	5.0	0.5	0.4	-0.56616	1.732171
1	1	10	0.5	0.8	-1.34019	1.815296
1	2	10	0.5	0.4	-2.12066	1.761921
1	4	10	0.5	0.4	-2.17291	1.764171

IV. RESULTS AND DISCUSSION

The velocity & temperature profiles are depicted for various flow factors like thermal Grashof number,stratification parameter,permeability parameter, magnetic field parameter and time in figures 1-8 and the skin friction and Nusselt number results are tabulated in Table-1. The impactmagnetic field factor on the velocity& temperature profiles are shownsin the fig.1& 5. Found the velocity demonishes& temperature increases with an increase of magnetic field limitation.Figures 2 & 6 explains the behaviour of thetemperature&velocityfor various values of permeability limitation. When increasing the values of permeability parameter the velocity increases and temperature drops. The effect of time on velocity & temperature summaries illustrated in fig's 3& 8. It's clear and the velocity profiles of the fluid rise and temperature fall down with an increase of time. Figure4 and 7 displays the effects of the stratification parameter on velocity& temperature summaries. Thevelocity &temperature decrease with increasing the stratification parameter.The skin friction and Nusselt numberarerevealed in table-1for several values of flow parameters. Skin friction &Nusselt number increase when increasing values of the magnetic field factor&stratification parameter. But Skin friction and rate of heat transfer decrease withriseinthermal Grashof number and time.

V. CONCLUSION

The present study gives the following conclusions areas :

- Velocity raise with the increase in$Gr, S, K$and t and whereas decreases with increase M.
- With increase of M and S,temperature of the fluid reduces.
- Skin friction increases with an increase of M, S, K and t but decreases when thermal Grashof number is increased.
- With an increase of M, Gr K,Sand t the Nusselt number increases.

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