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Effect of Electromagnetic Field on Forced Convective Heat Transfer in a Vertical Wavy Channel Divided by a Perfectly Conductive Baffle

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Abstract**—**The effect of electromagnetic field on forced convective heat transfer in open-ended vertical wavy channel was studied. The channel was divided into two streams by means of a thin, perfectly conducting baffle and hence the velocity was individual in each passage. The fluid was set with constant initial velocities by a pump. The coupled, nonlinear partial differential equations were solved numerically valid for small values of amplitude and frequency parameter. Numerical results were presented graphically for the distribution of velocity and temperature fields for varying physical parameters such as baffle position, Reynolds number, wall temperature ratio, Hartmann number and electric field load parameter at different positions of the baffle. It was established that, an increase in Reynolds number, leads to increase in velocity. This increase in velocity is further enhanced with increase in channel width. The electric load enhances velocity when it is negative but it retarded when it is positive. The increase in Hartmann number decreases the flow velocity of fluid in a channel. The wall temperature ratio and the Prandtl number enhance temperature distribution at different positions of the partition.

Keywords**—**Conductive Baffle; Electromagnetic Field; Forced Convection; Heat Transfer; Vertical Wavy Channel.

Abbreviations**—**Electromagnetic (EM); Finite Difference Method (FDM); Partial Differential Equations (PDEs).

I. INTRODUCTION

THE effect of an EM field on convective heat transfer is of great value since these fields induce currents in a moving conductive fluid, which in turn generates forces on the fluid and the induced electric current changes the magnetic field. The set of equations which describe this flow are both the hydrodynamic and Maxwell's equations of electromagnetism. These PDEs were solved simultaneously, numerically.

Forced convection is the flow in which a fluid is forced to flow over a surface or in a channel by external means such as a pump, suction device, fan, compressor, etc. A number of researches have been done on fluid flows, naturally, forced or mixed convection with the aim of fluid flow, heat transfer or both. Research has also been carried out on the influence of EM fields on these flows and further, investigation of the nature and orientation of the channel influence on these flows has been done.

Effect of an EM field on forced convection flow of an electrically conducting fluid in different geometries is of considerable interest to the technical field due to its frequent occurrence in the industrial, technological and geothermal applications. For example, in the geothermal region, the gasses are electrically conducted and undergo the influence of magnetic field. It has also applications in nuclear engineering in connection with reactors cooling. Other applications include: transpiration cooling of re-entry vehicles, rocket boosters, cross-hatching on ablative surface and film vaporization in combustion chambers and many others.

Research has been done on vertical channels which may be of plane walls, wavy and flat walls or both wavy. Notably, study on the effect of an EM field on forced convective heat transfer by an incompressible fluid through a vertical wavy channel with a conductive baffle, is not exhausted since more emphasis is on natural or mixed convection. In this research, investigation was done to establish the effect of EM field on forced convective heat transfer in a vertical wavy channel partitioned by a thin conductive baffle. This channel is open-ended and the conductive fluid is viscous and incompressible. The main objective of this research is to study the effect of an electromagnetic field on the forced convective heat transfer in a vertical wavy channel divided by a perfectly conductive baffle. Specifically, this numerical study was to determine:

- The velocity profiles and temperature distribution at different positions of the baffle.
- The effects of Re, M, m and electric load parameters in the flow channel.

The study has shown that; injecting some external force to the flow, promotes velocity of fluid flow and heat transfer and corrugated walls enhances fluid flow as well as heat transfer. These contributions are meant to promote efficiency in areas of engineering like in heat exchangers and geothermal industry among others.

II. LITERATURE REVIEW

The effect of EM on flow of fluid through a vertical channel is of great importance in both natural and scientific applications. These flows may be natural, mixed or forced through the channels whose walls are either porous or non-porous. This kind of fluid dynamics is applied in real life situations like refrigeration, petroleum firms, solar energy collectors, power generation plants, chemical distilleries and many others.

Prathap & Umavathi [13] investigated the effect of Electro-Magnetic Field on Free Convective Heat Transfer in a Vertical wavy Channel Divided by a Perfectly Conductive Baffle. They noted the following: Maximum main velocity profiles are obtained especially in the wider passage on increasing values of Grashof number and wall temperature ratio. The presence of Hartman number and electric field load parameter reduces the flow in both the streams at all baffle positions. The effects of Grashof number, wall temperature ratio, Hartman number, electric field load parameter and product of wave number and space co-ordinate on cross velocity are exactly opposite to their effect on main velocity. They also noted that temperature is unaffected with Grashof number, Hartman number, electric field load parameter at all baffle positions. The effect of wall temperature ratio promotes the temperature. Again these effects are more pronounced in a wider passage than in the narrower passage. The effects of the Grashof number and wall temperature ratio are seen to increase the skin friction at the wavy wall and decrease at the flat wall at all baffle positions. However, their effect is not very significant. The skin friction decreases at the wavy wall and increases at the flat wall with increase of Hartman number. The effect of electric field load parameter is to decrease the skin friction at the wavy wall and increase at the flat wall at all the baffle position. Finally, the effect of the wall temperature ratio is seen to increase the heat transfer at both walls at all baffle positions. The effect of the wave number and amplitude parameter is found to increase the rate of heat transfer at the wavy wall and decrease at the flat wall. Here also their effect was not very large. The effects of Hartman number and electric field load parameter on the rate of heat transfer at the wavy wall remains almost constant at both the walls at all the baffle position.

Umavathi et al., [5] studied mixed convective flow of immiscible viscous fluids confined between a long vertical wavy wall and a parallel flat wall. Their results indicate that: When the wall temperatures are 0 and 1, the Grashof number, viscosity ratio, width ratio promotes the flow whereas, conductivity ratio retards the flow; the effect of Grashof number, viscosity ratio, and width ratio on fluid velocity perpendicular to the channel length diminishes the flow whereas, it increases as the conductivity ratio increases; the Nusselt number remains invariant on Grashof number but it decreases at the wavy wall and increases at the flat wall as width ratio decreases and conductivity ratio increases and finally it was noted that, the skin friction increases at the wavy wall and decreases at the flat wall as Grashof number increases for different wall temperature ratio. Bhupendra et al., [4] investigated Hall Effect on MHD mixed convective flow of a viscous incompressible fluid past a vertical porous plate immersed in porous medium with heat source/sink. Their observations among others include: an increase in Hall parameter leads to a decrease in the velocity for both air and water, while a reverse effect is observed for the applied magnetic field (M), an increase in Hall parameter leads to an increase in the velocity for air, while the reverse phenomenon is observed for water, values of velocity decrease as the values of M increase for air, while, there is a rise in the values of velocity in water and velocity increases gradually near the plate and then decreases slowly far away from the plate. Sreedhara et al., [17] performed an experimental heat transfer studies of water in corrugated plate heat exchangers: effect of corrugation angle. They observed that heat transfer coefficient and Nusselt number were higher for a bigger corrugation angle since high turbulence was created by this angle at a given Reynolds number. They also found out that at higher corrugation angles, higher heat transfer rates were achieved.

Prathap et al., [8] studied free convection of Walter's fluid flow in a vertical double-passage wavy channel with heat source. They noted that, the maxima of main velocity profiles are obtained for increasing values of Grashof number, wall temperature ratio and heat source/sink especially in the wider passage. The effect of viscoelastic parameter reduces the main velocity in stream-1 and increases in stream-2 for wider passage with equal wall temperature. As product of wave number and space co-ordinate increases, the main velocity increases at the wavy wall and remains constant at the flat wall at all baffle positions. The effects of Grashof number, wall temperature ratio and wave number and space co-ordinate on cross velocity are exactly opposite to their effect on main velocity. The effect of viscoelastic parameter on cross velocity remains invariant. They also noted that temperature profiles remain almost invariant with changes in the Grashof number and viscoelastic parameter at all baffle positions. The effect of wall temperature ratio promotes the temperature and the product of wavy number and space co-ordinate also increases the temperature at the wavy wall and remains constant at the flat wall. Further they realized that the skin friction increases at the wavy wall and decreases at the flat wall for increasing Grashof number, heat source/sink and wall temperature ratio for the wider passage. The viscoelastic parameter, wave number and amplitude parameter reduces the skin friction at both the walls and lastly discovered that the effect of Grashof number, wave number and the amplitude parameter decreases the Nusselt number at the wavy wall and increase at the flat wall, while the effect of heat source/sink enhances the Nusselt number at the wavy wall and reduces at the flat wall. The effect of viscoelastic parameter remains constant at both the walls at all baffle positions. The Nusselt number increases at both the walls with increase of wall temperature ratio.

Linga & Muralidhar [9] investigated unsteady convective heat and mass transfer flow of a viscous fluid in a vertical wavy channel with variable wall temperature and concentration. They found out that, the greater the constriction the larger the temperature; the higher the actual concentration in the entire flow region, the smaller the absolute initial velocity and larger absolute final velocity in the flow region. Veli et al., [15] studied the flow characteristics and heat transfer enhancement in 2D Corrugated Channels. Their results showed that the heat transfer through corrugated walled geometries is always higher than that of the flat plate. It was observed that heat transfer between the corrugated walls and base flow depends on the distance between walls. As the Reynolds number increases, the isotherm lines move toward the corrugated walls and the Nusselt number and heat transfer increase. The sudden increase in the local Nusselt number occurs at the duct throats. Hasan et al., [6] studied effects of corrugation frequency and aspect ratio on natural convection within an enclosure having sinusoidal corrugation over a heated top surface. The higher the corrugation frequency, the more enhancement of heat transfers from the heated wall. Both the average and the maximum temperature show a decreasing trend with increase in Rayleigh number for all cases of different corrugation frequencies and aspect ratios. The value of average as well as maximum temperature increases with the increase of corrugation frequency and the decrease of aspect ratio.

Prasada et al., [2] investigated MHD convection flow in a vertical wavy channel with temperature-dependent heat source. Among other findings are: perturbation for Grashof number (G) greater than zero due to wavy walls retard the fluid motion everywhere in the channel except in a narrow layer; the skin friction decreases in magnitude with increase in Hartmann number and heat source parameter and increase in magnitude with increase in Arjumand [10] studied unsteady free and forced convective MHD flow through porous vertical channels with thermal waves. It was noted that the temperature of fluid increases due to decrease in Heat sink parameter and increase in Prandtl number and frequency parameter. The Grashof number, Permeability parameter and Hartmann number have negligible effect on Temperature of fluid. The Skin Friction coefficient at the wavy walls decreases due to decrease in Grashof number and increase in Hartmann number. The Skin Friction coefficient at the wavy walls increases due to increase in Prandtl number, Heat source parameter, Permeability parameter. Guria & Jana [3] studied hydrodynamic flows through vertical wavy channel with travelling thermal waves embedded in porous medium. They found that for small values of frequency parameter, the cross velocity first increases and then decreases with increase in frequency parameter. The flow is also reversed for the cross flow. It is seen that the shear stresses at the plates rises with an increase in the permeable parameter. The temperature profile decreases with an increase in the Prandtl number while it increases with increase in the permeable parameter. Further, it was seen that the heat transfer coefficient increases with an increase in the permeable parameter but decreases with an increase in the Grashof number. Ahammad et al., [11] analyzed MHD free convection flow along a vertical porous plate embedded in a porous medium with magnetic field and heat generation. They found out from their study: increasing heat generation parameter results growth of velocity boundary layer while enhancing magnetic field parameter, reduced boundary layer thickness. They also noted that temperature profiles were elevated by increasing magnetic field parameter and for more cooling buoyancy parameter should be increased. Finally, concentration fields had a significant effect of both magnetic field and heat generation parameters.

Balasubrahmanyam et al., [7] determined the combined effects of radiation and magnetic field on mixed convective heat and mass transfer through a porous medium in a vertical wavy channel with constant heat source. It was noted that an increase in radiation parameter results in an enhancement in the temperature; an increase in heat source parameter enhances temperature and for an increase in heat source parameter, temperature reduces in the fluid region and they also noticed that, the actual temperature decreases with an increase in Hartmann number. Vajravelu & Sastrip [1] studied free convective heat transfer in a viscous incompressible fluid confined between a long vertical wavy wall and a parallel flat wall. Haitham & Ahmet [12] studied thermodynamic analysis of fluid flow in channels with wavy sinusoidal walls and noted the following: as the Re increases, flow separation and re-circulation occurs in the module resulting in local concentrations of the entropy generation within the channel; increased height ratio led to more uniform distribution of the entropy generation in axial direction and as the length ratio decreased the re-circulation of fluid flow increased causing higher concentrations of local entropy generation in the channel module. Rahima & Ahsène [14] studied forced Convection of the Bi and Three-Dimensional flow in a Periodic Channel and their results showed that the Nusselt numbers are very high as compared to those of the smooth channel. This is due to the fact that the corrugated channel causes good mixing and thus leads to a great improvement of heat transfer. They also noted that an increase in the Reynolds number leads to a decrease in the friction coefficient. Mahadev M. Biradar [16] investigated magneto-convective flow and heat transfer of two immiscible fluids between vertical wavy wall and a parallel flat wall. The results include: effect of all the parameters except the Hartmann number and source or sink remains same for two viscous immiscible fluids; an increase in Hartmann number suppressed the velocity at the wavy and flat wall; suppression near the flat wall compared to wavy wall is insignificant and finally, velocity was large for source compared to sink for equal and different wall temperature. As indicated in the literature above, effects of EM field on forced convective heat transfer in a vertical wavy channel divided by a thin conductive baffle has not been exhaustively researched. The investigation was on effect of EM on forced convective flow through a vertical wavy channel which is divided by a partition (baffle) into two passages. The widths of the passages were varied by adjusting the baffle positions within the width of the channel and a constant velocity of the fluid was set at the inlet. This area was investigated since it had received little attention.

III. MATHEMATICAL FORMULATION

The physical configuration (Figure 1) below consists of an open-ended vertical channel with one wavy wall and the flat. The channel was divided into two passages by means of a perfectly conducting thin adjustable baffle and the onset axial velocities were set by the pump, for which the transverse thermal resistance, natural flow and continuity of temperature and heat flux at the baffle position were assumed. The X- axis was taken upwards and parallel to the flat wall, while the Y-axis was taken perpendicular to it in such a way that the wavy wall was represented by Y = $A\cos(kX)$) and Y = L the flat wall. The channel was occupied by a viscous, incompressible electrically conducting fluid. A uniform magnetic field, $B_{o,}$ was applied normal to gravity and electric field, $E_{o,}$ was applied parallel to gravity. The flow was assumed to be steady, laminar and fully developed. The wavelength of the wavy wall was large compared with the breadth of the channel. The wavy and flat walls were maintained at a constant temperature T_w and T_f, respectively.

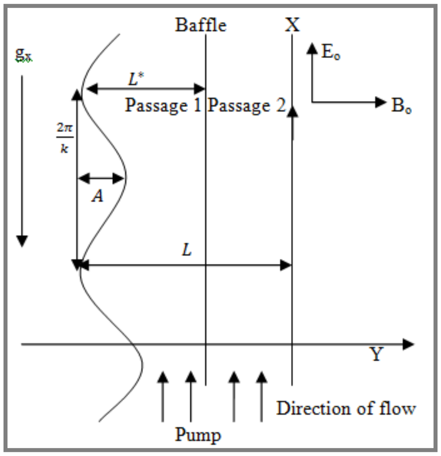

Figure 1: Physical Configuration of the Double-Passage Channel

IV. GOVERNING EQUATIONS

Fluid motion was governed by a set of coupled nonlinear partial differential equations derived from the basic laws of conservation of mass, momentum and energy equations. The unknowns were usually the velocity, pressure, density and temperature. These equations governing this flow were analyzed numerically. A computer program was used to generate solutions, data generated in tables, analyzed and represented in graphs. Finite difference method (FDM) of order two was employed in solving these PDEs. These equations governing the flow were derived, non-dimensionalized, descritized and solved using finite difference. Following the assumptions above, these equations include continuity, momentum and energy [Prathap & Umavathi, 13], which were as follows:

$$\frac{\partial U_i}{\partial X} + \frac{\partial V_i}{\partial Y} = 0 \tag{1}$$

$$\rho \Big(U_i \frac{\partial U_i}{\partial X} + V_i \frac{\partial U_i}{\partial Y} = -\frac{\partial P_i}{\partial Y} + \mu \frac{\partial^2 U_i}{\partial X^2} - \sigma B_o^2 U_i - \sigma B_o E_o, \tag{2}$$

$$U_i \frac{\partial T_i}{\partial x} + V_i \frac{\partial T_j}{\partial y} = \frac{k\partial^2 T}{\rho C_p \partial y^2} \tag{3}$$

Subject to the following conditions

$T_1 = T_w$, $U_1 > 0$ on Y=$A\cos(kX)$

$U_1 = U_2 > 0$, on $Y = L^*$

$T_1 = T_2, \frac{\partial T_1}{\partial Y} + \frac{\partial T_1}{\partial X} = \frac{\partial T_2}{\partial Y} + \frac{\partial T_2}{\partial X}$ on $Y = L^*$

$T_2 = T_f$, $U_2 > 0$ on $Y = L$

where U_1 and U_2 are velocity components and T is the fluid temperature.

These equations 1-3 above were non-dimensionalized using the following transformations:

$$x = \frac{X}{L}, y = \frac{Y}{L}, u_i = \frac{U_i L}{v}, \theta = \frac{T - T_s}{T_w - T_s},$$
$$P' = \frac{P}{\rho (v/L)^2}, m = \frac{T_1 - T_s}{T_w - T_s}, M = B_o L \sqrt{\frac{\sigma}{\rho v}}, E = \frac{E_o}{u_o B_o} \tag{4}$$

Using equations (4) in (1)-(3), the non-dimensional governing equations were as below;

$$\frac{\partial u_i}{\partial x}+\frac{\partial v_i}{\partial y}=0 \qquad (5)$$

$$u_i\frac{\partial u_i}{\partial x}+v_i\frac{\partial u_i}{\partial y}=-\frac{\partial {P'}_i}{\partial x}+\frac{1}{Re_L}\nabla^2 u_i-M^2(u_i+E \qquad (6)$$

$$u_i\frac{\partial \theta_i}{\partial x}+v_i\frac{\partial \theta_i}{\partial y}=\frac{1}{Pe}\nabla^2\theta_i \qquad (7)$$

Subject to the conditions:

$$\theta_1=1, u_1>0 \text{ on } \mathrm{Y}=A^o\cos(\lambda x$$

$$\left.\begin{array}{l} u_1=u_2>0 \\ \theta_1=\theta_2, \frac{\partial\theta_1}{\partial x}+\frac{\partial\theta_1}{\partial y}=\frac{\partial\theta_2}{\partial x}+\frac{\partial\theta_2}{\partial y} \end{array}\right\} \text{on } Y=L^*$$

$$\theta_2=m, u_2>0 \text{ on } Y=L$$

where P= $\frac{\mu C_p}{K}$ is Prandtl number, $A^o=\frac{A}{L}$ is the amplitude parameter, $\lambda=kL$ is the wavelength, $\theta=\frac{(T_1-T_s)}{(T_w-T_s)}$ is the wall temperature ratio, $E=\frac{E_o}{u_o B_o}$ is the electric field loading parameter, M= $B_oL\sqrt{\frac{\sigma}{\rho v}}$ is Hartman number, Re $=\frac{\rho vL}{\mu}$ is Reynold number and Pe=RePr is the Peclet number.

V. METHODS OF SOLUTION

The non-linear PDEs equations were solved using implicit FDM of order two following the following steps:

i. Generate a grid e.g. $(i\Delta x, j\Delta y,$ where we want to find an approximate solution for u(x,y) and v(x, y) for i, j = 0, 1, 2…..n
ii. Substitute the derivatives in a PDE system of equations with finite difference schemes and changed to linear system of algebraic equations.
iii. System of equations is solved using a computer program.

Finite difference grid was used to calculate values of at the mesh points in which each point was identified by double index (i, j). Using Crank-Nicolson FDM, the equations 5, 6 and 7 results to 8, 9 and 10 respectively. (Causon, D.M and Mingham, C.G, (2010). Introductory finite difference methods for PDEs).

$$\frac{1}{2}\ \frac{u_{i+1,j}^{n+1}-u_{i-1,j}^{n+1}}{2\Delta x}+\left(\frac{u_{i+1,j}^{n}-u_{i-1,j}^{n}}{2\Delta x}\right.=0 \qquad (8)$$

$$\begin{aligned}\frac{1}{2}\ u_{i,j}^{n+1}\ \frac{u_{i+1,j}^{n+1}-u_{i-1,j}^{n+1}}{2\Delta x}+u_{i,j}^{n}\ \frac{u_{i+1,j}^{n}-u_{i-1,j}^{n}}{2\Delta x}\\ =-\frac{1}{2}\ \frac{p_{i,j+1}^{n+1}-p_{i,j-1}^{n+1}}{2\Delta y}\\ +\ \frac{p_{i,j+1}^{n}-p_{i,j-1}^{n}}{2\Delta y}\\ -\frac{1}{Re}\ \frac{1}{2}\ \frac{u_{i+1,j}^{n+1}-2u_{i,j}^{n+1}+u_{i-1,j}^{n+1}}{(\Delta x)^2}\\ +\ \frac{u_{i+1,j}^{n}-2u_{i,j}^{n}+u_{i-1,j}^{n}}{(\Delta x)^2}\\ +\frac{1}{2}\ \frac{u_{i,j+1}^{n+1}-2u_{i,j}^{n+1}+u_{i,j-1}^{n+1}}{(\Delta y)^2}\\ +\ \frac{u_{i,j+1}^{n}-2u_{i,j}^{n}+u_{i,j-1}^{n}}{(\Delta y)^2}\\ -M^2\{(u_{i,j}^{n+1}-u_{i,j}^{n})+E\end{aligned} \qquad (9)$$

$$\begin{aligned}\frac{1}{2}\ u_{i,j}^{n+1}\ \frac{\theta_{i+1,j}^{n+1}-\theta_{i-1,j}^{n+1}}{2\Delta x}+u_{i,j}^{n}\ \frac{\theta_{i+1,j}^{n}-\theta_{i-1,j}^{n}}{2\Delta x}\\ +\frac{1}{2}\ v_{i,j}^{n+1}\ \frac{\theta_{i,j+1}^{n+1}-\theta_{i,j-1}^{n+1}}{2\Delta y}\\ +v_{i,j}^{n}\ \frac{\theta_{i,j+1}^{n}-\theta_{i,j-1}^{n}}{2\Delta y}\\ =\frac{1}{Pe}\ \frac{1}{2}\ \frac{\theta_{i+1,j}^{n+1}-2\theta_{i,j}^{n+1}+\theta_{i-1,j}^{n+1}}{(\Delta x)^2}\\ +\left(\frac{\theta_{i+1,j}^{n}-2\theta_{i,j}^{n}+\theta_{i-1,j}^{n}}{(\Delta x)^2}\right.\\ +\frac{1}{2}\ \frac{\theta_{i,j+1}^{n+1}-2\theta_{i,j}^{n+1}+\theta_{i,j-1}^{n+1}}{(\Delta y)^2}\\ +\left(\frac{\theta_{i,j+1}^{n}-2\theta_{i,j}^{n}+\theta_{i,j-1}^{n}}{(\Delta y)^2}\right.\end{aligned} \qquad (10)$$

Since Crank-Nicolson is an implicit scheme, values at time n+1 were found by forming a system of linear equations which lead to a tri-diagonal matrix that is solved by Matlab software.

VI. RESULTS AND DISCUSSION

The effect of electromagnetic field on forced convective heat transfer in a vertical channel whose walls are one wavy and the other flat. This channel is divided by a conductive partition into two passages. Dimensionless numbers have been studied, that is, their effect and relationship with velocity and temperature. These numbers include: Reynolds, Hartmann, wall temperature ratio, electric load and Prandtl numbers. These effects were established in the two streams, that is, between the baffle and the wavy wall and the partition and the flat wall.

Results in the first passage is as depicted by table 1, Figure 2 and Figure 3.The graph (Figure 2) indicate that, velocity increases with increase in Reynolds number. This implies that, the viscous force is minimized and hence inertial dominates leading to increased velocity. It is also shown that, as the partition is moved further away from the wall, the velocity increases at any given Re which also shows that, viscous force is overcome hence increase in velocity.

The electric load is the portion of a circuit that consumes electric power. The table (Table 1) depict that velocity decreases with increase in positive electric load. This implies that positive E retards the flow. Negative electric load promotes the flow. It is also indicated that, as you increase channel width, there is reduction of velocity. The effect of Hartmann number from the results in (Figure 3), is that, increase in M leads to a decrease in velocity. Hartmann number, M, is the ratio of Lorentz force to viscous force, thus an increase in M implies more retarding force to the flow of the fluid. This effect is more pronounced as the passage width is increased implying that the Lorentz force, that is, electromagnetic force dominates.

Table 1: Effect of E, on Velocity at Different Baffle Positions from the Wavy Wall

	BAFFLE POSITION L^*=0.2	**BAFFLE POSITION L^*=0.4**	**BAFFLE POSITION L^*=0.8**
VELOCITY WHEN E=-1	441.7672	356.3675	246.7893
VELOCITY WHEN E=0	431.7670	346.3670	236.7890
VELOCITY WHEN E=1	421.7666	336.3668	226.7888

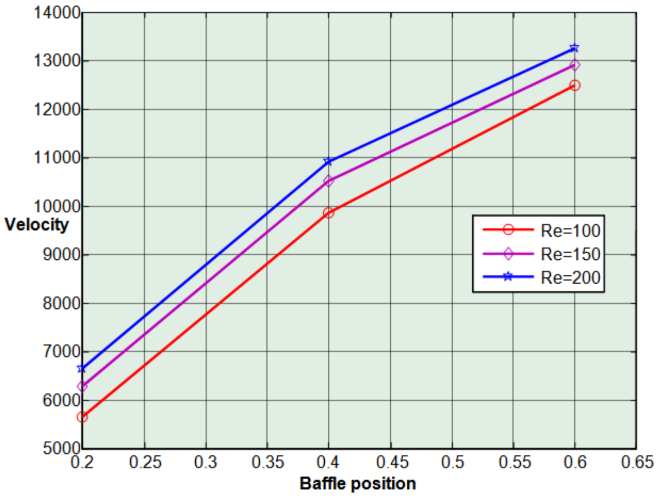

Figure 2: Velocity against Baffle Position at Varying Reynolds Numbers

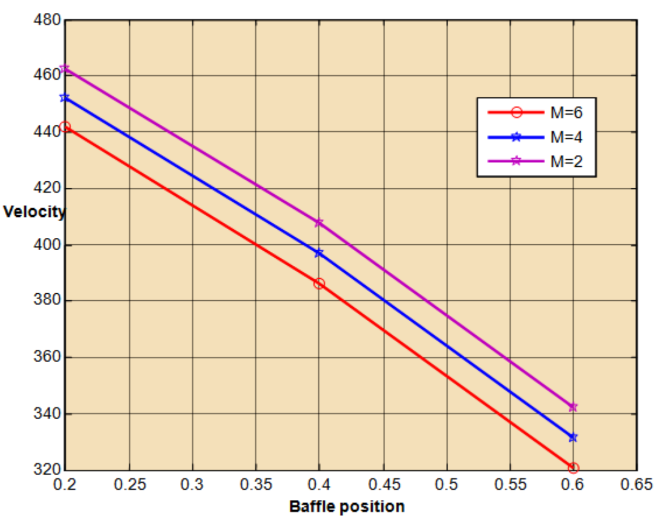

Figure 3: Velocity against Baffle Position at Varying Hartmann Numbers

In the second passage (stream between the partition and the flat wall), it was established as follows: Velocity decreases with reduction in width between baffle and the flat wall. This implies that, as the width increases the viscous force dominates at a particular Reynolds number. It is also seen that, as the Reynolds number increases, the velocity increases too implying that inertia force dominates (Figure 4). Further, it is noted that, velocity is enhanced in the first channel compared to the second one. This is as result of reduction of the viscous force by the corrugated wall. The Hartmann number, M, retards the velocity, that is, increase in M decreases the velocity. This implies that, when the eletromagnetic force dominates, the velocity is decreased (Figure 5). It is also noted that as the width decreases between the partition and the flat wall, the velocity also decreases.

In Figure 6, as the wall temperature ratio increases, the temperature also increases. It is seen that, as the baffle portion changes away from the wall, the temperature also increases. From the set of graphs above (Figure 7), it is indicated that as the Prandtl number decreases, the temperature decreases. Prandtl number is the ratio of momentum diffusivity to thermal diffusivity so the observation implies that as the thermal diffusion rate increases, the temperature decreases.

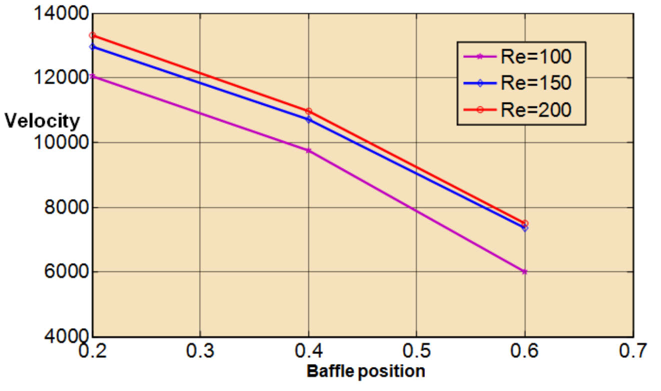

Figure 4: Effect of Reynolds Number on Velocity

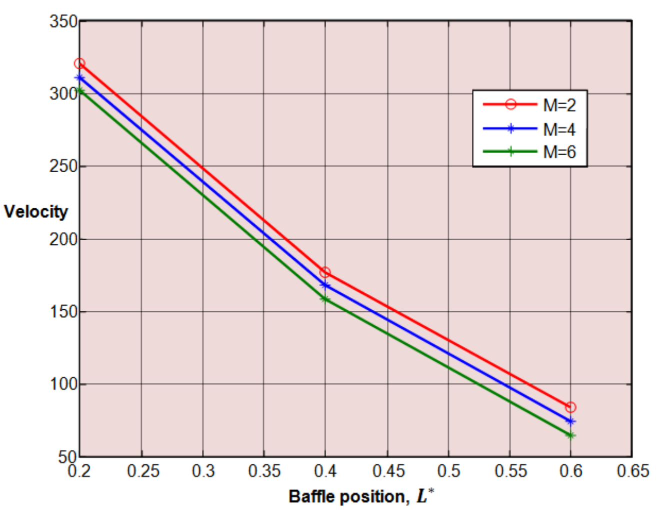

Figure 5: Velocity against Baffle Position at Varying Hartmann Numbers, M

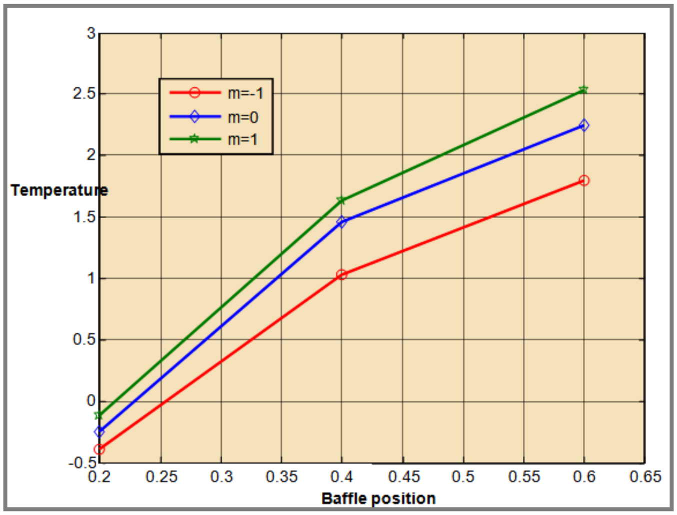

Figure 6: Variation of Wall Temperature Ratio and Temperature

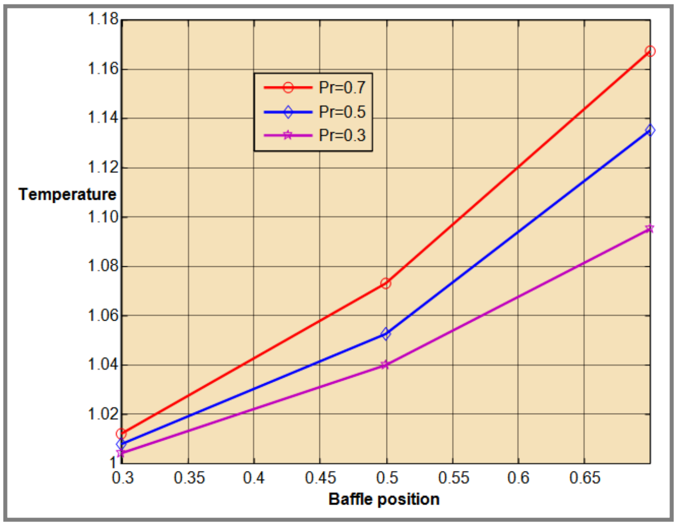

Figure 7: Variation of Prandtl Number and Temperature

VII. CONCLUSIONS

The effect of electromagnetic field on forced convective heat transfer in a vertical wavy channel divided by conductive partition was studied. It was found out that, as the Reynolds number increased, velocity of the fluid flow was enhanced. This implies that the inertial forces dominated over the viscous forces. Hartman number retards the flow velocity, that is, increased M implies electromagnetic dominates and as result lead to increased retarding force to the flow. It was also seen that reduction of electric load reduction promotes the fluid flow. It was further indicated that, the temperature is increased with increase in wall temperature ratio and Prandtl number. Finally, it was noted that, the wavy wall enhances the flow and temperature distribution.

VIII. FUTURE WORK

It is recommend that for enhanced flow and heat transfer, electric and magnetic fields are supplied. It is also worth to inject some pressure to the fluid for optimum results. Further, it is recommended that research be done on the following:

i) Effect of forced flow on skin friction on this kind of channel.
ii) Analytically study the effects of Reynolds Prandtl and Hartmann numbers, electric load and wall temperature ratio on this kind of set up.

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