TRANSIENT FREE CONVECTION FLOW PAST AN INFINITE VERTICAL PLATE WITH VARIABLE HEAT FLUX

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ABSTRACT

Transient free convection flows past an infinite vertical plate under different physical condition were studied in 60's by many researchers and all the papers are referred in Goldstein and Briggs [27]. In case of constant heat flux is rather a very restricted boundary condition. Many times the heat flux at the plate is oscillatory which effects free convection flow. Uplekar [95] and [96] discussed elastic viscous fluid past an infinite vertical plate under variable wall temperature and Laplace transform technique was applied Soundelgaker [86] to [89] has discussed various cases also in presence of magnetic field and used different techniques with different authors. Here we shall try to deal the flow of an electrically conducting incompressible viscous fluid past an infinite vertical accelerated plate.

Key Words : Convection, Incompressible, Oscillation

6.2 MATHEMATICAL ANALYSIS

Uplekar used the following equation in case of elastic viscous fluid [19] and [24], [27] :

(6.2.1) $$\frac{\partial u}{\partial t} = G\theta + \frac{\partial^2 u}{\partial y^2} - K\frac{\partial^3 u}{\partial y^2 \partial}$$

(6.2.2) $$\rho r \frac{\partial \theta}{\partial t} = \frac{\partial^2 \theta}{\partial y^2}`$$

Boundary condetions are om (3)

(6.2.3) $$u(\theta) = 0, \theta(0) = 1 or \frac{d\theta}{dy}(\vartheta) = -1$$

$$u(\infty) = 1, \theta(\infty) =$$

Boundary conditions used in (4):

(6.2.4) $t \le 0, \quad u = 0, \quad \theta = Vy$

$$t \ge 0, \quad u = 0, \quad \theta = G_r t$$

$$at\ y = 0,\ u = 1,$$

$$\theta = 0, \quad as\ y =$$

We have cosidered the flow of an electrically conducting viscous fluid past an infinite vertical plate impulsively started x' axis is taken along the plate in vertical direction and y' axis normal to the plate. An uniform magnetic field of strength B_0 is applied to the y' axis and induced magnetic field is taken negligible. The equations are as follows :

(6.2.5) $$\frac{\partial u}{\partial t} = G\theta + \frac{\partial^2 u}{\partial y^2} - M_u$$

(5.2.6) $$\rho r \frac{\partial \theta}{rt} = \frac{\partial^2 \theta}{\partial y^2}$$

$$u = 0, \quad \theta = Vy,$$

$$t \le 0 \theta = 1$$

(6.2.7) $$u = \frac{G}{M}\left(1 - + e\frac{Mt}{P_r - 1}\right)$$

$$u = 0, \quad \theta = 0 \quad at\ \ y \to 0$$

Taking Laplace transform of (6.2.6) and making use of Boundary conditions, we get :

$$\theta = \frac{1}{p\theta} e^{-\sqrt{p\rho r y}}$$

Taking inversion me obtain :

(6.2.8) $$\theta = erf_c\left(\sqrt{P_r}\frac{y}{2\sqrt{t}}\right) = erf_c\left(\eta\sqrt{P_r}\right)$$

Where $$\eta = \frac{y}{2\sqrt{t}}, u = \frac{y\sqrt{\rho_r}}{2\sqrt{t}}$$

$$\frac{\partial u}{\partial t}-\frac{\partial^2 u}{\partial y^2}+mU=Gerf_c\sqrt{\rho_r}$$

Taking Laplace, transform, we find

$$Pu-u_0-\left(\frac{d^2u}{dy^2}\right)+Mu=G\frac{e^{-\sqrt{P}\sqrt{\Pr}y}}{P}$$

$$(D^2-(p+M))u=\frac{-Ge-\sqrt{p}\sqrt{P_r y}}{p}$$

Solving above equations, we get

$$u=G_re^{-(p+M)y}-\frac{G\,\frac{e-\sqrt{P}\sqrt{\Pr}y}{P}}{Ppr-(p+m)}$$

(6.2.9) Using BC's, we have

$$u=\frac{G}{M}\left[\frac{-e^{-\sqrt{P}\sqrt{\rho r y}}}{P}+\frac{e^{-\sqrt{p}\sqrt{pry}}P_r-1}{p(P_r-1)-M}\right]$$

Taking inversion, we get

$$u=\frac{G}{M}(-e_r f_c\sqrt{P_r}\eta+$$

$$\frac{G}{M}\angle^{-1}P_{r-1}\left(\frac{e^{-\sqrt{p}\sqrt{\Pr}y}}{p(P_{r-1})-M}\right))$$

On using BC's we obtain

$$u=\frac{G}{M}\left(-e_r f_c e^{\sqrt{1-\Pr\eta}}\right)+\frac{G}{M}\frac{\angle^{-1}e^{-\sqrt{\Pr}y}}{P-\frac{M}{\Pr-1}}$$

$$Let\ p-\frac{M}{P_r-1}=P$$

$$u=\frac{G}{M}(-erf_c\sqrt{1-P_r}\eta+\frac{G}{M}\frac{\angle^{-1}e^{-\sqrt{Pr}y}\left(P+\frac{M}{\Pr-1}\right)}{P})$$

$$u=\frac{G}{M}(-erf_c\frac{\sqrt{P_r y}}{2\sqrt{t}}+e^{\frac{-M}{\Pr-1}}\sqrt{P_r y}\frac{\angle^{-1}e^{-\sqrt{\Pr y}}}{P})$$

$$=\frac{G}{M}\left(e_r f_c\frac{\sqrt{1-P_r y}}{2\sqrt{t}}+e^{\frac{-M}{\Pr-1}}\sqrt{P_r y}erf_c\frac{\sqrt{P_r y}}{2\sqrt{t}}\right)$$

Finally we get

(6.2.10) $$u=\frac{G}{M}e_r f_c\frac{\sqrt{P_r y}}{2\sqrt{t}}\left(-1-e^{\frac{-M}{Pr-1}\sqrt{Pr\, y}}\right)$$

(6.3) NUMERICAL & CONCLUSION

In order to get the Physical insight into the problem, numerical calculation have been carried out for

P_r=0.1, 0.7, M=2,4, t=0.2, 0.4, 0.5

$y\rightarrow u$

1. $u=[erf_c^{(0.707y)}][e^{0.6328y}-1]$

{M=2,G=2,t=0.1, P_r=0.15}

y	0	0.2	0.4	0.6	0.8	1.0	1.2
u	0	0.0813	0.1754	0.2857	0.4164	0.5721	0.7581

2. $u=[erf_c\,(0.25y)][e^{0.6328y}-1]$

{M=2, t=0.4, G=2. P_r=0.1}

y	0	0.2	0.4	0.6	0.8	1.0	1.2
u	0	0.0811	0.1734	0.2787	0.3986	0.5364	0.6933

3. $\theta=erf_c(y/u)$

y	0	1	2	3	4	5	6
u	0	0.648	0.7581	0.8706	0.9460	0.9825	0.9956

5. $u=0.5\,[erf_c(0.353y)]\,[e^{1.406y}-1]$

{M=4, t=0.2, G=2. P_r=0.1}

y	0	0.2	0.4	0.6	0.8	1.0	1.2
u	0	0.0977	0.2275	0.4011	0.6324	0.9444	1.3622

6. $u=0.5\,[erf_c\,(0.25y)]\,[e^{1.406}y-1]$

{M=4, t=0.4, G=2. P_r=0.1}

y	0	0.2	0.4	0.6	0.8	1.0	1.2
u	0	0.0976	0.2273	0.3997	0.6296	0.9354	1.3429

(a) **CONCLUSION**

From the above tables it is clear that velocity increase with the increase in M and also value of t and P_r as we move in positive direction along plate.

(b) The temperature increase on the positive side of the plate as value of P_r increases.

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