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Review Of Boundary Layer Flow Over An Inclined Sheet

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Abstract
In this paper we study about the Nonlinear Boundary layer flow over an inclined sheet. We study about the similarity transformation to convert partial differential equations into ordinary differential equations, and then use numerical approach to solve these equations. We also study about the applications of nanofluid in different field.
Keywords: - *Similarity transformation, Shooting method, Runge-kutta 4th order method.*

1- INTRODUCTION

There have been many studies regarding heat transfer of fluids over stretching sheet. In view of these, the present problem considers the mixed convective boundary layer flow of a viscous, incompressible nanofluid over an inclined stretching sheet. A nanofluid is a fluid containing nano-meter sizes particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides or carbon nanotubes. Common base fluids include water, ethylene glycol and oil. Choi striked the term nanofluid firstly. Nanofluids are primarily used for their enhanced thermal properties as coolants in heat transfer equipment such as heat exchangers, electronic cooling system and radiators. Nanofluids do not occur in nature. Nanofluids are produced by several techniques.The nanofluid is taken under study is copper-water nanofluid and water is considered as the base fluid with Pr=7.02 and density of water is 1000.52kg/m^3 at 20℃.The fluid flow over an inclined stretching sheet with an angle of inclination $\propto$ with the linear velocity $u_w(x)$ =ax. Here a is used as a constant term and x is taken as the coordinate calculated on the stretching surface. We used copper-water nanofluid in this study which is formed by mixing solid spherical copper nano particles of 100 nm diameter with water.

2- APPLICATIONS

Nanofluids are primarily used for their enhanced thermal properties as coolants in heat transfer equipment such as heat exchangers, electronic cooling system and radiators. Nanofluids can be used for liquid cooling of computer processors due to their high thermal conductivity. There is a new initiative which takes advantage of several properties of certain nanofluids use in cancer imaging and drug delivery. Magnetic nanofluids are to be used to guide the particles up the bloodstream to a tumour with magnets. Nanofluids are used for cooling of microchips in computers and elsewhere. Nanofluids are important because they can be used in numerous applications involving heat transfer and other applications such as in detergency.

3- EQUATION OF THE FLOW

Considers the steady, nonlinear two dimensional mixed convective boundary layer flow of a viscous, incompressible nanofluid over an inclined stretching surface .on keeping the origin fixed the sheet is stretched and with the change in inclination angles the variations can be seen. In this Cartesian coordinates are chosen .The stretching sheet is taken as x-axis and its perpendicular line is chosen as

the y-axis. The governing boundary layer equations are-

$$\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}=0 \quad (1)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=g\beta_{nf}(T-T_{\infty})\sin\alpha+g\beta^{*}_{nf}(C-C_{\infty})\sin\alpha-\frac{1}{\rho_{nf}}\frac{\partial p}{\partial x}+\nu_{nf}\left(\frac{\partial^2 u}{\partial y^2}\right) \quad (2)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha_{nf}\left(\frac{\partial^2 T}{\partial y^2}\right)+\in\left[D_B\left(\frac{\partial C}{\partial y}\ \frac{\partial T}{\partial y}\right)+\frac{D_T}{T_{\infty}}\left(\frac{\partial T}{\partial y}\right)^2\right] \quad (3)$$

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D_B\left(\frac{\partial^2 C}{\partial y^2}\right)+\frac{D_T}{T_{\infty}}\left(\frac{\partial^2 T}{\partial y^2}\right) \quad (4)$$

With boundary conditions

At y=0, $u=u_w(x)=ax, v=0, T=T_W, C=C_W$

At $y\to\infty u=0, T=T_{\infty}, C=C_{\infty}$

In the x and y directions the velocity components of the fluid are $u$and v.By similarity transformation above partial differential equation transformed into ordinary differential equation with these similarity variables-

$$\varphi(x,y)=(av_{nf})^{\frac{1}{2}}xf(n), \qquad n=y(\frac{a}{v_{nf}})^{1/2}$$

$$\theta=\frac{T-T_{\infty}}{T_W-T_{\infty}}\ , \qquad \emptyset=\frac{C-C_{\infty}}{C_W-C_{\infty}}$$

After similarity transformation momentum, energy and concentration equation can be written as-

$$f'''+ff''-(f')^2+\lambda\theta\sin\alpha+\lambda^{*}\phi\sin\alpha=0 \quad (5)$$

$$\frac{1}{(Pr)_{nf}}\theta''+f\theta'+N_b\phi'+N_b(\theta')^2=0 \quad (6)$$

$$\theta''+(Sc)_{nf}f\theta'+\frac{N_t}{N_b}\theta''=0 \quad (7)$$

With the boundary condition

$f(0)=0, f'(0)=1, \theta(0)=1, \phi(0)=1$

$f'(\infty)=0, \theta(\infty)=0, \phi(\infty)=0$

4- NUMERICAL ANALYSIS

Since equations are in nonlinear differential equations with boundary value problem and boundary value problem are hard to solve. So these equations can be converted into initial value problem by shooting method. Equations are numerically solved by using 4^{th} order runge kutta method. So we use similarity transform, shooting method and runge-kutta 4^{th} order in this system.

5- RESULTS

In this study, mixed convective boundary layer flow of a viscous, incompressible nanofluid over an inclined stretching sheet is studied and numerical results for velocity and temperature distribution are obtained.

Numerical solution are made for different values for physical parameters.That can be chosen as Nt (thermophoresis parameter) =0.1,0.2,0.3,0.4,0.5 and α=0°,30°,45°,60° and Pr(prandtl number)=6.06 for fixed values of Sc(Schmidt number)=10,Nb=0.1,λ=0.5 and λ^{*}=0.5.

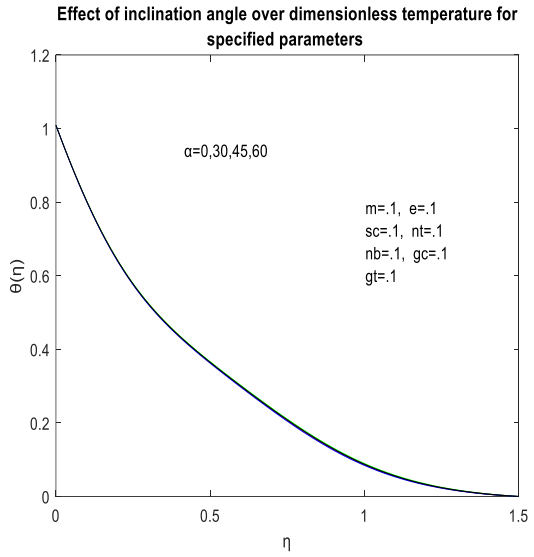

Fig.1

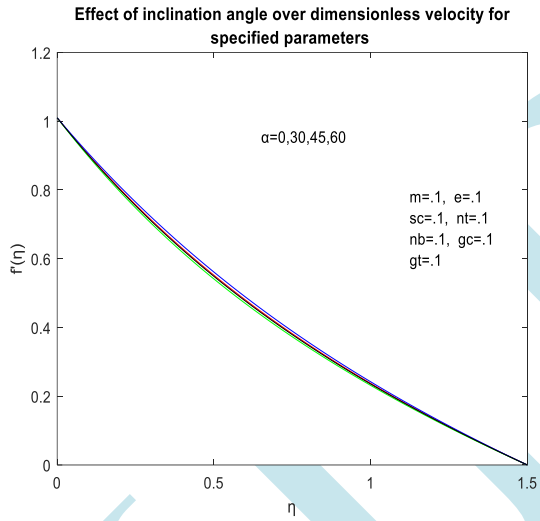

Fig.2

6- CONCLUSION

The conclusion of the problem is as follows:-

- When angle of inclination α=0˚, them results are in excellent agreement.
- When α increases then dimensionless velocity increases, dimensionless temperature and dimensionless concentration decrease.
- When Pr increases then dimensionless velocity and dimensionless temperature decreases.
- When Pr increases then dimensionless concentration increases up to certain distance from the plate and thereafter it gets decreased.

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