The Effect Chemical Reaction to Free Convection of Micropolar Fluid in a Vertical Channel

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Abstract. The present analysis is focused to the criteria for the onset of flow inversion of the fully developed free convection of micropolar fluid in a vertical channel under the effect of the chemical reaction. The governing equations force are solved and calculated numerically by Shooting Method based on Fourth order Runge Kutta Method. Parameter for the occurrence of invented flow by was presented. The exothermic chemical reaction is adopted to gain the optimally velocity, microrotasi and temperature.

Keywords: Micropolar Fluid; Chemical Reaction; Free Convection

1 Introduction

Micropolar fluids suggested by [1]simulated accurately the flow characteristics of polymeric additives, geomorphological sediments, colloidal and haematological suspensions, liquid crystals, lubricants etc. Studies of the flows of heat convection in micropolar fluids focus mainly on flat surfaces by Rahman et al. in[7]-[11]. [13] have considered natural convection flow of micropolar fluid along a vertical and a permeable semi-infinite plate embedded in a porous medium. The problem of fully developed natural convection heat and mass transfer of a micropolar fluid between porous vertical plates with asymmetric wall temperatures and concentrations is analyzed by [14].

Flow of fluids with internal heat sources are of great practical and theoretical interest. The fluid motion develops slowly following the development of non-uniformity in the temperature field. The volumetric heat generation/ absorption term exerts strong effectto the flow when the temperature difference is appreciably large. The analysis of temperature field as modified by the heat source in a moving fluid is important in view of chemical reactions.One of the earlieststudieson free convection of micropolar fluid inaverticalchannelwith uniform wall temperatures had been studied analytically by [2].

Foraboschi and Federico in [5] have assumed 2 state volumetric heat generation as depending on temperature difference

$$\theta = \begin{cases} \theta_0(T - T_0), T \geq T_0 \\ 0 \qquad\qquad , T > T_0 \end{cases} \tag{1}$$

In many chemical engineering processes chemical reactions take place between a foreign mass and the working fluid which moves due to stretching or otherwise of a surface. A chemical reaction is said to be first order and homogenous if its rate of reaction is directly proportional to the concentration and it occurs as a single phase volume reaction. Muthucumaraswamy studied the effects of a chemical reaction on a moving isothermal

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vertical surface with suction and [3]considered MHD free convection flow and mass transfer over a stretching sheet with chemical reaction [6].

In this paper, an model is bulit with effect of chemical reaction by varous parameters to micropolar fluid

2 Mathematical Formulation

Consider a laminar free convection flow from the micropolar fluid between two solid and thick plates between two parallel and vertical walls. The space between the plates is h. Walls at y = 0 and y = h are isothermal at certain temperaturesT_1 and T_2, where it is assumed that$T_1 \geq T_2$. The fluid has a vertical velocity distribution evenly up the U_0 stream at the entrance of the channel. Thus, the basic equation for asteady and fully developed flow from a thick, non-compactable and heat fluid that is assumed to be supplied to the surrounding fluid in[4] by an exothermic surface reaction [12]. On the basis of this assumption, the equation describes the physical situation

$$(\mu + \kappa)\frac{d^2u}{dy^2} + \kappa\frac{dn}{dy} + \rho g\beta(T - T_0) = 0 \quad (2)$$

$$\gamma\frac{d^2n}{dy^2} - \kappa\left(2n + \frac{du}{dy}\right) = 0 \quad (1)$$

$$\frac{d^2T}{dy^2} = Qk_0ae^{-\frac{E}{RT}} \quad (4)$$

Subject to boundary condition

$$\begin{aligned} u(0) = 0, \quad T(0) = T_1, \quad n(0) = 0 \\ u(h) = 0 \quad T(h) = T_2 \quad n(h) = 0 \end{aligned} \quad (5)$$

Reactions occur only on surfaces that are constructed by Arrhenius first order kinetic. The closure system by conservation of mass flux *M* is ∫ U dY=M [4]. The construction of non-dimensional equations for this equation becomes

$$(1 + K)\frac{d^2U}{dY^2} + K\frac{dN}{dY} + \theta = 0 \quad (6)$$

$$\left(1 + \frac{K}{2}\right)\frac{d^2N}{dY^2} - K\left(2N + \frac{dU}{dY}\right) = 0 \quad (7)$$

$$\frac{d^2\theta}{dY^2} = -K_Fe^{\theta} \quad (8)$$

Where $j=h^2$ and *K* is material parameter which defined by

$$\gamma = \left(1 + \frac{\kappa}{2\mu}\right)h^2 = \left(1 + \frac{K}{2}\right)h^2$$

$$K = \frac{k}{\mu}$$

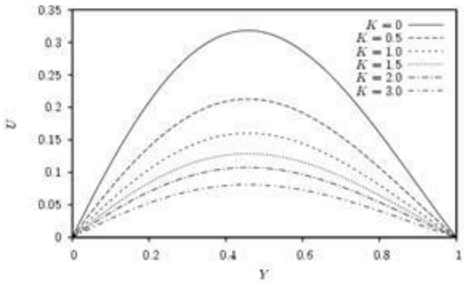
boundary condition be

$$\begin{aligned} U(0) = 0, \quad \theta(0) = R_T, \quad N(0) = 0 \\ U(1) = 0 \quad \theta(1) = -R_T, \quad N(1) = 0 \end{aligned} \quad (9)$$

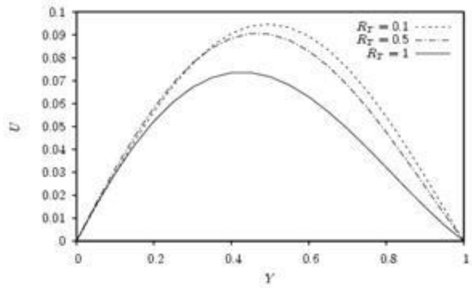
Here, effect of micropolar based on $K, N \neq 0$.

3 Result And Discussion

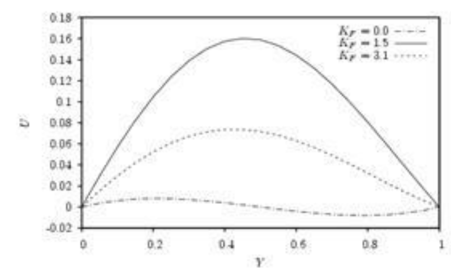
The effects of chemical reaction by various *K, K_F, and RT* are presented in Figure 1-3, respectively. **Figure 1**: First figures show that velocity increases as value *K*, maximum velocity was obtained for *K* value was getting big. Whereas, velocity increase as R_T small. I velocity is maximum when Frank Kamenetskii numberK_F=1.5. **Figure 2**:Figures 2 show that microrotation decreases as various value of material parameter K.Microrotation is maximum when temperature different ratio (R_T) is getting big. Whereas, microrotation has minimum value for various value of K_F for Y<0.5, while, microrotation has maximum value for various value of K_F for Y≥0.5. Finally, microrotation approach optimal when K_F =1.5. **Figure 3**: Figures 3 show that temperature has maximum value as various value of material parameter K at Y=0,4, Temperature is maximum at Y≥0,45 for temperatur different ratio (R_T =0.1) and Temperature is maximum at Y<0,45 for temperature different ratio (R_T =1). Finally, temperature approach maximum when K_F =1.



(a)



(b)



(c)

Fig. 1. Plots of U versus Y for different values of (a) K where K_F=1.5,R_T=1.0,(b)K_F where R_T=1.0, K=1.0 and (c) R_T where K_F=1.5, K=1.0

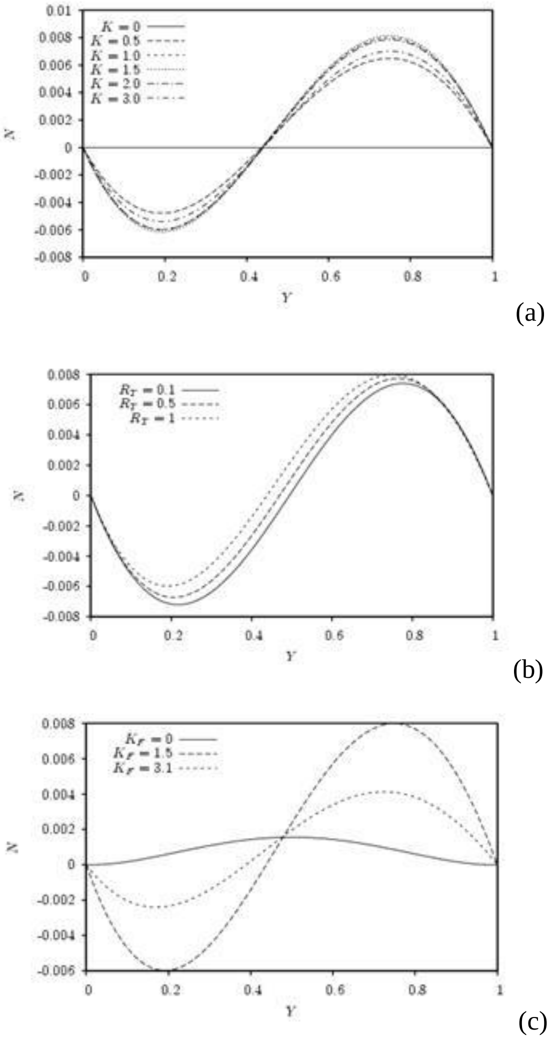
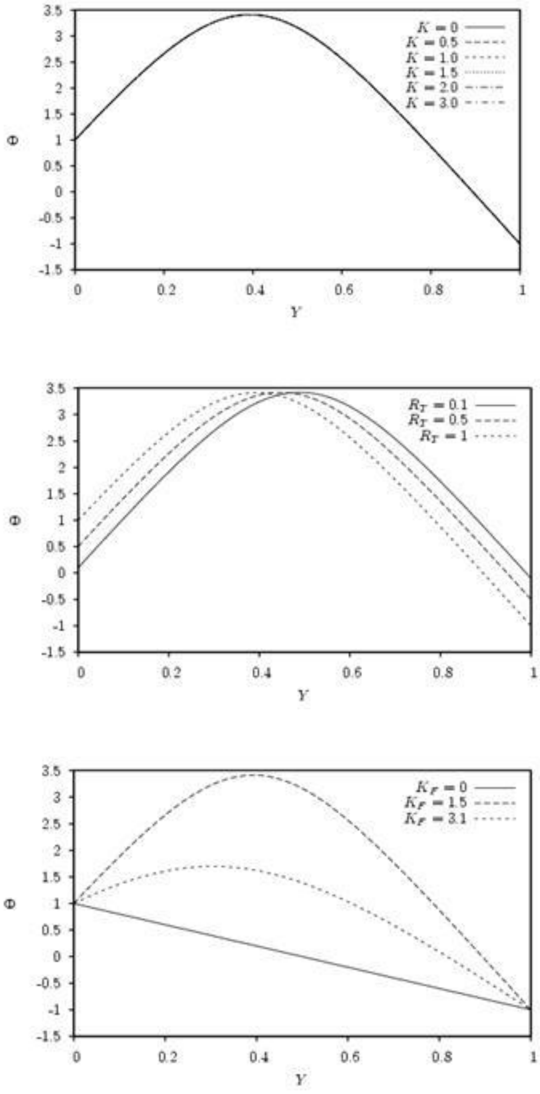


Fig. 2. Plots of N versus *Y* for different values of (a) K where K_F=1.5,R_T=1.0,(b)K_F where R_T=1.0, K=1.0 and (c) R_T where K_F=1.5, K=1.0



(a)

(b)

(c)

Fig. 3. Plots of Θ versus Y for different values of (a) K where K_F=1.5,R_T=1.0,(b)K_F where R_T=1.0, K=1.0 and (c) R_T where K_F=1.5, K=1.0

4 Conclusions

Parameters for the occurrences flow reversal by freeconvection of Mocrpolar fluid under the effect of chemical reaction in a vertical channel are presented. It can be concluded that flow reversal adjacent to the cold wall is found to exist with in the channel as the ratio of Frank-Kamenetskiinumber and Reynolds number is above a thre shold value. The exothermic chemical reaction is found to enchance the flow reversal and made flow reversal possible for symmetrical walls temperatures.

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Nomenclature

u	non-dimensional velocity, m/s.
T	non-dimensional temperature
T_0	reference temperature
t	non-dimensional time, s
K_F	Frank-Kamenetskiinumber
g	acceleration due to gravity
R_T	Temperaturedifferenceratio
k	kinematic rotational viscosity, N.s/m^2
n	Micro-rotation velocity
ρ	Density of fluid
U	Dimensionlessvelocitycomponentsin the x-direction
X,Y	Dimensionlessspacecoordinates
Θ	Dimensionlesstemperature
K	Non-dimensional material Parameter

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