Effects of Thermophoresis and Brownian Motion on MHD Williamson Nanofluid flow in Porous Media over a Stretching Cylinder

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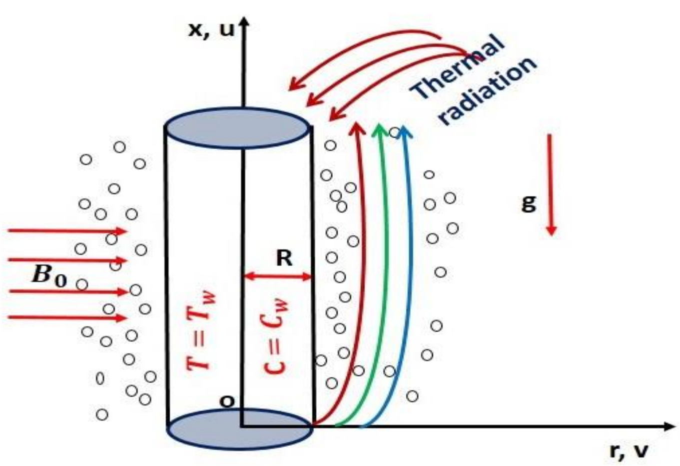
1. INTRODUCTION & OBJECTIVE

Non-Newtonian fluid flow, heat and mass transfer over an elongating sheet or cylinder are of great interest to scientists, engineers due to their wide range of applications, including pipe industry, and copper wire thinning. The study also considers the effects of a magnetic field, viscous dissipation, radiative heat flux, heat source/sink, and chemical reactions. The Buongiorno nanofluid was used to achieve Brownian motion and thermophoresis. The primary focus of this research is to understand the unique rheological behavior of the Williamson nanofluid and how it affects flow dynamics in this specific configuration. To achieve this, the researchers employed a similarity transformation to transform non-linear PDEs into nonlinear ODEs, which were tackled numerically using the Keller Box method. The results were compared with earlier literature to ensure accuracy. The rates of heat/mass flux were tabulated for various physical parameters. The findings indicate that increasing the value of porous media, magnetic and slip parameters decreases the velocity boundary layer, while enhancing the radiative flux escalates the rate of heat transfer on the surface of the elongating cylinder. Taking into consideration these assumptions, the Boussinesq's approximation can be expressed by maintaining all the abovementioned assumption



$$\frac{\partial(\mathrm{ru})}{\partial \mathrm{x}}+\frac{\partial(\mathrm{rv})}{\partial \mathrm{r}}=0, \tag{1}$$

$$u\frac{\partial \mathrm{u}}{\partial \mathrm{x}}+\mathrm{v}\frac{\partial \mathrm{u}}{\partial \mathrm{r}}=\nu\left(\frac{1}{\mathrm{r}}\frac{\partial \mathrm{u}}{\partial \mathrm{r}}+\frac{\partial^2 \mathrm{u}}{\partial \mathrm{r}^2}+2\sqrt{\Gamma}\frac{\partial \mathrm{u}}{\partial \mathrm{r}}\frac{\partial^2 \mathrm{u}}{\partial \mathrm{r}^2}+\frac{\Gamma}{\sqrt{2\nu}}\left(\frac{\partial \mathrm{u}}{\partial \mathrm{r}}\right)^2\right)-\frac{\sigma B_0^2}{\rho}\mathrm{u}-\frac{\nu}{\mathrm{k}}\mathrm{u} +\mathrm{g}\beta_{\mathrm{T}}(T-T_\infty)+g\beta_c(C-C\_\infty), \tag{2}$$

$$u\frac{\partial \mathrm{T}}{\partial \mathrm{x}}+\mathrm{v}\frac{\partial \mathrm{T}}{\partial \mathrm{r}}=\frac{\kappa}{\rho C_p}\left(\frac{1}{\mathrm{r}}\frac{\partial \mathrm{T}}{\partial \mathrm{r}}+\frac{\partial^2 \mathrm{T}}{\partial \mathrm{r}^2}\right)+\tau\left(D_B\frac{\partial \mathrm{T}}{\partial \mathrm{r}}\frac{\partial \mathrm{C}}{\partial \mathrm{r}}+\frac{D_T}{T_\infty}\left(\frac{\partial \mathrm{T}}{\partial \mathrm{r}}\right)^2\right)-\frac{Q_0}{\rho C_p}(\mathrm{T}-\mathrm{T}_\infty)-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial \mathrm{r}}, \tag{3}$$

$$u\frac{\partial \mathrm{C}}{\partial \mathrm{x}}+\mathrm{v}\frac{\partial \mathrm{C}}{\partial \mathrm{r}}=D_B\left(\frac{1}{\mathrm{r}}\frac{\partial \mathrm{C}}{\partial \mathrm{r}}+\frac{\partial^2 \mathrm{C}}{\partial \mathrm{r}^2}\right)+\frac{D_T}{T_\infty}\left(\frac{1}{\mathrm{r}}\frac{\partial \mathrm{T}}{\partial \mathrm{r}}+\frac{\partial^2 \mathrm{T}}{\partial \mathrm{r}^2}\right)+k_2(C-C_\infty) \tag{4}$$

The boundary conditions are,

$$u=U_w\,(x)+A^*\nu\frac{\partial \mathrm{u}}{\partial \mathrm{r}},\ \ T=T_w,\qquad C=C_w\ at\ \ r=R\,,$$
$$u\to\ 0, T_w\to\ T_\infty,\ \ C_w\to\ C_\infty\ as\ \ r\to\infty.$$

2 RESULTS & HIGHLIGHTS

The study examines the effects of emerging factors were studied, the key findings of the study are as follows:

- Thickness of the velocity declines with the increase of Weissenberg number, Slip parameter, Porosity, Magnetic field, whereas the velocity boundary layer is enhanced with the increase in curvature parameter, Richardson number**.**
- The rate of heat transfer increases with the rise of Curvature parameter, Radiation, heat source and sink, whereas it decreases for Prandtl number.
- An increase in Schmidt number, chemical reaction substantially reduces concentration magnitudes and species boundary layer thickness, whereas an increase in curvature parameter induces the opposite effect.

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