Numerical computation of heat and mass transfer of nano fluid (Al_2O_3-$C_2H_6O_2$) over a porous stretching sheet with non-linear thermal radiation using Sisko fluid model

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PAPER FOR THE YOUNG SCIENTIST AWARD

ABSTRACT

This study presents a comprehensive numerical investigation of heat and mass transfer characteristics in the context of an Al_2O_3 suspension in $C_2H_6O_3$ flow over a porous stretching sheet. The analysis incorporates the intricate influence of non-linear thermal radiation and employs the Sisko fluid model to capture the rheological behavior of the fluid mixture. The Sisko nanofluid model is one of the most sought-after mathematical model which prophesies the interesting features of Newtonian and non-Newtonian fluids (shear thickening and shear thinning fluids). The governing equations, including those for mass, momentum and energy are transformed into a dimensionless form to facilitate numerical solution using suitable similarity transformations. The numerical solution of resulting similarity equations with associated conditions are obtained employing four-stages Lobatto-IIIa-bvp5c-solver based on a finite difference scheme in MATLAB. The investigation delves into the intricate interplay between various influential parameters, including the nanoparticle volume fraction, Sisko fluid parameter, porous medium permeability, stretching sheet velocity, and non-linear thermal radiation effects. The outcomes of this study reveal appropriate insights into the heat and mass transfer phenomena within the Al_2O_3 suspension-$C_2H_6O_3$ system. Evaluation of Nusselt and Sherwood numbers provides insights into the heat and mass transfer rates, respectively. The findings underscore the potential of Al2O3 nanoparticles to enhance heat transfer in ethylene glycol-based suspensions. Additionally, the investigation emphasizes the importance of considering non-linear thermal radiation effects and the Sisko fluid model for a more accurate prediction of nanofluid behavior. The outcomes of this research contribute to a deeper understanding of nanofluid dynamics and offer valuable guidance for the optimization of heat transfer systems in diverse engineering applications.

Key words: Sisko nanofluid, MHD, Porous medium, Thermal radiation.

MATHEMATICAL FORMULATIONS

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0, \tag{1}$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\frac{a}{\rho_{nf}}\frac{\partial^2 u}{\partial y^2}-\frac{b}{\rho_{nf}}\frac{\partial}{\partial y}\left(-\frac{\partial u}{\partial y}\right)^n-\frac{\sigma B_0^2 u}{\rho_{nf}}-\frac{\mu}{\rho_{nf}K}u, \tag{2}$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right)-\frac{1}{\left(\rho c_p\right)_{nf}}\left(\frac{\partial q_r}{\partial y}\right)+\tau\left[D_B\left(\frac{\partial C}{\partial y}\right)\left(\frac{\partial T}{\partial y}\right)+\frac{D_T}{T_\infty}\left(\frac{\partial T}{\partial y}\right)^2\right] \tag{3}$$

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D_B\frac{\partial^2 C}{\partial y^2}+D_T\frac{\partial^2 T}{\partial y^2} \tag{4}$$

The appropriate boundary constraints for the eqns. (1) – (4) are as follows:

$$u = U_w = cx, v = 0, T = T_w, C = C_w \quad at y = 0 \tag{5}$$

$$u \rightarrow 0, T \rightarrow T_\infty, C \rightarrow C_\infty, at\ y \rightarrow \infty. \tag{6}$$

RESULTS AND DISCUSSIONS

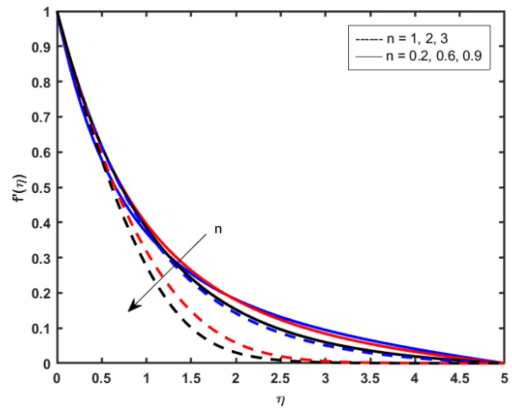

Fig. 1 Impact of n on velocity profile.

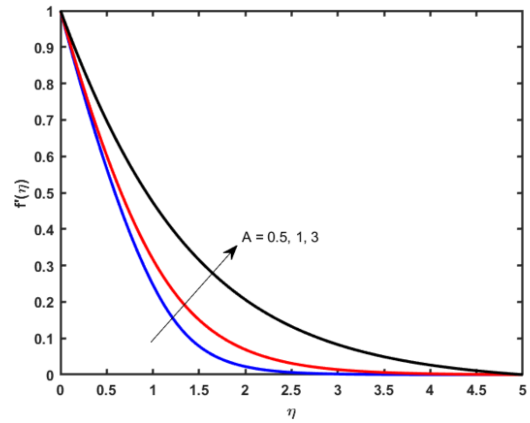

Fig. 2 Impact of A on velocity profile.

The rheological flow behaviors of Al_2O_3- $C_2H_6O_3$ are demonstrated in Fig. 1. With the variation of flow index value (n). Increasing the flow index values decreases the fluid mobility (Solid lines represents shear thickening fluids, doted lines represent shear thickening fluids). From fig. 2. Elucidates the variation of Sisko fluid parameter (A) on the velocity profile. Augmenting values of Sisko fluid parameter strengthen the momentum boundary layer thickens.

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