Exact and numerical solutions of a fully developed generalized second-grade incompressible fluid with power-law temperature-dependent viscosity

Abstract

We compute exact and numerical solutions of a fully developed flow of a generalized second-grade fluid, with power-law temperature-dependent viscosity ($\mu=\theta^{-M}$), down an inclined plane. Analytical solutions are found for the case when $M=m+1$, $m\neq1$, m being a constant that models shear thinning ($m<0$) or shear thickening ($m>0$). The exact solutions are given in terms of Bessel functions. The numerical solutions indicate that both the velocity and the temperature increase with decreasing Froude number and that there is a critical value of *Fr* below which temperature "overshoots" its free surface value of unity. This phenomena is not reported in the work of Massoudi and Phuoc [Fully developed flow of a modified second grade fluid with temperature dependent viscosity, Acta Mech. 150 (2001) 23–37.] for viscosity that depends exponentially on temperature.

Keywords

- Non-Newtonian fluids;
- Second-grade fluid;
- Temperature-dependent viscosity;
- Super-temperature