## ABSTRACT

A large number of fluids do not follow the linear stress-strain rate model, applicable for Newtonian fluids. Such fluids are classified as non-Newtonian fluids. Flow of non-Newtonian fluids is encountered in diverse industrial applications. Researchers, over the years, have suggested several non-Newtonian fluid models such as power law model, Sisko model, third grade model, visco-elastic model etc. Sisko model and third grade fluid model are applicable for the stress and strain rate data, for a wider range of the shear rate compared to the case of power law model. Though a few studies on Sisko fluids and third grade fluids have been carried out, but several problems of fundamental and practical interest, are yet to be explored. Considering this, different problems of Sisko fluids and third grade fluids, from the standpoint of engineering applications, have been chosen for the present study. The equations, governing the flow and heat transfer are non-linear in nature and have been solved by employing analytical and semi-analytical methods. Analytical or semi-analytical methods provide a deeper physical insight in to a problem and present a better frame work for understanding the parametric dependence. Though analytical techniques suffer from a number of limitations, there implementation does not require large computational resources. Further, they can serve as the base solutions for many elaborate computational techniques. Driven by these facts, analytical and semi-analytical methods are employed for solving the nonlinear equations in the present investigation.

The present study, primarily, has two objectives. The first objective is to focus on the non-linear aspects of flow and heat transfer of typical non-Newtonian fluids. Two non-Newtonian fluids, namely Sisko fluid and third grade fluid are selected for the study. The second objective is to apply analytical and semi-analytical techniques for solving the governing equations, describing the flow and heat transfer of non-Newtonian fluids. Traditional perturbation method, homotopy perturbation method, least square method, and collocation method have been employed for different problems.

First, homotopy perturbation method (HPM), an analytical tool, widely adopted by the contemporary researchers, is chosen for analyzing the free surface flow of a Sisko fluid driven by a vertical belt and parallel stratified flow of two immiscible Sisko fluids over a flat inclined plane. The first problem, which is primarily a revisit of the belt driven transport problem, highlights the importance of proper selection of the guess solution in HPM, and makes corrections of the previously published results, which were inconsistent with the physics of the problem. Then thin film gravity-driven flow of two immiscible Sisko fluids is analytically investigated by adopting HPM. The non-linear governing equations of flow are solved by HPM and the effects of the Sisko fluid parameter and the non-Newtonian index on the velocity are analyzed.

Then, HPM is applied to an internal flow and heat transfer problem of a Sisko fluid for flow through a narrow rectangular channel, subjected to constant wall temperatures. The non-linear governing equations are solved employing HPM and the expressions for non-dimensional velocity and temperature are obtained. An analytical study on the velocity, temperature, and the wall heat flux is carried out by varying the Sisko fluid parameter, non-Newtonian index, and the Brinkman number. Then, flow and heat transfer of a Sisko fluid in a cylindrical pipe, subjected to a constant surface heat flux both for heating and cooling, is studied. A semi-analytical technique, the least square method (LSM) has been chosen for investigating the flow and thermal

characteristics of the problem. The non-linear equations governing the momentum and energy conservation equations are solved by LSM and the effect the Sisko fluid parameter, non-Newtonian index, Brinkman number on the non-dimensional velocity, temperature, and Nusselt number is analyzed. The results indicate that the non-dimensional temperature increases significantly with an increase in the Brinkman number. Further, it is observed that an increase in the Sisko fluid parameter results in a decrease in the non-dimensional temperature. For heat transfer of Sisko fluids in a pipe, it is observed that an increase in the Sisko fluid parameter enhances the heat transfer coefficient for heating; a reverse trend is observed for cooling.

Finally, electro-magneto-hydrodynamic (EMHD) and magneto-hydrodynamic (MHD) flow and heat transfer of a third grade fluid through parallel plate channels have been considered. The EMHD problem deals with the forced convection for heating and cooling of the fluid, while the MHD problem considers mixed convection both for buoyancy assisted and buoyancy opposed flow conditions for the vertical orientation of the channel. In the EMHD flow and heat transfer, LSM is employed to get the solution of the non-dimensional velocity, temperature and Nusselt number over a range of parameters. For the MHD mixed convection of third grade fluid, a semi-analytical method namely collocation method (CM) is employed. The governing equations are solved adopting CM and the effect of the third grade fluid parameter, Hartmann number, and the mixed convection parameter on the non-dimensional velocity, temperature and Nusselt number is analyzed. The results indicate that for EMHD problem, for heating, the temperature difference between the fluid and the wall decreases significantly with an increase in the third grade fluid parameter. For MHD mixed convection, it is observed that the incipient flow reversal occurs at higher values of the mixed convection parameter with an increase in third grade fluid parameter.