

In this thesis, heat and mass transport models tailored for fractional order derivatives of non-Newtonian fluids have been developed and analyzed for various flow situations. The non-Newtonian fluid models discussed here are of Maxwell and Oldroyd-B fluid. The consequences of these non-Newtonian fluid models are addressed for cylindrical coordinates. The first problem we have discussed is an analytical study of combined heat and mass transfer in MHD free convective flow of Maxwell fluid. In addition, the dynamics of the fluid are subject to arbitrary motion of a cylinder that is heated and has a varying concentration of fluids. Several cases of generalized boundary conditions are analyzed, and their consequences in engineering and applied science are addressed. To move further, we have developed the problem with the use of fractional order derivatives analysis and employed non-integer order derivative operators in the sense of Caputo (C), Caputo-Fabrizio (CF), and Atangana-Baleanu (AB). We then proceeded with our investigation of the heat transfer phenomenon of mixed convective flow of Maxwell fluid using fractional calculus modelling. The flow phenomenon occurs within a cylinder. Chapter 5 presents the numerical investigation of Maxwell fluid with the Caputo fractional order derivatives operator, which is published in the Mathematics journal. However, chapter 6 presents the numerical investigation of Maxwell fluid with the Atangana-Baleanu (AB) in the Caputo sense fractional order derivatives operator, which is published in Chaos, Solitons, and Fractals. Finally, incompressible MHD Maxwell and Oldroyd B fluid with unsteady flow are considered within a cylinder with thermal radiation and ramped wall conditions. The problem is being solved using Caputo (C) and Caputo Fabrizio (CF), a non-singular fractional order derivative operators and a relative analysis is performed. The velocity, temperature, and concentration profile results were obtained using Homotopy Perturbation Method and Artificial Neural Network (ANN). Both the fluid models fulfil the imposed initial and boundary conditions. Graphical results are employed to demonstrate the essential features of different parameters. The results of the Integer-Order Derivative in a Limiting Sense compared with other Models are quite intriguing as they provide more accurate results for engineering and applied sciences.