CHAPTER 6

Conclusion

The prime objective of the present thesis is the theoretical and numerical analysis of magnetohydromagnetic nanofluid flow past plates and in channels. MHD flow is significant in engineering, biomedical engineering, aeronautics, MHD pumps, magnetic drug targeting, and so on. Transportation of cancer-killing drugs to affected areas without harm to surrounding tissues is one of the significant implementations of MHD flow. The flow properties such as velocity, temperature, and concentration, and physical quantities such as drag coefficients and, heat and mass transfer rates are discussed. In bioconvective flow, the microbial concentration, and the microorganism density number are also considered. The external magnetic field is applied normally to the fluid flow and due to the assumption of a small magnetic Reynolds number, the induced magnetic field has been neglected. Tiwari-Das nanofluid models are employed to describe fluid motion. The thesis involved the discussion of water-based nanofluids with nanoparticles $Cu, Fe_3O_4, TiO_2, Al_2O_3 - Fe_3O_4, CNT - Fe_3O_4$, and $TiO_2 - Ag$. The impact of external constraints such as thermal radiation, chemical reaction, viscous dissipation, stratification, and heat generation, to amplify or delay the beginning of convection as required in realistic implementations, is analyzed by observing the results of augmenting associated parameters.

- The Lorentz force generated due to the presence of a magnetic field, resists the fluid flow, and hence reduces the fluid velocity. This resistance enhances the friction between fluid layers which implies, the generation of heat and extension of solutal and microorganisms boundary layer thickness.

- The velocity field lines are grown due to the strengthening of the electric field.

- The electric field accelerates fluid motion and it dominates the resistive force obtained due to the magnetic field. Hence in the presence of an electric field, the fluid velocity enhances even the magnetic field intensity increases.

- Volume fraction of nanoparticles enhances the temperature field.

- Among water-based nanofluids with Cu, Fe_3O_4 and TiO_2 nanoparticles, Cu has a significant role to enhance fluid velocity.

- As the positive values of the Reynolds number describes the injection effects, the heated nanoparticles move to the fluids from surfaces that augment fluid velocity and fluid temperature. The inverse of this process occurs in the case of suction. Due to suction, the fluid particles tend to stick with surfaces, and heat is absorbed by surfaces, which reduces momentum, temperature, and solutal boundary layer thickness.

- Greater chemical reaction parameter values accelerate nanoparticle consumption, reducing the concentration of chemical species and increasing mass transfer rates. The fluid's density reduces by this; hence, the microorganisms tend to move to the vacant area in a bioconvective flow.

- The presence of a porous medium disturbs the fluid flow which causes the fluid particles to collide and generate internal heat energy. This thermal energy boosts the microorganism boundary layer thickness.

- Dissipative flow enhances the collision of fluid particles, thus generating frictional energy and hence internal heat.

- Fluid temperature is significantly increased by improving heat source, porosity, and radiation.

- The improvement of fluid temperature reduces the heat transfer rates (or Nusselt number), as it measures the rate of heat transferred from the surface to the fluid. But, when greater radiation is applied to the fluid flow, an immense surface heat flux is produced, which promotes higher heat transfer rates, even the fluid temperature enhances.

Magnetic fields and electric fields have a crucial role to control flow with the desired velocity. It can be implemented to improve the magnetic drug delivery system, by establishing more explicit ways to transport cancer-killing drugs to affected areas. The thermal conductivity of the fluid is influenced by improving temperature and heat transfer aspects that are implemented to prevent exhaustion of energy in engineering and industrial field. High temperature is used to destroy diseased cells in the biomedical field. Chemical reactions are taken into account as they find applications in the biochemical system, catalysis, batteries, corrosion phenomenon, combustion, and electrolytic cells. The flow modeled with the porous channel can be implemented in heat exchangers, transpiration cooling of gas turbine blades, porous walled flow reactors, solar energy collectors, and so on, by improving the thermophysical properties of the fluid under various situations. The stretching rate of sheets strongly affects the final product quality and, the exponential velocity and temperature distributions influence the admirable grade products attained in the annealing and thinning of copper wires.

FUTURE SCOPE OF THE STUDY

The scope of this research work lies in analyzing and interpreting the flow properties and physical quantities of the nanofluid flow in the presence of a magnetic field. Using ternary hybrid nanofluids instead of regular nanofluids or hybrid nanofluids, improves the stability and thermal properties at an advanced level, and considering proper ternary hybrid composite assures its potential utilities. However, a lot of research work is still required in the fields of characterization and application of ternary hybrid nanofluids to overcome challenges. The transportation of fluids in some biological organisms can be modeled with specific fluids, by modifying the flow models in chapter 2 and chapter 3. Not much has been learned about exponential stretching surfaces. It's a new way to make a lot of inventions that can be applied on an industrial scale. Studies on bioconvective flow through exponential stretching surfaces have a long way to go. Each chapter can be extended by considering different flow mediums and flow models. Also can be extended by considering various non-Newtonian fluids and various advantageous effects like nonlinear thermal radiation and space-dependent heat source.

Publications in Journals and Presentations

Publications:

1. Thyvalappil Sugathan Neethu and Sujesh Areekara and Alphonsa Mathew, “A Statistical Approach On Three Dimensional Free Convective Flow of Water Based Nanofluids Between Two Vertical Porous Plates Moving In Opposite Direction,” Heat Transfer Wiley , vol. 50, no. 5, pp. 5170-5197, July. 2021, https://doi.org/10.1002/htj.22120

2. Alphonsa Mathew and T.S. Neethu and Sujesh Areekara, “Three-dimensional hydromagnetic hybrid nanoliquid flow and heat transfer between two vertical porous plates moving in opposite directions: Sensitivity analysis,” Heat Transfer Wiley, vol. 50, no. 7, pp. 6548-6571, May. 2021, https://doi.org/10.1002/htj.22192

3. T.S.Neethu and Sujesh Areekara and A.S. Sabu and Alphonsa Mathew and K.K. Anakha, ”Bioconvective electromagnetohydrodynamic hybrid nanoliquid flow over a stretching sheet with stratification effects: A four-factor response surface optimized model,” Waves in Random and Complex Media, April. 2022, https://doi.org/10.1080/17455030.2022.2066218

4. T.S. Neethu and A.S. Sabu Alphonsa Mathew and A. Wakif and Sujesh

Areekara, "Multiple Linear Regression on Bioconvective MHD Hybrid Nanofluid Flow past an Exponential Stretching Sheet with Radiation and Dissipation effects," International Communications in Heat and Mass Transfer, vol. 135, pp. 106115, June. 2022, https://doi.org/10.1016/j.icheatmasstransfer.2022.106115

Presentations:

1. T.S. Neethu, Heat transfer in free convective MHD flow past a hot vertical plate, International Conference on Pure and Applied Mathematics, SCSVMV, Enathur, Kanchipuram, Tamilnadu, held on 17 - 19 December 2018.

2. T.S. Neethu, An oscillatory free convective MHD flow in a rotating vertical channel, International Conference on Mathematics 2018, St. Thomas College (Autonomous), Thrissur, Kerala, held on 29 - 30 June 2018.