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Notice for the PhD Viva Voce Examination

Mr Joby Mackolil (Registration Number: 1942069), PhD scholar at the School of Sciences, CHRIST (Deemed to be University), Bangalore will defend his PhD thesis at the public viva-voce examination on Wednesday, 12 April 2023 at 10.30 am in the Syndicate Room, (Room No. 802), Ground Floor, Auditorium Block, CHRIST (Deemed to be University), Bengaluru - 560029.

Title of the Thesis	:	**Sensitivity Analysis of Heat Transport in Nanofluids with Marangoni Convection**
Discipline	:	**Mathematics**
External Examiner (Outside Karnataka)	:	**Dr Ram Prakash Sharma** Associate Professor Department of Mechanical Engineering National Institute of Technology Yupia, Papum Pare District Arunachal Pradesh -791112
External Examiner (Within Karnataka)	:	**Dr Jawali C Umavathi** Professor Department of Mathematics Gulbarga University Sedam Road, Jnana Ganga Kalaburagi - 585106 Karnataka
Supervisor	:	**Dr Mahantesh B** Associate Professor Department of Mathematics School of Sciences CHRIST (Deemed to be University) Bengaluru - 560029 Karnataka

The members of the Research Advisory Committee of the Scholar, the faculty members of the Department and the School, interested experts and research scholars of all the branches of research are cordially invited to attend this open viva.

Registrar

Place: Bengaluru
Date: 05 April 2023

ABSTRACT

The mathematical modeling of the Marangoni convective flow of nanofluids and optimization of the heat transport rate is carried out in this research work. The thermal, thermo-solutal, mixed thermo-solutal Marangoni convection problems are modeled in the presence of an external magnetic field. The thermal phenomenon is scrutinized by including thermal radiation which is quantified by using the Rosseland approximation. Different external effects are included in the problems and a detailed parametric analysis is carried out by using graphical visualizations. The nanofluids are modeled by choosing realistic nanofluid models along with experimental data. The governing equations are constructed by utilizing the conservation equations of mass, momentum, energy and concentration. Suitable transformations are adopted to convert the governing partial differential equations to ordinary differential equations and similarity solutions are obtained. The Runge-Kutta based method and MATLAB solver are adopted to tackle the nonlinear ordinary differential equation system. This technique involves the usage of four-stage Lobatto IIIa collocation formula and yields fifth-order accurate results. The accuracy of the numerical results is further ensured by comparing the limiting cases of the modeled problem with the literature. The optimization of the heat (and mass) transport is carried out by using the mathematical and statistical technique - Response Surface Methodology (RSM). The face-centered central composite design is used in the experimental design for optimization. Quadratic empirical models are fitted for the response variables and these models are utilized to estimate their sensitivity towards the pertinent factors.

It is found that the aggregation of nanoparticles leads to a higher thermal conductivity which enhances the temperature profile in Marangoni convective flows. Accurate quadratic models (with high coefficient of determination) have been fitted and optimized levels of the factors that maximize the heat transport have been estimated for each modeled problem. The interactive effects of the factors are studied using three-dimensional surface plots. Moreover, the augmentation on the flow and thermal profiles for a change in each independent parameter has been calculated. The inclination angle of the magnetic field can be used to regulate the convective flow. Among the linear and exponential heat sources, the heat transport rate is enhanced more by the exponential heat source. Considering the cross-diffusion effect, the mass transport is augmented more by the Soret effect. On the contrary, the heat transport is augmented predominantly by the Dufour effect. The entropy generation in the fluid system gets increased by the thermal radiation and hence, the Bejan number rises which indicates that the heat transport irreversibility is predominant. The results of this research work can be applied in crystal growth, soap film stabilization, coating processes, and growth of silicon wafers which involve Marangoni convective flows. The convection driven by Marangoni effect is also prominent in microgravity situations. In such cases, the convective flows in the fluids will be driven by surface tension gradients. Moreover, the optimized heat transport levels can be used to improve the efficiency of hydromagnetic semiconductor crystals.

Keywords: Marangoni convection; Nanofluid; Response Surface Methodology; Optimization; Sensitivity analysis

Publications

1. **J. Mackolil** and B. Mahanthesh, “Computational simulation of surface tension and gravitation-induced convective flow of a nanofluid with cross-diffusion: An optimization procedure”, Applied Mathematics and Computation, vol. 425, pp. 127108, 2022.
2. **J. Mackolil** and B. Mahanthesh, “Thermo-solutal Marangoni convective assisting/ resisting flow of a nanofluid with radiative heat flux: A model with heat transfer optimization”, ZAMM - Journal of Applied Mathematics and Mechanics, vol. Ahead-of-print, 2022.
3. **J. Mackolil** and B. Mahanthesh, “Optimized heat transport in Marangoni boundary layer flow of a magneto nanofluid driven by an exponential interfacial temperature distribution”, ZAMM - Journal of Applied Mathematics and Mechanics, vol. Ahead-of-print, 2022.
4. **J. Mackolil** and B. Mahanthesh, “Heat transfer optimization and sensitivity analysis of Marangoni convection in nanofluid with nanoparticle interfacial layer and cross-diffusion effects”, International Communications in Heat and Mass Transfer, vol. 126, pp. 105361, 2021.
5. **J. Mackolil** and B. Mahanthesh, “Inclined magnetic field and nanoparticle aggregation effects on thermal Marangoni convection in nanofluid: A sensitivity analysis”, Chinese Journal of Physics, vol. 69, pp. 24-37, 2021. Chapter 9. Conclusions
6. **J. Mackolil** and B. Mahanthesh, “Optimization of heat transfer in the thermal Marangoni convective flow of a hybrid nanomaterial with sensitivity analysis”, Applied Mathematics and Mechanics, vol. 42, no. 11, pp. 1663-1674, 2021.
7. **J. Mackolil** and B. Mahanthesh, “Heat transfer enhancement using temperaturedependent effective properties of alumina-water nanofluid with thermo-solutal Marangoni convection: A sensitivity analysis”, Applied Nanoscience, vol. Aheadof- Print, pp. 1-12, 2021.
8. **J. Mackolil** and B. Mahanthesh, “Sensitivity analysis of Marangoni convection in TiO2-EG nanofluid with nanoparticle aggregation and temperaturedependent surface tension”, Journal of Thermal Analysis and Calorimetry, vol. 143, no. 3, pp. 2085-2098, 2020.
9. **J. Mackolil** and B. Mahanthesh, “Study on Marangoni mixed convective flow of magnetized nanofluid” (Under Review).