Preface

In the rapidly advancing domains of engineering and biomedicine, the significance of computational fluid dynamics (CFD) has become increasingly critical. As a sophisticated analytical tool, CFD enables researchers and engineers to simulate and analyze fluid flow, heat transfer, and mass transfer phenomena with remarkable accuracy. This capability has catalyzed significant innovations and enhancements across a variety of applications. This book, *CFD Simulation: Thermo-Fluids and Nanofluids in Engineering and Biomedicine*, expertly edited by Fateh Mebarek-Oudina, stands as a comprehensive resource that encapsulates the latest advancements and applications of CFD technology in these dynamic fields.

The integration of nanotechnology into fluid dynamics has fundamentally altered our approach to thermal management and fluid behavior analysis. Nanofluids – engineered colloidal suspensions comprising nanoparticles dispersed in conventional base fluids – exhibit enhanced thermal properties that significantly improve heat transfer efficiency. This volume delves into the wide-ranging applications of nanofluids, spanning energy systems and biomedical devices, thereby underscoring their potential to address some of the most pressing challenges faced by modern engineering.

The chapters in this collection have been carefully curated to present a holistic perspective on the current state of research in CFD simulations. Each chapter examines distinct yet interconnected aspects of thermo-fluids and nanofluids, enriching our understanding of their practical implications.

Chapter 1, authored by Ch. Maheswari and G. Dharmaiah, investigates the effects of Hall current and aligned magnetic fields on the magnetized hybrid flow over a movable slender needle. This foundational study is essential for comprehending how magnetic fields influence fluid dynamics, particularly in applications related to biomedical devices and microfluidics.

In Chapter 2, Fazal Haq, Muzher Saleem, and Mujeeb ur Rahman delve into entropy optimization in bio-convective and reactive micropolar nanofluid flow affected by Arrhenius kinetics. Their research highlights the critical role of entropy generation in enhancing the performance of bio-convective systems, emphasizing its relevance for both biomedical engineering and environmental sustainability.

Meriem Nouira, Neda Azimi, and Esmail Sharifzadeh contribute to Chapter 3 with a CFD analysis focused on nano-enhanced phase change materials. This study demonstrates the potential of nanofluids to improve thermal energy storage systems – crucial elements for renewable energy applications and energy-efficient technologies.

Chapter 4, authored by Emmanuel O. Atofarati and Fateh Mebarek-Oudina, explores the characteristics of magnetothermal and magnetorheological nanofluids. The authors examine simulation techniques, applications in biomedical engineering, and safety considerations, shedding light on how these fluids can be tailored for therapeutic uses.

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In Chapter 5, Atofarati, Casey A. Ndanduleni, Teboho Ramathe, and Zhongjie Huan discuss advancements and challenges associated with nanorefrigerants in engineering. They provide insights from experimental findings and CFD simulations, highlighting the potential of nanorefrigerants to enhance cooling systems and reduce energy consumption.

Chapter 6, by Gouri Sankar Barik, Kharabela Swain, and Patitapaban Panda, investigates the interaction of the Lorentz force on Darcy-Forchheimer flow and heat transfer of hybrid nanofluids past a stretching sheet. Their findings are invaluable in understanding the impact of external forces on fluid behavior, which is crucial for optimizing industrial processes.

In Chapter 7, authors Muhammad Waseem, Muhammad Jawad, Sidra Naeem, and Fateh Mebarek-Oudina explore the effects of motile microorganisms on the three-dimensional flow of non-Newtonian thermo-fluids influenced by a Riga plate. This research is particularly pertinent for biomedical applications, where the interplay between microorganisms and fluid flow can significantly affect drug delivery systems and tissue engineering.

Raoudha Chaabane's contribution in Chapter 8 centers on lattice Boltzmann simulations of copper-water nanofluid, providing an in-depth analysis of this advanced computational methodology and its implications for improving heat transfer in various engineering applications.

Chapter 9, by Sangamesh, Vinod Y., and K. R. Raghunatha, examines the stagnation point flow of magnetohydrodynamic (MHD) nanofluid over an exponentially stretching sheet, considering radiation effects. Their research emphasizes the importance of magnetohydrodynamic interactions in developing advanced cooling systems and materials processing techniques.

In Chapter 10, Tahir Naseem, Maryam Saeed, and Fateh Mebarek-Oudina present a study on irreversible entropy generation in radiative viscous fluid flow with Joule heating over a permeable, radially stretching disk. This chapter underscores the critical role of entropy generation in optimizing thermal systems and highlights key strategies for enhancing efficiency.

Chapter 11, authored by Hanumesh Vaidya, K. V. Prasad, Fateh Mebarek-Oudina, Rajashekhar Choudhari, D. Tripathi, and Triveni, discusses the effects of electromagnetohydrodynamics on temperature-dependent peristaltic transport of Buongiorno nanofluids in porous media. Their research offers valuable insights into enhancing heat transfer efficiency, which is vital for various applications.

B. Ould Said and Fateh Mebarek-Oudina contribute to Chapter 12 by examining the convective flow of magnetized nanoliquids in porous enclosures with elliptical obstacles of varying diameters. This study deepens our understanding of complex flow patterns in porous media, with significant implications for both engineering and environmental science.

Chapter 13, authored by Sangamesh, Vinod Y., and K. R. Raghunatha, investigates the Dufour and Soret effects on nanofluids over an exponentially stretching sheet with a chemical reaction. Their work explores the intricate interplay between thermal and concentration gradients and its implications for optimizing chemical processes and material synthesis.

In Chapter 14, Muhammad Sohail, Esha Rafique, and Syed Tehseen Abbas explore heat transfer in dissipative water-based hybrid nanofuels under radiation, applying the Optimal Homotopy Asymptotic Method (OHAM). Their research offers valuable insights into the dynamics of hybrid nanofuels and contributes to advancements in energy systems.

Chapter 15, the investigation of heat and mass transfer processes is crucial in many industrial applications, particularly those involving nanofluids. In this chapter, Manoranjan Mishra, Pallab Kumar Kar, Kharabela Swain, and F. Mebarek-Oudina delve into the behavior of Casson hybrid nanofluids under specific flow conditions. This study addresses the complexities of non-Newtonian fluid dynamics, enhancing our understanding of flow behavior over stretching sheets while incorporating factors such as velocity slip and the effects of suction/injection. Their findings contribute not only to the theoretical framework of fluid dynamics but also to practical applications in industries such as materials processing and manufacturing.

In conclusion, *CFD Simulation: Thermo-Fluids and Nanofluids in Engineering and Biomedicine* is more than just a collection of research articles; it embodies the collaborative spirit of the scientific community and reflects an unyielding pursuit of knowledge within the realm of fluid dynamics. This book serves as an invaluable resource for researchers, engineers, and academics, providing critical insights while illuminating future pathways for exploration in this essential and expanding field. I hope that the findings shared in this volume will inspire ongoing research and innovation, fostering a deeper understanding of the complex interactions governing fluid behavior and their varied applications in the real world.

Fateh Mebarek-Oudina