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Editorial

Numerical Simulation of Convective-Radiative Heat Transfer

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Heat transfer including heat conduction, thermal convection, and thermal radiation is a major transport process that occurs in various engineering and natural systems such as heat exchangers, solar collectors, nuclear reactors, atmospheric boundary layers, electronical and biomedical systems, and others. The sustainable development of modern engineering devices and natural bio- and geosystems requires keen insight into the thermal convective and thermal radiative transport phenomena within these systems. As a result, a detail investigation of these mentioned heat transfer mechanisms is very important and useful. Such analysis can be performed using theoretical techniques, experiments or numerical methods. It should be noted that numerical simulation includes the advantages of both theoretical approaches, where a study can be conducted for many different control parameters and experiments and a detailed analysis of real physical system is possible.

This Special Issue consists of thirteen articles dedicated to convective stagnation point flows [1,2], non-Newtonian fluid heat transfer [3,4], fin efficiency [5], bubbly flow and heat transfer [6,7], cooling of heated elements [8,9], phase change materials application [10], vortex heat transfer enhancement [11], flow and heat transfer in engineering systems [12,13]. Moreover, numerical analysis in these mentioned papers [1–13] has been performed using MATLAB software [1–3,6,13], ANSYS software [5,9,12,13], COMSOL software [10] and using developed in-house computational codes [4,7,8,11].

The objective of this Special Issue is to demonstrate the recent studies on the numerical simulation of convective and radiative thermal transport phenomena in engineering and natural systems that can be very useful for specialists in mechanical and chemical engineering, physics and mathematics. The next paragraphs include a brief overview of these mentioned papers with some innovative ideas.

Thus, we begin from the works on stagnation point flows and heat transfer of nanofluids [1,2]. Jamaludin et al. [1] have studied mixed convection stagnation point flows and heat transfers of a water-based nanofluid past a vertical stretching/shrinking sheet under an influence of thermal radiation and internal heat generation. The formulated partial differential equations have been transformed to ordinary differential equations using the suitable similarity variable. Obtained equations have been solved by means of special procedure in MATLAB software. Authors have found that separation of the boundary layer can be obtained with a rise of the thermal radiation parameter, heat source intensity and shrinking parameter, while an attenuation of the boundary layer separation occurs with nanoparticles concentration, heat sink intensity, suction and stretching parameters. Khashi'ie et al. [2] have examined numerically three-dimensional stagnation point nanofluid flow, heat and mass transfer past a moving sheet under an influence of uniform magnetic field, anisotropic slip, Brownian diffusion and thermophoresis. Using the similarity transformations, the obtained ordinary differential equations have been solved by the special procedure in MATLAB software. It has been revealed that energy transport strength can be reduced with a rise of the anisotropic slip, while the boundary layer thickness can be decreased with a raise of the Brownian diffusion parameter.

Non-Newtonian fluids are widely used in various engineering systems. Naganthran et al. [3] have analyzed numerically the Carreau thin film flow and energy transport past a

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stretching sheet under an influence of thermocapillarity. Using the similarity transformation, the obtained ordinary differential equations have been solved by means of MATLAB software [1,2]. Authors have ascertained that the film thickness can be reduced by a growth of the unsteadiness parameter and injection intensity. Loenko et al. [4] have scrutinized numerically natural convection of non-Newtonian power-law fluid in a square chamber under an influence of local heat-generating elements placed on the bottom wall and cooling from the vertical borders. Using the non-dimensional and non-primitive variables the formulated governing equations have been solved by the developed in-house computational code based on the finite difference method. Authors have found that pseudoplastic liquids characterize more intensive heat removal from the heated element.

Comparison between analytical and numerical data for analysis of fin efficiency has been made by Bosnjakovic et al. [5]. Numerical analysis has been performed using ANSYS CFD software. Authors have shown that usage of analytical correlations leads to the achievement of a lower fin efficiency coefficient compared to numerical data at about 10–12%. Starace et al. [6] have developed a semi-analytical approach of a single vapor bubble injected in a fluid of a multi-stage system using the Fourier heat conduction approximation. This developed model has shown an existence of optimal injection depth for effective heat transfer. Experimental and numerical investigation of bubbly flow and heat transfer in a sudden pipe expansion has been conducted by Lobanov et al. [7]. Numerical simulation has been performed using the developed in-house computational code based on the finite volume method for the Reynolds-averaged Navier–Stokes equations with the low-Reynolds number elliptic blending second-moment turbulence closure. Authors have shown the heat transference augmentation in bubbly flow.

Thermal convective and radiative energy transport mechanisms play an essential role in the case of heat-generating elements cooling. Thus, Miroshnichenko et al. [8] have studied numerically turbulent natural convection and thermal radiation of air in a square cavity bounded by heat-conducting solid walls, under an influence of a local heat-generating element placed on the internal surface of the bottom wall of finite thickness and convective heat exchange with an environment. Using the non-primitive variables, special algebraic transformation of physical coordinates and the k-ε turbulence model, governing equations have been solved by the developed in-house computational code based on the finite difference technique. The performed analysis has demonstrated that the total energy transport can be augmented by growth of the surface emissivity. Brodnianska and Kotsmıd [9] have examined numerically laminar natural convection of air from the heated horizontal tubes in a two-dimensional space. Using the ANSYS Fluent software, authors have obtained new correlating equations for the average Nusselt number illustrating a growth of the average Nusselt number with Rayleigh number and general tube ratio spacing. Three-dimensional numerical simulation of thermal energy storage systems based on the phase change material for the hot water tank has been performed by Bayomy et al. [10]. Using COMSOL Multiphysics software (COMSOL AB, Stockholm, Sweden), authors have revealed that a raise of the hot water supply for the charging period allows the increase of the storage efficiency.

Investigation of physical mechanisms of vortex heat transfer enhancement in the narrow plane-parallel channel using inclined oval-trench dimples has been performed by Isaev et al. [11]. The turbulent convective heat transfer has been modeled using the Reynolds-averaged Navier–Stokes equations with the standard and modified Menter SST models. The developed in-house computational code has allowed the conclusion that a rise of the dimple length leads to a reduction of the separation zone and backflow enhancement. Palacio-Caro et al. [12] have examined numerically fluid flow and heat transfer in an electric tempering furnace. Using the ANSYS Fluent software (Ansys, Inc., Canonsburg, PA, USA), authors have revealed that thermal homogeneity inside the process chamber can be improved by a growth of the fan rotating speed. Gonzalez-Duran et al. [13] analytically and numerically have investigated thermal behavior of the cell in an adiabatic calorimeter. Numerical research has been performed using the ANSYS software. The obtained results have shown that a difference between analytical and numerical data rises with a growth of the temperature and reduces for the steady state.

These published papers have shown an importance and usefulness of analysis of heat transfer mechanisms, including thermal convection and radiation, employing numerical methods.

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