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Editorial

Numerical Simulation of Convective Heat Transfer

Mikhail A. Sheremet [1,2]

[1] Laboratory on Convective Heat and Mass Transfer, Tomsk State University, 634050 Tomsk, Russia; sheremet@math.tsu.ru
[2] Laboratory for Interdisciplinary Problems of Energy Production, Ulyanovsk State Technical University, 432027 Ulyanovsk, Russia

Convective heat transfer as an energy transport phenomenon occurs in various engineering and natural systems such as heat exchangers, chemical reactors and solar collectors, cooling systems, transportation of contaminant in urban landscape and air pollution, motion of sea or ocean waves and others. Therefore, understanding and manage of these processes demand to simulate the transport phenomena in different working media. Nowadays, a development of computer equipment allows to conduct numerical simulation of convective heat transfer in complicated domains that can be considered as an effective method to solve the mentioned challenges. Moreover, very often numerical investigation is a single technique to get important physical properties of the considered phenomena.

This Special Issue includes eight papers devoted to different topics containing numerical simulation of convective flow and heat transfer in both different engineering devices such as thermal energy storage systems [1,2], thermoelectric generator module [3], honey dehydrator [4], electric vehicles [5], elements of thermal power equipment [6,7], and natural human system for the medicine purpose during the hyperthermia treatment [8]. It should be noted that computational simulation in these published papers [1–8] has been conducted employing the in-house algorithms [1,4,6,8], OpenFOAM software [2], COMSOL software [3], and ANSYS Fluent software [5,7].

The aim of this Special Issue is to show the recent advances in numerical simulation of convective heat transfer for engineering and natural systems that can be very useful for scientists and engineers in mechanical and chemical engineering, physics, mathematics and medicine. Next paragraphs contain a brief overview of these published articles.

It is well-known that mathematical modelling and numerical simulation are very good techniques for development, optimization and creation of modern devices that can be used in industry, medicine, science and in household use. The first published papers in this Special Issue deal with numerical simulation of heat and mass transfer in various engineering systems. Thus, Bondareva et al. [1] have studied convective heat transfer strength during the melting phenomenon in copper finned heat sink filled with lauric acid in order to intensify the thermal energy removal from the local element of constant volumetric heat generation. The used partial different equations based on the non-primitive dimensionless variables in combination with initial and boundary conditions have been worked out employing the computational algorithm developed using C++ programming language. The in-house code has been validated comprehensively using the mesh sensitivity analysis and experimental data of other authors. As a result of numerical investigation on fins geometry influence, the authors have revealed that a raise of the transverse subfins length characterizes a reduction of the average heater temperature due to the formation of extended heat transfer surface. At the same time, an elongation of these subfins illustrates uniform melting of phase change material within the heat sink. König-Haagen et al. [2] have analyzed five of the most encountered and famous fixed grid approaches based on both enthalpy and temperature formulations for simulation of melting heat transfer in different engineering systems. The authors have conducted calculations using OpenFOAM software. It has been found that all resilient solvers allow receiving almost similar solutions

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for identical characteristics. At the same time, the apparent heat capacity technique results to wrong outcomes and all solvers are less resilient when the advective term of the energy equation includes the latent part of the enthalpy.

Selimefendigil et al. [3] have investigated 3D nanojet impingement for the thermoelectric generator module using COMSOL software. The authors employed the single-phase nanofluid model for the water containing single walled-CNT particles with well-known theoretical correlations for dynamic viscosity and thermal conductivity of the nanosuspension. The developed code has been validated using the mesh sensitivity test and numerical and experimental outcomes of other researchers. Analysis has been performed for hot and cold nanojets from upper and bottom sides of the thermoelectric generator module. It has been ascertained that for low and high Reynolds number combinations, the generated power raises by about 81.5% whilst the conversion efficacy increases by 23.8%. Moreover, with an increment of the distance between the inlet and target impinge surface the generated power diminishes and conversion efficacy illustrate non-monotonic behavior. Morawski et al. [4] have formulated the mathematical model based on the heat and mass balance for the rotary-spray honey dehydrator with a heat pump and a closed air circuit. This developed model has been validated using the experimental data. Some differences can be found for the performed comparison that can be explained by usage of such a balance model for analysis. At the same time, employing this simple model allows to design honey dehydrators.

Nowadays development of effective cooling systems for various engineering devices is the crucial challenge. Bae et al. [5] have performed a numerical analysis of turbulent fluid flow and heat transfer in a water elbow type channel with vortex generators using ANSYS Fluent software. Turbulent heat transfer has been described using the k-ε turbulence model. The non-uniform mesh with 40 million elements has been used for analysis. The authors have found that employing the vortex generators, the temperature of the cooling element in the models with a single-vortex generator and pair-type vortex generator can be reduced by 3.8 °C and 6.0 °C that corresponds to 4.1% and 6.5% enhancement, respectively. Kim [6] has scrutinized numerically the fully-developed Carreau fluid flow in a circular pipe under an influence of uniform heat flux on the tube wall. The author ha studied the behavior of the Nusselt number for different governing parameters. As a result, the author has extracted the correlation for the Nusselt number in the case of Carreau fluid flow where the modified form of the apparent index has been used to improve the accuracy of the correlation. Baranova et al. [7] have numerically scrutinized turbulent fluid flow and heat transfer in the T-junction. The Reynolds-averaged Navier-Stokes (RANS) equations combined with Menter's shear stress transport k-ω model have been employed for analysis within the ANSYS Fluent software. The authors have shown that the motion in the main pipe is stratified downstream behind the T-junction and to obtain the full mixing the velocity at the inlets of the main pipe should be increased. Moreover, the maximum temperature fluctuations can be found close to the mixing zone. At the same time, comparing RANS and LES approaches with experimental data, one can conclude that RANS equations can be used to obtain qualitative and quantitative outcomes for mixing phenomena in the main pipe behind the T-junction.

As it has been highlighted the mathematical modeling can be used not only for solution of the engineering problems in industry but also for development of medical treatment. Thus, Srivastava et al. [8] have proposed an efficacy wavelet technique based on nonorthogonal Fibonacci wavelets to analyze the bioheat transfer equations in multilayer skin tissues during hyperthermia treatment. Detailed description of this technique has been performed with an illustration of the solution of dual-phase-lag model of heat transfer. As a result, the authors have highlighted that this proposed technique can be widely used for analysis of physical and biological problems.

These published articles have demonstrated an importance and usefulness of convective heat transfer investigation using computational techniques for practice and science.

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