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Editorial

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Introduction to the Special Issue on Advances in Modeling and Simulation of Complex Heat Transfer and Fluid Flow

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Heat transfer and fluid flow are fundamental phenomena in nature and engineering. Modeling and simulation of heat transfer and fluid flow are significant for a wide range of scientific and industrial applications. Along with the development of computer industry and the advancement of numerical methods, significant progresses have been witnessed in modeling and simulation of heat transfer and fluid flow. Solid foundation in both hardware and software has been established to study the heat transfer and fluid flow processes because of its importance in reducing production costs, discovering new phenomena and developing new technologies, etc. However, the accurate modeling and efficient, robust simulation of complex heat transfer and fluid flow still remain challenging. And multi-disciplinary research effort has been a clear and general trend. To highlight the recent advances and challenges in numerical modeling, algorithm, and computation of complex heat transfer and fluid flow, the guest editors organized a special issue on "Advances in Modeling and Simulation of Complex Heat Transfer and Fluid Flow" within *Computer Modeling in Engineering & Sciences*.

This special issue received 25 active submissions contributed from influential universities, colleges and institutes. After a strict peer review process, a total of 15 research articles were accepted for publication in this special collection. These papers cover the state-of-the-art numerical modeling and simulation of heat transfer and fluid flow. They not only present the ongoing research, but also show observations of general trends in predictable future. The 15 research articles can be classified into 3 groups and a brief summary of each group is presented below.

The first group consists of 5 papers that devote to the numerical modeling of heat transfer and fluid flow problems. Wang et al. [1] presented an efficient proper generalized decomposition (PGD) reduced-order model to accelerate simulations of the transient, non-linear coupled system of hydraulic fracturing problem in the paper titled "A numerical study on hydraulic fracturing problems via the proper generalized decomposition method". Validation shows the results of PGD can match well with these of standard finite element method, moreover, PGD can achieve real-time calculations during the hydraulic fracturing treatment due to its high efficiency. Zhan et al. [2] simulated the leakage and diffusion processes of dangerous chemicals in inland rivers in the paper entitled "Numerical study on the leakage and diffusion characteristics of low-solubility and low-volatile dangerous chemicals from ship in inland rivers”. In their simulations, the standard k-ε model was used to calculate the turbulent flow, and the VOF method was applied to describe the leakage, drift and diffusion process of dangerous chemicals groups on the water surface. In the article entitled “A staggered grid method for solving incompressible flow on unstructured meshes” by Shu et al. [3], a finite volume method based unstructured grid was developed to solve 2D viscous and incompressible flows. The proposed method is based on the concept of pressure-correction and solved by using a semi-staggered grid technique, which can handle cells of arbitrary shapes in 2D computational domain. Liu et al. [4] presented the article “Modeling tracer flow characteristics in different types of pores: visualization and mathematical modeling”. In this work, microscopic experiments at pore level were carried out and an improved mathematical model for tracer transport was proposed to clarify the effects of micro heterogeneity on aqueous tracer transport. The mechanisms of tracer in different types of pores were analyzed and characterized. In the last paper of this group entitled “Study on a dual embedded discrete fracture model for fluid flow in fractured porous media”, Zhang et al. [5] developed a dual embedded discrete fracture model (EDFM) for efficient simulation of fluid flow in fractured porous media. In the proposed model, the fluid flow in large-scale fractures was directly described by the EDFM, while that in the small-scale fractures was upscaled through local simulation by EDFM instead of using fine mesh.

The second group of papers concerns the performances and/or characteristics of heat transfer and fluid flow in various engineering applications. In the paper “Numerical analysis on multi-field characteristics and synergy in a large-size annular combustion chamber with double swirlers” by Fu et al. [6], authors carried out numerical computation and analyses on the velocity, temperature and pressure fields in a large-size annular combustion chamber with double swirlers to evaluate the flow and heat transfer performance of heavy-duty gas turbine. The influences of several factors on multi-field characteristics and synergy were investigated on the basis of field synergy theory. Guan et al. [7] investigated the intensity correlation between secondary flow and heat transfer to efficiently use vortex generators in the circle tube-finned heat exchangers to strengthen the heat transfer in the article “Numerical study of the intensity correlation between secondary flow and heat transfer of circle tube-finned heat exchanger with vortex generators”. In this work, 22 different structures of circle tube-finned heat exchanger with or without VGs were numerically studied, and the influence of six parameters of vortex generators on the performance of heat transfer and fluid flow was revealed. In the article entitled “Thermal modeling and analysis of metal foam heat sink with thermal equilibrium and non-equilibrium models”, Li et al. [8] numerically studied the thermal performance of metal foam heat sink by using the local thermal non-equilibrium (LTNE) model and local thermal equilibrium (LTE) model. Comparisons of thermal performance based on LTE and LTNE models were evaluated by considering effects of metal foam morphological and channel geometrical parameters. Lu et al. [9] proposed a simple Fourier series method to construct the rough surface of microchannel in the paper “A new method of roughness construction and analysis of construct parameters”. The roughness with a hydraulic diameter of 0.5 mm was constructed and the effects of triangulate size and correlation length during roughness construction were studied. In the work of “Comparison of thermal performance for two types of ETFP system under various operation schemes”, Li et al. [10] conducted a comparative study on the thermal performance between two types of earth to fluid pipe (ETFP) system under various operation schemes on the basis of numerical prediction. The influence factors of the shallow-buried horizontal ETFP and deep-buried vertical U-shape ETFP were studied. In particular, the effects of three operation schemes designed based on the actual operation conditions were analyzed and compared.

The third group is related to the applications in subsurface petroleum engineering and oil-gas field surface engineering. In the paper entitled “Dimensionless variation of seepage in porous media with cracks stimulated by low-frequency vibration”, Zheng et al. [11] studied the effect of low-frequency vibration on the seepage in dual-porous media for the application of wave stimulation technology in developing reservoirs with natural cracks. Variable physical properties were simulated to check the applicability of external low-frequency vibration load on dual-porous media. Wang et al. [12] developed a workflow for geophysical and production data history matching by modifying ensemble smoother with multiple data assimilation for reservoir inverse modeling in the work "Geophysical and production data history matching based on ensemble smoother with multiple data assimilation". The P-wave impedance data was subsampled to reduce the computational cost in this method, and the application scope and computational performance were validated through two cases. In the article "Study on the variation rule of produced oil components during CO_2 flooding in low permeability reservoirs", Hou et al. [13] established the physical model of the produced oil components (POC) variation during CO_2 flooding in low permeability reservoir, and clarified the variation reason and rule. Results indicate that the existence of inter-well channeling-path and permeability difference between matrix and channeling-path are the main reasons for the POC variation during CO_2 flooding in low permeability reservoirs. Zhang et al. [14] presented a 3D physical model based on the CFD methodology to study the natural gas leakage and dispersion accidents at the street intersection of a building group in the article "Numerical study on the gas leakage and dispersion at the street intersection of a building group". The model was validated using the data from field tests and wind tunnel experiments. And the pressure, wind, and concentration of natural gas dispersion at the street intersection were analyzed in detail. In paper "Study on the economic insulation thickness of the buried hot oil pipelines based on environment factors", different from previous studies, Fan et al. [15] established a model for determining the economic insulation thickness of the buried hot oil pipelines by taking the environmental factor into account. The model was solved using the golden section method while considering the costs of investment, operation, environment and the time value of money.

The guest editors are glad to share the above articles with relevant communities of interest. Although this special issue cannot cover all the topics in this area, we believe it will provide a valuable volume to readers on the significant advances both in theory and computational methods of complex heat transfer and fluid flow. Furthermore, the guest editors sincerely hope this special issue can provide a platform for bringing together researchers to exchange the latest ideas, and to promote further collaborations in the community.

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