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Special Topic on Selected Papers from the 11th National Congress on Fluid Mechanics of China

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Fluid mechanics covers a vast scope of flow phenomena that occur in nature, biology, and numerous engineering fields. The National Congress on Fluid Mechanics of China was initiated by the Chinese Society of Theoretical and Applied Mechanics in 1963 in Shanghai. The main goal of the state conference is to provide good opportunities for people working in various branches of fluid mechanics, including theoretical, experimental, and computational fluid dynamics as well as relevant interdisciplinary subjects. The 11th National Congress on Fluid Mechanics of China was held in Shenzhen on December 3–7, 2020. It serves again as a forum for scientists in the local fluid mechanics community to exchange their original ideas and new findings.

This special topic consists of ten papers nominated by the organization committee of the conference. Topics cover supersonic flow,[1–4] hydrodynamics,[5,6] industrial fluid mechanics,[7–9] and the application of machine learning methods in the fluid–structure interaction.[10] The studies utilize a variety of experimental and computational methods as well as machine learning methods.

Supersonic flows were studied by four groups of researchers. Yu *et al.*[1] presented an interesting investigation on the flow and aerodynamic heating characteristics of air and hydrogen–oxygen combustion gas under the same total temperature and pressure. The carefully conducted laboratory experiments were analyzed and compared with the numerical results of the two-dimensional axisymmetric compressible fluid flows. The authors concentrated on the variations of temperature and velocity of the combustion gas flow in a nozzle and the shock standoff distance and stagnation pressure for the combustion gas flows around a sphere. Their numerical results lead to a semi-empirical formula for the heat flux of the stagnation point heated by high-speed hydrogen and oxygen equivalent ratio combustion gas. Duan *et al.*[2] performed novel direct numerical simulation to study the interaction between a shock wave and the supersonic turbulent boundary layer in a compression–decompression corner with a fixed 24° deflection angle at Mach 2.9. The authors developed the high-order finite difference code OpenCFD-SC and reproduced the classic shock wave/turbulent boundary layer interaction flow around the corner of greater height and provided the variations of the separation region size and the low-frequency unsteadiness for the model of smaller height. Huang *et al.*[3] developed a numerical method for modeling liquid jet atomization in supersonic gas crossflow considering compressibility of the gas and incompressibility of the liquid. The authors proposed four different stages of the liquid jet breakup process, particularly at the Mach number for the gas crossflow on liquid jet atomization. Cui *et al.*[4] conducted a reactive molecular dynamics study of atomic oxygen collisions over the graphene surface for the incoming gas at different translational energies, incident angles, and O/O_2 ratios. The goal is to understand the complicated gas–solid interaction under highly hypersonic non-equilibrium flow and shed light for the future design and optimization of thermal protection materials.

Hydrodynamics with the free surface and flow instability around underwater bodies were studied in two papers. Zhao *et al.*[5] implemented a multi-cell linked list algorithm coupling with the adaptive particle refinement in the smoothed particle hydrodynamics method to simulate the three-dimensional two-phase flow with the free surface. Their results show the high efficiency of the numerical model and the detailed information of the pinch-off depth, the velocity fields, and cavity evolution. Zhao *et al.*[6] investigated the transitions of bow boundary layers over axisymmetric bodies numerically. The authors discussed the effect of the body shape and the oncoming flow velocity on transition locations of laminar flow fields over the underwater axisymmetric bodies and concluded that the late transition location and a large diameter close to the leading edge occur for the SUBOFF forebody shape.

A set of three papers covers the industrial flows associated with wind turbines, annular linear induction pumps, and microfluidics. Du *et al.*[7] studied the influence of atmospheric stability on the turbine wakes at a certain hub-height turbulence intensity via large-eddy simulation. Their results show that spanwise turbulence transport plays a crucial role in wake recovery, and atmospheric stability influences this transport by redistributing the turbulence intensity between the three components and altering the spatial scales of atmospheric motion. The mechanisms of a faster recovery of wind turbine wakes under the convective atmospheric condition and a slower recovery of wakes under the stable condition are revealed. Zhao *et al.*[8] performed numerical simulations of magnetohydrodynamic flows in an annular linear induction pump with a full-scale pump channel considering the magnetic-fluid coupling effect. After validating the numerical model with the available experimental data, the authors presented computed flow patterns at different flow rates and unstable behaviors of vortex flows in the pump. Their results show that the magnetic-fluid coupling effect amplifies the disturbances in either the magnetic field or the fluid field, and the sudden occurrence of vortex flows induces large current density that leads to an increase in Ohmic dissipation and a decrease in the energy conversion efficiency from the magnetic field into the fluid. Pang *et al.*[9] investigated the single-phase flow and droplet flow in a rectangular microchannel with a T-junction experimentally and numerically. The focus of the study is to understand the effects of droplets on the flow in the branch channel and the behaviors of droplets flowing in a channel with the branch. Their results show that the droplet behavior can be divided into three modes according to the volumetric flow rate ratio between two channels, namely, flow into the side branch, a split at the junction, and flow into the downstream channel.

Regarding the application of the machine learning methods in fluid–structure interactions, Zheng *et al.*[10] used machine learning technologies in active flow control for the vortex induced vibration of a cylinder. The authors implemented the algorithm of suppressing the vortex induced vibration using an adaptive control of a pair of jets as actuators and two machine learning methods, and concluded that, compared with the triangle control agent in the active learning framework, the real-time control in the reinforcement learning framework can work better to suppress the vibration amplitude.

In conclusion, the selected papers investigated supersonic flows, free surface flows, turbulent flows, and multiphase flows numerically and experimentally as well as an application of machine learning methods. They shed light for understanding the mechanisms of the complicated flows and developing efficient numerical methods. Contributions made by the younger generation of scientists from the universities and research institutes reflect the recent progress in the studies on fluid mechanics and its applications in China.

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