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Editorial

Symmetry in Fluid Flow

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Fluid flows sometimes exhibit symmetricity under certain conditions. However, such a symmetric flow is not always realized if such conditions are changed. For example, the plane Poiseuille flow, which exhibits a parabolic velocity profile formed between two parallel walls, has an exact symmetric solution of Navier–Stokes equation, but its symmetricity breaks under the condition of a high Reynolds number. This kind of flow transition from a steady symmetric state to another more complex state is not only realized in fluid flow experiments or analyses but also observed in natural fluid flow phenomena. The breaks of flow symmetry have been studied theoretically, experimentally, and numerically in the fields of fluid mechanics and thermal engineering because of their importance and relevance in terms of flow control and heat transfer enhancement. However, breaks of flow symmetry have not been sufficiently elucidated due to the non-linear characteristics of fluid flow. The Special Issue focuses on breaks of flow symmetry due to various kinds of factors such as shear, buoyancy, centrifugal force, and surface tension.

As a matter of fact, 11 papers were published in the Special Issue "Symmetry in Fluid Flow". They can be roughly classified into several topics: channel flow with sudden expanded section and reattachment [1], shock wave and discontinuity [2], heat transfer [3–6], natural convection and its stability [7–9], drag reduction and laminarization [10], and conformal invariance [11]. The followings are a brief summary of each classified topic.

Masuda and Tagawa [1] carried out a two-dimensional numerical simulation for oscillatory flow between parallel flat plates with the suddenly expanded section whose expansion ratio is 3 and aspect ratio is 7/3. The turbulent kinetic energy, which can be decomposed into the harmonic and non-harmonic components, was introduced. It was reported that the peaks of the non-harmonic component were generated in the region of the expanded section.

Telega et al. [2] presented the results of the experimental research on the symmetry of supersonic flow in a symmetric convergent-divergent nozzle. The investigations were focused on the fact that for some flow conditions, the flow in a precisely symmetric nozzle becomes asymmetric. An explanation of the phenomena is provided in their paper.

Song et al. [3] numerically investigated the effect of transverse pitch between a pair of delta-winglet vortex generators arranged in a common flow down configuration on the symmetrical flow structure and heat transfer performance. The results showed that symmetrical longitudinal vortices form a common flow down region between the vortices. They concluded that a reasonable transverse pitch of delta-winglet vortex generators in a common-flow-down configuration is recommended for high thermal performance. Song et al. [4] numerically studied the heat transfer and pressure-loss characteristics of a pair of winglet vortex generators with different transverse pitches. The optimal transverse pitch of the studied winglet pair with the best thermal performance was reported. The increments in the vortex intensity and the Nusselt number for the optimal pitch were increased by up to 21.4% and 29.2%, respectively. Luo et al. [5] numerically investigated

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the thermal-hydraulic performance in a novel annular tube formed by outer straight and inner twisted oval tubes. In particular, inner twisted oval tubes with different aspect ratios and twist ratios were studied. The heat transfer was well improved by the symmetrical secondary flow in the annulus. Gurgul et al. [6] numerically investigated the turbulent single-phase array of ten minijets impinging on a heated surface, which lead to the intensification of heat transfer between the fluid and the surface. Average surface Nusselt number values were compared with the experimental correlations and exhibited the same tendency.

Wada et al. [7] numerically investigated the Rayleigh–Bénard convection of paramagnetic fluid in which several pairs of alternating-pole magnets are employed and aligned near the bottom heated wall. It was reported that, since the magnetic force at the junction of pair magnets becomes strong remarkably and in the same direction as the gravity, descending convection flow was locally enhanced. Tagawa [8] numerically studied the effect of the direction of external horizontal magnetic fields on the linear stability of the natural convection of liquid metal in an infinitely long vertical rectangular enclosure. It was reported that the natural convection is once destabilized at a certain low Hartmann number but it is stabilized at high Hartmann numbers, when the applied magnetic field is perpendicular to the temperature gradient. Fornalik–Wajs et al. [9] numerically analyzed the combined effect of the application of nanofuids and the utilization of a strong magnetic field in order to attempt to enhance the heat transfer performance. The results exhibited a flow structure with a diagonal axis of symmetry in all analyzed cases and stabilizing effect of magnetic field. It was reported that the Nusselt number increases with an increasing value of magnetic induction but decreases with an increasing concentration of nanoparticles.

Fu et al. [10] carried out an experiment with water injected from a porous channel wall at a small velocity into the drag-reducing flow of surfactant solution. The results showed that the injected ultrathin water layer under present experimental conditions affected the anisotropy of the drag-reducing flow.

Wacławczyk et al. [11] addressed the problem of the existence of conformal invariance in a class of hydrodynamic models. This connected their study with previous observations where CG invariance of zero-vorticity isolines of the 2D Navier–Stokes equation was analyzed numerically and confirmed only for large scales in the inverse energy cascade.

Finally, I would like to thank all the contributors to the Special Issue for sharing their research, and the anonymous reviewers for donating their time to improve the quality of the submitted papers.

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