PREFACE: SPECIAL ISSUE ON VISUALIZATION OF COMPLEX FLUID–THERMAL PHENOMENA

The subject domain of fluid flow and heat transfer offers tremendous opportunities for recording unexpected and interesting image sequences that improve interpretation and provide utility. With the development of high-speed optical imaging systems as well as efficient computational fluid dynamics simulation tools, it is now possible to record details of flow structures and their evolution in diverse contexts.

This special issue stems from the ninth International and 49th National Conference on Fluid Mechanics and Fluid Power, held at the Indian Institute of Technology Roorkee (Roorkee, India) during December 14–16, 2022. The issue provides the readers with information on new developments in the exciting field of flow visualization. It includes lead and original research articles on experimental and computational studies that imaginatively reveal details on fluid flow and thermal phenomena. Explaining three-dimensional (3D) time-resolved measurements and simulations—particularly within the context of flow structures—also constitute the theme of this special issue.

The articles in this special issue were selected from those presented during the aforementioned conference. Other factors, such as referee comments received during evaluation of each manuscript submitted for the conference, were considered. The topicality of these articles for the special issue were examined by the editorial board. Subsequently, the authors of the short-listed articles were asked to submit full-length versions for the special issue. These articles were also subjected to independent peer review.

The special issue begins with two review articles, one that connects spatial and temporal statistics of wavy flow from laser Doppler velocimetry signals and another related to surface actuation for flow control. Mujawar et al. (Identification of Wavy Flow Sub-Regimes Using Power Spectrum of Laser Doppler Velocimetry Signals) reviewed methods by which power spectrum analysis can be used to accurately categorize wavy flow sub-regimes in two-phase gas–liquid flow in micro-channels, including the creation of a flow sub-regime map demarcating two-dimensional and 3D large- and small-amplitude waves. Sharma and Dutta (Effect of Bio-Inspired Modification on Fluid-Structure Interaction and Its Control: A Review) synthesized and evaluated research on passive and active modifications with the goal of developing a new approach that will stimulate further research. Their review elaborates on flow interactions with control structures such as riblets, flexible geometry, and synthetic jets for practical applications. Among the contributed articles, Sellan et al. (Blending Hydrogen with LPG and Methane in Premixed and Stratified Flames: An Experimental Study) described experimental work that investigates the effects of blending hydrogen into liquefied petroleum gas/air and methane/air flames under various stratified mixture conditions. On a laboratory scale, a swirl-stabilized burner with two annular tubes was used to examine the stability and structure of the flames. Maurya and Dutta (Experimental Investigation of Secondary Flow during the Droplet Formation in the Flow-Focusing Channel) investigated the complex dynamics of droplet formation in a flow-focusing channel, in which they used a micro-particle image.
velocimetry system to perform the experiments. The growth of droplets was observed during four stages: lagging, filling, necking, and detachment. Gupta et al. (Characterization of Separated Shear Layer of Elevated Jet in Crossflow at Low Velocity Ratio) experimentally investigated the flow dynamics of separated shear layers of an elevated jet-in-crossflow. Their work aimed to enhance the understanding of the downwash of jet fluid into the stack-wake region, akin to plume downwash in chimney flows, particularly at low-velocity ratios. Dwivedi and Muralidhar (Numerical Simulation of Drop Spreading over a Pillared Surface) studied the spread and impact of water drops with diameters on the order of 45 μm over micro-pillars. The pillars studied had a diameter of 3.2 μm, while the height and pitch were varied from 15 to 20 and 6 to 9 μm, respectively. The stability of the equilibrium configuration and the transitions in the Cassie–Wenzel wetting states were examined. The results of 3D simulations showed that drops rebound when pillars are closely spaced. Thulasi et al. (Effect of Flexible Flap Length on Flow Generation by an Airfoil Pitching in Quiescent Fluid) experimentally investigated the effect of the length of a chordwise flexible surface, such as a flap attached to the trailing edge of a symmetric rigid airfoil purely pitching in quiescent fluid on flow, and thus creating thrust generation. Singh et al. (Visualization and Analysis of Accelerating Transonic Flow over Typical Launch Vehicle Model Using Image Processing) utilized high-speed shadowgraphy and unsteady pressure measurements to describe the formation and transit of a lambda-shock system that occurred over the payload region of a launch vehicle at transonic Mach numbers. The test section Mach number was varied continuously from 0.85 to 0.95. Analyses based on image processing indicated systematic downstream movement of the shock system until a value of 0.92 and rapid oscillations upstream and downstream of the mean position at higher Mach numbers. Using 3D simulations, Sahu et al. (Impact of Recirculation Zones on the Near Field Entrainment Characteristics of Swirling Liquid Jet) analyzed the entrainment of ambient fluid at its interface with a swirling liquid jet for moderate Reynolds number. Their results indicated that the surrounding air exhibited toroidal recirculation zones, which caused the accumulation of ambient air at the interface and led to the engulfment of the ambient fluid.

The articles highlighted here cover a broad range of subjects within fluid mechanics and thermal sciences, with due emphasis on imaging—both from experiments and simulations. The editors hope that the readership of the journal finds these papers to be timely and topical and will be enthused to submit their recent and quality research for future publication in the journal.

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