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Editorial

Gas-Liquid Two-Phase Flow in a Pipe or Channel

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This Special Issue contributes to highlight and discusses topics related to various aspects of the two-phase gas-liquid flows. They can be used both in fundamental sciences and practical applications. We consider that the main goal has been successfully reached. This Special Issue received investigations from Russia, China, Thailand, ROC-Taiwan, Saudi Arabia, and Pakistan. We are happy to see that all papers present findings characterized as unconventional, innovative, and methodologically new. We hope that the readers of the journal Water can enjoy and learn about experimental and numerical study of two-phase flows using the published material, and share the results with the scientific community, policymakers and stakeholders.

Two-phase gas-liquid flows are frequently applied in energy, nuclear, chemical, geothermal, oil and gas and refrigeration industries. Two-phase gas-liquid flows can occur in various forms, such as flows transitioning from pure liquid to vapor as a result of external heating, separated flows, and dispersed two-phase flows where one phase is present in the form of droplets, or bubbles (i.e., liquid or gas) in a continuous carrier fluid phase (i.e., gas or liquid). Typically, such flows are turbulent with a considerable interfacial interaction between the carrier fluid and the dispersed phases. The variety of flow regimes complicates significantly the theoretical prediction of hydrodynamics of the two-phase flow. It requires application of numerous hypotheses, assumptions, and approximations. Often the complexity of flow structure allows theoretical description of its behavior, and so empirical data are applied instead. The correct simulation of two-phase gas-liquid flows is of great importance for safety and design of energy equipment elements.

The simultaneous measurements of the hydrodynamic and thermal characteristics of spray cooling were performed in [1]. The size of individual droplets before their impact on the forming liquid film and estimation of the number of droplets falling onto the impact surface from the impinging spray was performed using the high-speed recording with high spatial resolution. The authors showed various possible scenarios for this interaction, such as the formation of small-scale capillary waves during impacts of small droplets, the appearance of "craters", and splashing crowns in the case of large ones. Evolution of the non-steady state temperature fields during spray cooling in regimes without boiling was measures using high-speed infrared thermography. It was shown that, for the studied regimes, the heat transfer weakly depends on the heat flux density and is primarily determined by the mass flow rate of the spray.

The flow structure, turbulence modification, and heat transfer augmentation in a droplet-laden dilute flow over a single-side backward-facing step were numerically studied in [2]. Numerical simulations were performed for water droplets, with inlet droplet diameters d_1 = 1–100 μm and the mass fraction M_{L1} = 0–0.1. There was almost no influence of a small number of droplets on the mean gas flow and coefficient of wall friction. A substantial heat transfer augmentation in a droplet-laden mist separated flow was shown. Heat transfer enhancement was revealed both in the flow recirculation and flow relaxation zones for fine dispersed droplets, and the largest droplets augmented heat transfer mainly

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after the flow reattachment point. The largest heat transfer enhancement in a droplet-laden flow was obtained for small evaporating particles.

Authors of [3] carried out the experimental and numerical study of the mean and turbulent flow structure and heat transfer in a bubbly gas-liquid flow at a single-side backward-facing step. The flow was directed upward in a duct. The carrier fluid phase velocity was measured using the PIV/PLIF system. The set of two-dimensional RANS equations was used for modelling two-phase bubbly flow. The motion and heat transfer in the dispersed phase were modelled using the Eulerian approach with taking into account the bubbles break-up and coalescence. The method of delta-functions was employed to simulate the distribution of polydispersed gas bubbles. Small bubbles were presented over the entire duct cross-section and the larger bubbles were mainly observed in the shear mixing layer and flow core. The recirculation length in two-phase bubbly flow was shorter (almost twice) than in the case of single-phase fluid flow. The position of the heat transfer maximum was located after the reattachment point. The addition of air bubbles leaded to a significant increase in heat transfer (up to 75%).

An overview of the methods for predicting the pressure drops and heat transfer of two-phase flows in small-diameter ducts and a comparison of several methods were presented in [4]. The comparison was performed for the conditions of high reduced pressures $p_r = p/p_{\mathrm{cr}} \approx 0.4$–$0.6$, where p_{cr} is the critical pressure. The results of authors experimental studies of pressure drops and flow boiling heat transfer of freons in the region of low and high mass flow rates G = 200–2000 kg/(m^2·s) were presented in the paper. A description of the experimental stand was given, and a comparison of own experimental data with those obtained using the most reliable calculated relations was carried out.

The experimental study of the flow structure and the water holdup in an oil–water–gas three-phase flow in a horizontal and vertical pipe was carried out in [5]. The three-phase flow consisted of white mineral oil, distilled water, and air. The flow pattern maps in terms of the Reynolds number and the ratio of the superficial velocity of the gas to that of the liquid mixture for different Froude numbers were given by authors. The relationship between the transient water holdup and the changes of the flow patterns in horizontal and vertical sections of the pipe were presented. Authors presented the dimensionless power-law correlation for the water holdup in the vertical section.

The numerical and experimental study of ultrasonic atomization of fluids using silicon-based three Fourier-horn ultrasonic nozzles was carried out in [6]. COMSOL Multiphysics 5.4 was used to perform numerical analysis. The design and characteristics of microprocessor-based ultrasonic nozzles based on silicon with a frequency of 485 kHz were presented. During operation, deionized water was initially sprayed onto the microdroplets, which were stably and continuously formed. A new ultrasonic nebulizer promotes the development of resonance of capillary surface waves at a given frequency. The developed device is compact and energy-saving. It can be used in the green energy industry and non-invasive drug delivery.

Poincare-Light Hill Technique was used for the theoretical analysis of wall shear stress on the MHD two-phase fluctuating flow of dusty fluid in [7]. The flow between two parallel non-conducting plates was considered. The conversion of heat created a fluid flow. Spherical dust particles were evenly dispersed in the base fluid. It was pointed that an increase in Grashof number, radiation variable parameter, and dusty parameter led to an increase in velocities of carrier fluid and dusty particles. On the other hand, a decrease in phase velocities was found with an increase in magnetic parameter. An increase in radiation caused an increase in temperature. The behavior of base fluid and dusty particles was similar.

Authors of [8] studied the non-chemical treatment of aqueous systems with humid air exposed to IR waves. It was shown for the first time that in the samples of deionized water and mineral water, the redox potential and surface tension decreased, and the dielectric constant increased. The treatment of carbonate or phosphate buffers leads to a significant increase in their buffering capacity against acidification and leaching. In water samples treated with humid air without IR processing, no changes were observed.

New experiments have been carried out to study the characteristics of the development of the self-aeration region in a flow along a flat chute [9]. A double-tip conductivity probe was used. The self-aerating area with a free surface was from 27.16% to 51.85% of the liquid depth. The average and fluctuational velocity of the flow in the transverse direction increased downstream the flow inlet. In this area, fluctuations in the flow velocity in the cross-sections were smoothed out as the flow develops. Higher velocity fluctuations in the direction corresponded to the presence of much stronger turbulence increased the diffusion of air bubbles from the free surface of the water to the flow.

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