8TH INTERNATIONAL SYMPOSIUM ON GAS-LIQUID TWO-PHASE FLOWS

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The 8th International Symposium on Gas-Liquid Two-Phase Flows took place during the ASME/JSME Joint Fluids Engineering Division Summer Meeting held July 6-10, 2003 at the Sheraton Waikiki Hotel, Honolulu, Hawaii, and was sponsored by the Multiphase Flow Technical Committee of the ASME Fluids Engineering Division and the Japan Society of Mechanical Engineers (JSME). Over the last 18 years, this symposium has regularly appeared, approximately every other year, in ASME conferences. Its scope has been as broad as its name implies, offering a forum for the presentation and discussion of gas-liquid research work covering the range of the spectrum from theory and fundamentals to experimentation and applications.

During this eighth incarnation, the symposium included 49 papers distributed over 11 sessions and an additional panel discussion session dedicated to "Open Questions and New Directions in Gas-Liquid Flows." As in the past, a broad range of topics was covered. Among these, Bubbly Flows had a prominent presence with 13 papers (3 sessions) predominantly covering experimental work on single-bubble or bubble-chain dynamics, bubbly flows in pipes, channels and bubble columns, as well as bubbly flows in more complex geometries such as sudden duct expansions and around cylinders confined in channels. Two keynote papers in this area addressed issues of bubble clustering near the walls in bubbly channel flows (So et al., FEDSM2003-45387) and a review of modern imaging and pulsed-light velocimetry measuring techniques in bubbly flows (Sommerfeld and Bröder, FEDSM2003-45794). A substantial group of eight papers (two sessions) addressed Computational Methods for the Simulation of gas-liquid flows and their applications, covering novel schemes that incorporated level-set, characteristics-matching and preconditioning methodologies and offering numerical simulation results on the motion of free-surfaces and flows of practical interest and complexity such as boiling flows during the quenching of engine blocks. A keynote paper in this area discussed an improved implementation of a level-set method in three dimensions (Takahira et al., FEDSM2003-45389). Applications of gas-liquid flows to Complex and Industrial Systems were strongly represented by 10 papers (two sessions) covering phase-separation technology and swirling flows relevant to the oil industry, flows in rod-bundle geometries relevant to the nuclear industry, two-phase flow development during depressurization of liquid filled industrial vessels, flow measurement in automotive air-conditioning heat exchangers and in rapidly rotating annular systems as well as two-phase flow characteristics in helically coiled tubes. Gas-Liquid flows in micro-scale geometries are a rapidly emerging area of research interest and were addressed by five papers (one session) predominantly dealing with flows in micro-channels. Three papers dealing with the stochastic representation of droplet motion in annular flows, swirling spray combustion LES and wake disappearance in multiphase flow, represented droplet flows. A keynote paper completed one session in this area (Theofanous and Dinh, FEDSM2003-45371) providing a review of the aerobreakup field while presenting interesting new insights into the mechanisms occurring under rarified supersonic conditions. Theory and Modeling of gas-liquid flows was covered by one session with four papers that addressed modeling of thin liquid films on inclined surfaces, lift and dispersion forces in bubbly flows, and liquid film formation and entrainment generation in horizontal annular flows (keynote paper by Fukano, FEDSM2003-45815). The five papers of the last session of the symposium addressed issues in non-bubbly flow regimes such as turbulence modification in annular flows, application of real time electrical tomography to phase detection and measuremnt, air-oil flows through sudden expansions, the effect of surfactants on the slug flow regime, and measurement of interfacial area concentration in this regime.

During the symposium review process, a group of papers was recommended by the symposium reviewers for an accelerated review towards publication in the Journal of Fluids Engineering. Ten of these papers follow this introductory editorial in this special issue of the Journal of Fluids Engineering, and cover the breadth of experimental, computational and modeling work in gas-liquid flows.

The first group of papers consists of predominantly experimental investigations. The leading paper by Theofanous et al. provides original observations of interfacial phenomena and mixing patterns during the breakup of Newtonian liquid drops, when these are impulsively subjected to a high-Mach number rarified airflow environment. This study covers a wide range of Webber numbers, identifies several breakup regimes and associated transition criteria, and offers qualitative and quantitative insights into interfacial phenomena and breakup mechanisms occurring during the aerobreakup of liquid drops.

Air-water downward flow is the object of the second and third papers. Kim et al. identify regime transitions in such flows by employing a novel combination of an impedance-based void meter and neural network method. They demonstrate that, unlike vertical upwards flow, regime transition boundaries in co-current downward flows are strongly dependent on pipe diameter. The paper also presents local measurements of void fraction, interfacial area concentration and bubble velocity and size. Experimental results are analyzed in the perspective of the drift flux model and the authors present new correlations for the distribution parameter that can be useful in applying the drift flux model in practical gas-liquid flow systems. The paper by Sun et al. focuses on local measurements in vertical-downwards, dilute air-water bubbly flows through the use of Laser Doppler Velocimetry for the liquid velocity and miniaturized conductivity probes for the bubble velocity and void fraction. They observe off-center liquid mean velocity maxima and flatter mean liquid velocity profiles in two-phase flow relative to the single-phase flow counterpart. The liquid fluctuation intensity is shown to increase with increasing average void fraction especially at low superficial liquid velocities. An estimate of the distribution parameter and drift velocity is also provided as relevant to a practical application of the drift flux model.

The fourth paper of this group investigates two-phase flow in micro-channels, a topic of recent and growing research interest. Chung et al. identify flow regimes and transition boundaries for both square- and circular-cross section micro-channels, demonstrating a significant dependence of the regime transition boundaries on the shape of the channel cross section. Although gas and liquid superficial velocities are varied over two orders of magnitude, bubbly, churn and purely annular flows are not observed. Measurements of void fraction indicate that an empirical correlation developed from circular micro-channel data is equally successful in predicting void fraction from volumetric flow ratio in the square micro-channel. Measurements of frictional pressure drop are used to verify that the Lockhart-Martinelli correlation with a modified correlation constant performs well in predicting the experimental data for both circular and square micro-channels.

The last paper of this group by Oropeza-Vasquez et al. presents the experimental investigation and evaluation of a liquid-liquid cylindrical cyclone separator developed for oil-water separation as needed by the oil-industry. The device achieves effective water content reduction of an oil-water mixture. A mechanistic model for the prediction of separation efficiency is presented for use in design and performance analysis of such industry-relevant systems. The performance of this model is successfully validated through comparisons with the results of experimental tests.

The second group of papers covers theoretical and computational aspects of gas liquid flows. The first paper of this group by Podowski and Kumbaro addresses theoretically both stationary and moving liquid films on inclined solid surfaces from vertical to horizontal. The authors develop analytical expressions for the distribution of the thin liquid film thickness on inclined solid surfaces on the basis of first principles. Their results cover the full range from the liquid free surface to the disjoining-pressure-dominated (asymptotic) region. In the case of moving surfaces, an elegant derivation of an analytical solution for the thin film evolution is presented and a clear explanation of why liquid film thickness is normally beyond the range of Van der Waals forces is given.

The second paper of this group focuses on the modeling of dispersion and lift forces for use in simulations based on a two-fluid model. The turbulent dispersion model of Lopez de Bertodano et al. is based on a Bolzman-type kinetic transport equation. The two-fluid model is tested for a bubbly jet with 1-mm bubbles and shown to yield satisfactory results in the jet far field through comparisons with experimental data. The sensitivity of the results to the lift coefficient is shown not to be significant. This work provides a first assessment of the performance of the two-fluid model in a free shear dispersed gas-liquid flow.

Takahira et al. present a three-dimensional level set method for the simulation of high-density ratio flows in the third paper of this group. The conservation equations are solved using a fractional step method on a non-staggered grid and a semi-implicit time stepping scheme. The authors improve the stability of the algorithm by improving the treatment of the convection terms, the interpolation method used to obtain the volume flux on the computational cell faces, as well as the Poison solver for the pressure. The mass conservation performance of the algorithm is also enhanced through an improved reinitialization procedure for the level set function. The scheme is shown to perform very well for test problems involving bubble coalescence and a bubble bursting through a free surface, and holds good promise for high-density ratio two-phase flow simulations.

The fourth paper of the group by Nourgaliev et al. pursued the same goal as the previous paper for compressible multi-fluid, high density-ratio problems by introducing an original and very promising approach. The authors introduce a novel algorithm referred to as "characteristics-based matching" (CBM) to capture a moving boundary condition. The scheme is based on a level set method and a "Ghost Fluid Method" strategy to tag computational nodes. The boundary conditions are implemented through a characteristic decomposition in the direction normal to the boundary. The CBM method suppresses over and under-heating errors and is shown to yield very good results in a broad variety of multi-phase test problems.

Shin et al. present a two-dimensional numerical algorithm for the simulation of gas-liquid flows in the last paper of the series. The authors use a finite-difference Runge-Kutta method employing Roe's flux difference splitting and MUSCL-TVD schemes. Preconditioning is used to extend the functionality of the algorithm to nearly incompressible flows. Simulation of several cavitating test flow problems are carried out using a homogeneous cavitation model. The algorithm performance is successfully validated at low Mach numbers through comparison of the computational cavitation results with experimental data.

The co-organizers of the eighth international gas-liquid flow symposium would like to thank the authors of the papers in this special issue of the Journal of Fluids Engineering for their interesting contributions, as well as the reviewers who contributed their time, experience and constructive criticism towards the improvement of the quality of these papers.

On behalf of the symposium co-organizers,
Dimitris E. Nikitopoulos