Experimental Investigation of Bubbly Jets

Rade Milenkovic [a], Dr. Beat Sigg [b] and Prof. Dr. George Yadigaroglu [c]

[a] Doctoral candidate, Laboratorium für Thermalhydraulics, Paul Scherrer Institute, CH-5323 Villigen PSI
[b] Laboratorium für Kerntechnik ETH, c/o PSI, CH-5323 Villigen PSI
[c] Laboratorium für Kerntechnik, ETH Zentrum CLT, CH-8092 Zürich

Dispersed multiphase flows constitute classes of fluid flows of universal importance in process and energy technology as well as in environmental flows. Progress has been achieved during recent years in the analysis of bubbly two-phase flows mainly because of their increased amenability to numerical simulation, but also due to the availability of more powerful experimental means.

To improve physical insight and to support numerical analyses, a number of basic experiments in bubbly flows have been carried out. In the field of free shear flows, research has been performed on bubbly jets and plane bubbly mixing layers. In these tests, effects of bubble sizes and concentration on turbulence, velocity and void distributions, shear-layer spreading rates, mixing, characteristic length scales and velocity correlations have been studied. However, these measurements only provide results for statistical properties and the spatial distribution of local stochastic variables and do not investigate spatial coherence and effects of large structures (vortices), which are very important in shear layers and have been extensively analyzed in single-phase flows.

In general, it has been found that the following, not sufficiently explored phenomena should be analysed in the framework of an experimental project on vertical bubbly jets:

1) The influence of bubble size and void fraction on shear layer spreading (distribution of velocity, bubble and possibly scalar concentration). Previous results are contradictory and the spreading of momentum and scalars has not been distinguished.
2) The role of flow parameters used to characterise buoyant-jet development on one hand, i.e. Reynolds- and Richardson number, inlet and boundary conditions, and on the other hand, of those that determine bubble movement and turbulence modulation, such as, Reynolds and Froude number, Trapping parameter, Stokes number and length-scale ratio. The downstream variation of parameters that are defined locally has also to be investigated.
3) The interaction between coherent structures and bubbles as well as the feedback from bubble agglomeration on the development of these structures.

The general goal of the project is to contribute to the understanding of the above-mentioned phenomena and to provide experimental information especially regarding the large structures; such large structures will also be triggered externally to allow statistical ensemble averaging of the data. Special emphasis will also be attributed to the careful determination of inlet conditions and effects of bubble size and void fraction. A unique aspect of the experiment will be the use of monodisperse, controlled diameter bubbles.

The experiments will be carried out in bubbly jet flows formed by a vertical water jet containing bubbles of various well-controlled sizes and volume fraction; the jet will be injected in a sufficiently large Plexiglas tank to minimize wall effects. Experimental techniques such as Particle Image Velocimetry (PIV) and Image Analysis will be applied besides local void-fraction and bubble-velocity measurements using optical probes and, if necessary, hot-wire anemometry for local liquid velocity measurement.