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PARTICLE AND GAS MASS TRANSFER IN SPARGER GAS-LIQUID SYSTEMS: A COMPARATIVE EXPERIMENTAL STUDY USING A WIRE-MESH SENSOR

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Gas-liquid spargers are ubiquitous to multiphase mass transfer systems in the chemical or energy conversion industries. Despite of its key importance, there is a lack of detailed data and experimental studies on two-phase flow mass transfer due to its inherent complexity. Wire-mesh sensors, an electrode-based tomograph system, can provide high temporal (3200 Hz) and spatial (1 mm) resolution measurements of the void fraction in complex flows such as gas-liquid spargers. The mass concentration of ion-based tracers can be simultaneously measured in the liquid phase. Cross-correlation techniques can be used to derive gas and liquid phase axial velocities, and thus the associated gas and mass fluxes through the sensor plane.

Two separate measurements of multiphase mass transfer are performed in an upward co-current gas-liquid $50\,mm$ side square column where either micrometer-sized (aerodynamic diameter = 0.7-1.5 µm) NaCl-based aerosol or CO_2 gas are injected under the same gas-liquid flow conditions. A three-layer WMS is located at an adjustable height h from a 6 mm vertical injector point. At the current regime, the resulting hydrodynamics is a heterogeneous bubbly flow with ellipsoidal caps and small spherical bubbles. The formation of a mass transfer wake of dissolved particles or gas is observed downstream of every rising bubble. The retention, i.e., the efficiency of the mass transfer, is the ratio $RF = m_l/m_{in}$ between the transferred, or equivalently, the measured accumulated mass advected by the liquid m_l, and the injected species m_{in}. For micrometre aerosol-laden flows, the strong inertial forces during the bubble formation lead to a high retention at the injector location. Comparatively, the retention driven by the inertial motion of the Hill's vortex in rising bubbles presents a slower and weaker contribution. For CO_2 gas-liquid mass transfer, the inertial effects at the injector do not contribute significantly to the gas retention. The gas transfer increases in height with the acceleration of the liquid-gas relative motion, and the axial spreading of the bubbly flow.

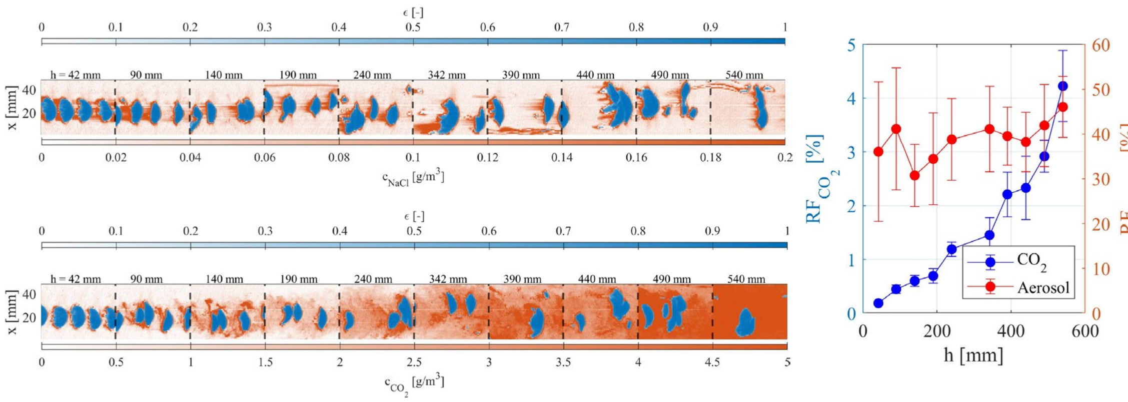

Figure 1: Projection for 400 frames of the void fraction ε and the dissolved species concentration c at every height h for the Aerosol (top left) and CO_2 (bottom left) cases. Retention factor RF for Aerosol and CO_2 (right).

Our WMS measurements provide a comprehensive visualization and quantitative evaluation of the fundamental multiphase transfer driving forces for particles and gases. These results support the development and validation of high-fidelity simulation codes, a better understanding of this fundamental phenomenon, and its influence on industrial systems.

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