Measurement of turbulence energy transport in upward/downward bubbly flows

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The modifications of the turbulence energy transport due to bubbles were investigated in upward and downward flows. The experimental technique consisted on the combination of a time resolved Particle Tracking Velocimetry (PTV) system, a Shape Projection Imaging (SPI) system and a pressure sensor. The spatial and temporal resolutions of the PTV system were sub-kolmogorov. This high resolution PTV technique was used to estimate the liquid phase velocity fields. The PTV resolution was enough high to accurately estimate the turbulence kinetic energy (TKE) dissipation rate. The SPI system provided the measurement of the bubble behavior, particularly the estimation of the local void fraction, the bubble diameter and the bubble velocity.

The experiments were performed in a vertical pipe in which the flow can be downwardly moved by gravity or upwardly pumped. Different void fractions and bubble diameters were tested at a Reynolds number of 20000.

The analysis was divided is two parts. First, we investigated the turbulence kinetic energy budget in order to get information about the energy transfer due to bubbles. Estimating each term of the equation of the TKE, we were able to analyze the influence of bubbles on these terms. For example, we observed a reduction of the energy production and an increase of the TKE dissipation rate. These two quantities are balanced in the case of single phase flow, thus it was possible to estimate the transfer of energy due to bubbles.

The second part of the analysis was the investigation of the length scale governing the energy transfer from bubbles to turbulence. This analysis was based on a filtering technique derived from Large Eddy Simulations (LES) and applied to PTV measurements. Studying the subgrid-scale energy budget we were able to estimate the transfer of energy due to bubbles depending on the length scales and to determine the most efficient length scales.