

Abstract

Promising technological applications of two-phase flows in space have captured the increasing interest of the space sector, provoking a strong demand for more fundamental knowledge. Great efforts have been made in recent decades to study the behavior of two-phase flows in low-gravity environments, which is expected to be different than the behavior observed in the presence of gravitational forces. Nevertheless, many phenomena are still poorly understood. The development of any of these new technologies demands a better knowledge of two-phase flows.

In this manuscript we address questions regarding the generation of gas-liquid flows and their behavior in conditions relevant for a microgravity environment. In particular, we focus on an air-water mixture formed in a capillary T-junction. To this end, an experimental setup has been designed to accurately control both gas and liquid flow rates. We performed a quantitative characterization on ground of the T-junction, whose operation is robust to changes in gravity level. Its main performance is the generation of bubbles at a regular frequency with small size dispersion. We obtained two working regimes of the T-junction and identified the crossover region between them.

Bubble, slug, churn and annular flow regimes have been observed during the experiments and a flow pattern map has been plotted. We present an experimental study on the bubble-slug transition in microgravity-related conditions. In addition, we address questions regarding the existence of a critical void fraction in order for the bubble-slug transition to occur.

The gas-liquid flow has been characterized by measuring the bubble generation frequency as well as the bubble and liquid slug sizes. Since bubble dynamics is also expected to be different in the absence of buoyancy, the bubble velocity has also been studied. The mean void fraction appears as one relevant parameter that allows for the prediction of frequency, bubble velocity, and lengths. We propose curves obtained empirically for the behavior of generation frequency, the bubble velocity and the lengths. The dependence of the frequency on the Strouhal dimensionless number has been analyzed.

A numerical study of the formation of mini-bubbles in a 2D T-junction by means of the fluid dynamics numerical code JADIM is also presented. Simulations were carried out for different flow conditions, giving rise to results on the bubble generation frequency, bubble velocity, void fraction and characteristic lengths. Numerical results have been then compared with experimental data.