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A NON-INVASIVE ELECTRICAL TECHNIQUE FOR DETERMINING BUBBLES CHARACTERISTICS IN LOW GAS CONCENTRATION BUBBLY FLOWS

Abstract

This work is about a very sensitive electrical technique capable of depicting accurately fast local variations of the liquid medium impedance in bubbly flows generated by fluctuations in bubble sizes and bubble velocities. Information on gas concentration and bubble sizes is obtained by processing of electrical signals in the frequency and energy domains. The focus of the technique is on being non-intrusive but yet capable of detecting features far away from the walls and on attaining high sensitivity for very low gas volumetric concentrations. To manage this, all kinds of parasitic noise (from the device itself, auxiliary units, surroundings etc) and the effects of electrode polarization and stray capacitance have been successfully suppressed. Conventional electrical techniques operate at much higher gas concentrations and even so they are used only for the determination of average gas concentrations and not for evaluating bubble sizes. High quality electrical signals were acquired during bubbly flows inside a tube (id=21mm) at different conditions (steady/pulsatile flow, liquid flow rates, liquid viscosity, salinity) for bubble sizes between 50μm and 500μm and for volumetric gas concentrations from 0.01% to 10%. Electrical measurements were validated against optical measurements. All measurements were performed in a fully automatic flow loop furnished with basic hydraulic devices, measuring sensors and controllers. The loop is equipped with test sections and diagnostic ports that can accommodate electrical, optical, acoustic and pressure probes. This research is funded by an ESA/GSTP project (In-Vivo Embolic Detector (IVED), ESA Contract No: 18354/04/NL/PA, ESA Technical Officer: Michel Lazerges). IVED development is divided in two major phases: In-vitro development and in-vivo development. The in-vitro development - measurements in tubes and mimicking tissues- has been just successfully concluded having achieved a superb measurement sensitivity that can reliably sense gas concentration fluctuations down to 0.001%. This opens the way for very accurate bubble characterization in physical/biophysical experiments (liquids degassing in tanks and metabolic closed loops, bubbly flow in pipes and heat exchangers, extracorporeal blood circulation during heart surgery etc) and in humans during Decompression Sickness (astronauts during EVAs, divers, caisson workers etc). IVED is entering now the in-vivo development phase where measurements are performed in veins of anesthetized swines. If these prove successful tests on humans will come next.