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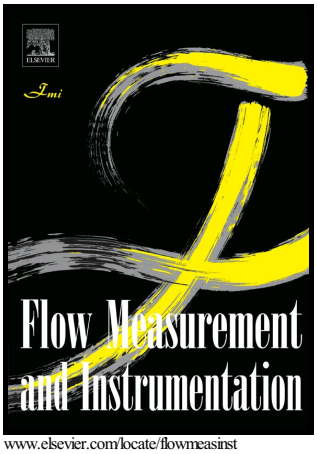

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Imaging of oil-water flow patterns by Electrical Capacitance Tomography

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Abstract

Electrical Capacitance Tomography (ECT) is well established as a tool for multiphase flow studies when permittivities of the media in the flow, are not too different, e.g. for oil and gas. In this work, we investigate how ECT performs for high permittivity contrasts as for oil and water. The main objective of the study has been to perform analysis on ECT data to identify flow regimes. Different oil-water flow patterns were generated for a range of mixture velocities (0.25-1.5 m/s) and water cuts (0%-97.5%) at different pipe inclinations (-5°,-1°, 0°, +1°, +5°) The test fluids were de-ionized water and mineral oil (Exxsol D60). The tests were performed in a 15m long, inclinable stainless steel pipe with inner diameter of 56.3 mm. Flow patterns were determined by visual observation and high-speed video. Cross-sectional images of flow patterns were obtained using ECT to study how far so called "soft-field" sensing methods can reveal details of multiphase flow. Normalized data of individual inter-electrode capacitances were analyzed to obtain local volume fractions of the two phases for each representative flow pattern. Gamma densitometry was deployed along with ECT for obtaining simultaneous measurements and comparing with volume fractions estimated using inter-electrode capacitance values.

Even though ECT is a fast data acquiring and online flow imaging technique, the image resolution is low or biased due to several factors. Some of the limitations are due to the maximum number of independent capacitance measurements possible with the ECT module used. There are some shortcomings of the Linear Back Projection (LBP) image reconstruction algorithm, also higher permittivity contrast between oil and water contributes for deficiencies of the ECT images and there is dependence on accurate sensitivity mapping for the various electrode combinations. Off-line iterative image reconstruction improved the image quality and the accuracy of the estimation of volume fractions. ECT images were sufficient for qualitative identification of flow patterns, but it was difficult to acquire image details of the flow such as droplets and small-scale phase distributions.

The local volume fractions revealed by inter-electrode capacitance measurements and gamma densitometry were in reasonable agreement. These same capacitances showed consistency with negligible standard deviation, while the standard deviation of the gamma densitometer readings were much higher. However, it is possible to determine flow patterns based on a combination of inter-electrode capacitance measurements, together with volume fraction variations.

Key words: Electrical Capacitance tomography; Oil-water flow patterns; Image reconstruction; Inter-electrode capacitance; local volume fraction