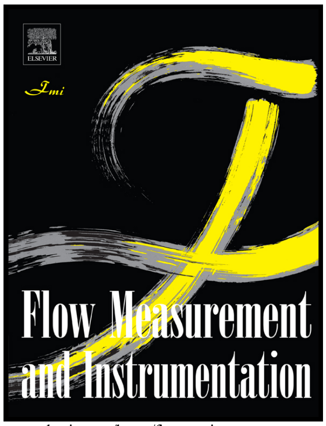

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A New Visualisation and Measurement Technology for Water Continuous Multiphase Flows

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ABSTRACT:

This paper reports the performance of a research prototype of a new multiphase flow instrument to non-invasively measure the phase flow rates, with the capability to rapidly image the flow distributions of two- (solids, gas or oil in water) and three-phase (gas and oil in water) flows. The research prototype is based on the novel concepts of combining vector Electrical Impedance Tomography (EIT) sensor (for measuring dispersed-phase velocity and fraction) with an electromagnetic flow meter (EMF, for measuring continuous-phase velocity with the EIT input) and a gradiomanometer flow-mixture density meter (FDM), in addition to on-line water conductivity, temperature and absolute pressure measurements. EIT-EMF-FDM data fusion embedded in the research prototype, including online calibration of reference conductivity and online compensation of conductivity change due to the change of fluids' temperature or ionic concentration, enables the determination of mean concentration, mean velocity and hence the mean flow rate of each individual phase based on the measurement of dispersed-phase distributions and velocity profiles. Results from recent flow-loop experiments at Schlumberger Gould Research (SGR) will be described. The performance of the research prototype in flow-rate measurements are evaluated by comparison with the flow-loop references. The results indicate that optimum performance of the research prototype for three-phase flows is confined within the measuring envelope 45%-100% WLR and 0%-45% GVF, which is the sweet point of the measurement system. Within the scope of this joint research project funded by the UK Engineering & Physical Sciences Research Council (EPSRC), only vertical flows with a conductive continuous liquid phase will be addressed.

Keywords tomography, multiphase flows, visualisation, metering.

1 INTRODUCTION

The advent of surface multiphase flowmeter (MPFM) is fundamentally changing the production monitoring of complex flows from oil-gas production wells. This transformation is driven by new technology to measure rapid variations in oil-water-gas multiphase flows equivalent or better than conventional separators. The capability to measure multiphase flow rate in real time increases operational efficiency, saving both time and cost. Accurately quantifying individual fluid phases in a production stream allows operators to make more informed decisions about well performance, to better identify, understand and remediate problematic wells, optimise artificial lift operations and build dynamic reservoir models (Xie *et al*. 2007).

Commonly used methods for measuring multiphase flows are based on γ-ray attenuation, RF/microwave and/or electrical impedance techniques in combination with a differential-pressure device such as a Venturi flowmeter (Xie *et al*. 2007, Thorn *et al*. 2012). Phase fraction measurement based on γ-ray attenuation methods is elegant; there are however practical or logistical difficulties to overcome when an intense radiation source is used to achieve both the temporal and spatial resolution at the expense of increasing safety precautions (Van Santen *et al.* 1995). An MPFM based on nuclear magnetic resonance (NMR) technique is currently under development (Appel *et al.* 2011), but an NMR system tends to be complex and expensive and has limitation in temporal resolution and hence in velocity measurement-range. The status of these commercial available MPFM flow meters without separation process is still a distance to the fiscal demands at approximately 0.25-1% relative error but is approach to approximately 5-10% for reservoir management and 2-5% for production

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