Application of Earth’s Field Nuclear Magnetic Resonance to Multiphase Flow Metering

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Instantaneous multiphase flow metering has significant potential in a number of industries; including the oil and gas industry in terms of assisting the development of marginal oil/gas fields as well as monitoring sub-sea processing1. Multiphase flow meters (MPFMs) provide numerous benefits with respect to both process safety and reducing operational costs. In terms of on-line multiphase flow measurement we present the use of nuclear magnetic resonance (NMR) as a multiphase flow meter that is completely non-invasive, does not require any nuclear source material, provides a number of mechanisms to differentiate phases and is able to measure both velocity and phase fraction.

Furthermore we present an NMR multiphase flow meter that makes use of the Earth’s magnetic field2. This system, constructed and fully operations at UWA, consists of a pre-polarising permanent magnet located upstream of an Earth’s field NMR detection coil (which operates at a resonance frequency of ~2KHz). By appropriate analysis (using mathematical Tikonov Regularisation techniques) of the raw 1H NMR data (the free induction decay (FID)) acquired for a flowing stream we are able to determine the velocity probability distributions. The accuracy of the system (for such single phase water flow) is verified over a wide parameter space by direct comparison of the mean values of the velocity distributions to the velocities measured from an in-line rotameter. This is in effect a ‘time-of-flight’ measurement.

In two phase gas/liquid flow, NMR signal analysis is used to track both the liquid holdup and liquid velocity over time (at 1-2 Hz). This readily enables various two phase flow regimes (e.g. stratified or slug flow) to be instantaneously identified, which is useful in its own right and critical to the subsequent NMR data analysis. The NMR liquid holdup measurement show a good correlation to video analysis of a transparent section of the flowing stream and matches well with the expected superficial system liquid velocity. Finally a proposed extension of the apparatus to three phase flow and high pressure and temperatures will be outlined.

**References**

**1** Thorn, R., Johansen G.A and Hjertaker, B.T., Three-phase flow measurement in the petroleum industry, *Meas. Sci. Technol.*, 24(2013) 012003.

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**3** O’Neill, K.T., Stanwix, P.L., Johns, M.L. and Fridjonsson, E.O., Quantitative Velocity Distributions via Nuclear Magnetic Resonance Flow Metering, submitted to *J. Magn. Reson.*