A review of the theory of Coriolis flowmeter measurement errors due to entrained particles

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In a Coriolis flowmeter, the driver vibrates a pipe and pickup sensors detect the twist of the pipe due to the Coriolis effect. The twist is proportional to the mass flow rate of the fluid and the driver frequency is proportional to the density of the fluid. For normal operation of Coriolis flowmeters, the mass flow rate and density of the fluid is measured under the assumption that the center-of-mass (CM) is fixed on the axis of the vibrating pipe. This assumption of a fixed CM is violated if either compressibility or phase decoupling occurs[1].

Phase decoupling is a phenomenon which takes place in two-phase flow. Errors due to phase decoupling occur because the acceleration of the two phases is different. "Bubble theory" is a theoretical treatment of errors due to phase decoupling[2,3]. For this error type, measurement errors are negative, i.e. measurements are below the true mixture value.

To date, the published bubble theory has dealt with inviscid entrained particles having zero density combined with either viscous or inviscid fluids. In this paper, we review the complete bubble theory, which includes effects associated with finite particle density and viscosity[4]. Those particle properties enable the modelling of mixtures where the particles have non-negligible density and viscosity.

Predicted measurement errors for different two-phase mixtures as a function of the volumetric particle fraction α are shown in Figure 1.

[a] Siemens A/S, Flow Instruments, Nordborgvej 81, 6430 Nordborg, Denmark

[1] Weinstein, *Ph.D. Thesis, University of Colorado* (2008)

[2] Hemp and Sultan, *Proc. Int. Conf. Mass Flow Measurement, IBC Technical Services*, 1 (1989)

[3] Hemp et al., *IEE One-day Seminar*, 1 (2003)

[4] Basse, *Flow Meas. Instrum.* **37**, 107 (2014)

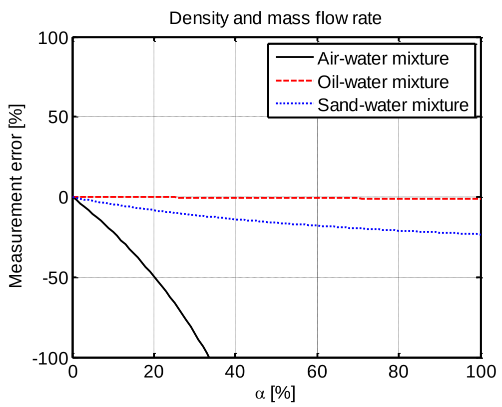

Figure 1: Density and mass flow rate error for mixtures: Air-water (solid black line), oil-water (dashed red line) and sand-water (dotted blue line).