The Effect of Gas-Water Interfacial Hydrates in Water Dominant Multiphase Flow

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Hydrate formation poses an inherent risk to the multiphase flowing systems in gas production. Hydrate growth takes place at the gas-water interface and the total interfacial area is important in Hydrate Volume Fraction (HVF) model predictions. Previous studies observed the interfacial area to continuously deplete and replenish due to hydrate growth and hydrate layer shedding, respectively. This in turn affects the hydrate growth mechanism, where interfacial area driven growth becomes diffusion limited upon formation of full hydrate shells. This work focuses on bubble dynamics in multiphase flow and outlines a framework for gas-water contact area modelling.

The High-Pressure Water Tunnel (HPWT) is a vertically oriented flowloop with *in-situ* visual observation capabilities. It consists of two horizontal sections, one upward flowing section and the other downward flowing, analogous to subsea jumpers and risers which present higher hydrate risk. The system was filled with 17 vol.% methane gas and 83 vol.% water, where hydrates were formed at 900 psia and 275 K. Gas bubble dispersions in turbulent flow were observed using a high-speed camera at three pump speeds; 40%, 60% and 80%.

Hydrate particles were observed to shed into the continuous phase from larger bubbles. At 40% pump power, bubbles below 700 µm diameter exhibited complete coverage while bubbles greater than 700 µm were partially covered. As pump power increased, the bubble diameter for complete coverage decreased. The data suggests a bubble size threshold before complete hydrate shell formation becomes impossible and bubbles can maintain gas-water contact. The presence of hydrates was also observed to increase the bubble travel velocity by ~55% above the baseline of non-hydrate forming systems. Individual bubble velocity also increased with increasing area coverage. The outlined model framework for gas-water contact area prediction incorporates velocity, hydrate covered area, bubble drag, bubble shape factors and surface tension.