**Detection of Hydrate Formation and Deposition Using Microwave Sensing Techniques**

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A novel microwave apparatus has been applied to the investigation of hydrate formation and deposition in methane and water mixtures. Gas hydrates pose a significant risk to the reliable and safe production of oil and gas resources with the possibility of impeding flow or ultimately plugging lines. It is imperative that the instance of hydrate formation and the rate of deposition be monitored so as to protect downstream operations and maintain product throughput. We present a new sensing method based on microwave cavities to deliver improved detection capabilities by exploiting the contrast in dielectric properties of hydrate, ice and water. The cavity geometry spatially isolates a region of high electric field strength which is sensitive to small changes in dielectric properties. In the microwave region (> 10 MHz) of the electromagnetic spectrum, the dielectric constant of the bulk hydrocarbon phase (dielectric constant ~ 1-2) is distinctly smaller than hydrate (3.1) and water (82). Thus, the conversion of free water to hydrate or the deposition of hydrate will significantly shift the resonant frequency of the cavity. Furthermore, using finite element analysis, the deposition amount and rate can be estimated by comparison of sensor response to a simulated normalised frequency response. The sensors have the added benefit of being robust and metallic, allowing them to emulate the surface of pipeline interiors. For the methane-water system investigated, conversion of 600 nanolitres free water to hydrate exhibited resonant frequency shifts of approximately 1.6 GHz. This clear observation of a phase change is similarly evident for the dissociation of hydrate. Operators can use these capabilities to quantify the required hydrate remediation using injection of thermodynamic hydrate inhibitors, and/or altering pipeline conditions (T,p).