Early Solid Detection Sensor for Production Line Monitoring

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The rising demand for natural gas is expanding the scope of offshore gas production, with significant implications for the energy sector. However, the complex gas extraction process presents some challenges, including the risk of solid deposits forming in pipelines. For example, water can solidify and accumulate as hydrate deposits on the walls of the pipelines, gradually reducing the flow until it leads to complete blockage.

To avert solid formation, pressure and temperature conditions prone to such occurrences are usually avoided by employing inhibitors which depress the freezing point of the mixture. These strategies generally rely on thermodynamic models, but, at their core, remain an expensive and inelegant solution to the problem. Lower cost strategies revolve around efficiently managing the risk of solids formation and blockage, requiring real-time monitoring of hydrate deposits during routine operations. Currently, hydrate blockages are typically identified during operations when an increasing pressure drop is observed, signalling that the flow restriction is already underway. To proactively address this challenge, there is a pressing need to develop an inline sensor capable of real-time monitoring to detect the onset of hydrate deposits, providing time to analyse the problem and mitigate any potential blockage risk - ultimately enhancing operational efficiency.

This research introduces an innovative in-line Electromagnetic Sensor for Solid Deposits (ISD) able to be used within high-pressure pipelines, developed and demonstrated through microwave resonator technology. The sensor facilitates real-time monitoring of solid deposits on pipeline walls. Employing finite element analysis, a signal processing method was devised to quantify the volume of solid deposits. The ISD sensor underwent successful testing on a pilot-scale flow loop, comprehensively monitoring the entire clogging process—from water condensation and the initiation of hydrate solids deposition to accumulation and eventual blockage. The sensor is designed not only for natural gas applications but also for diverse purposes such as CO_2 transportation or sequestration, hydrogen liquefaction, and various types of solids including waxes and bio-fouling.

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