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The Importance of Deposition Measurements in the Simulation and Design of Subsea Pipelines

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Abstract

Conventional practices for estimating the amount of deposited organic solids in pipelines are usually based on either the assumption of total deposit equal to total precipitate or the predictions with simulation packages using limited lab-scale deposition data with stock tank oil under laminar flow in small flow loops. Such practices, however, often lead to either overdesign or underdesign of pipelines and surface facilities. For optimized designs, more representative lab-scale deposition measurements which lead to more representative simulations are therefore required. In this work, a high pressure deposition cell which operates based on the Taylor-Couette (TC) flow principals and can mimick pipeline operating conditions is used to generate more representative deposition data with live reservoir fluids under turbulent flow conditions. The analogy between TC flow and pipe flow is explained and a scalability flow chart for linking the lab scale deposition data from TC configuration to pipe configuration is presented. Through a case study, the scaled deposition data is then used to tune a wax deposition model in the OLGA®5 simulation package. Next, the tuned model is applied to predict wax deposition under actual production and transportation conditions. The importance of tuning the deposition models with live fluid data under turbulent flow conditions is also shown by comparing to results obtained from conventional dead oil low shear data.

Introduction

Precipitation and subsequent deposition of organic solids such as waxes and asphaltene in well bores, production systems, export lines and downstream processing have created numerous challenges for the oil and gas industry. The large capital and operating costs associated with prevention and remediation of deposits has created the need for improved methods to measure, model and control deposition. The rate of deposition of organic solids is a complex function of thermodynamics, fluid flow and heat and mass transfer, and therefore, difficult to predict at realistic field conditions. The deposition rate is strongly influenced by both fluid composition and flow regime.

In most production systems, the inside wall temperature is lower than the temperature of bulk fluid in the line. When the wall temperature falls below the wax appearance temperature wax deposition may occur. Wax deposition has been modeled with commercially available steady state and transient pipeline packages using laboratory measured deposition data. However, conventional deposition testing for wax is performed with dead oil systems under low shear conditions. Scaling of these data to the live oil and turbulent flow conditions found in the field is unreliable and can lead to overly pessimistic predictions of deposit growth and conservative design decisions.

In addition to wax precipitation and deposition, large pressure and temperature drops often encountered in deepwater production systems increase the risk of asphaltenes precipitation and their subsequent deposition. Commingling in the well bore or at manifolds of incompatible fluids and gas lift may also destabilize the system. Since asphaltene precipitation and deposition in the field mainly happens at high pressures where the solution gas is still in the oil, dead oil asphaltene precipitation and deposition testing is not representative of the field conditions.

Recently, a high pressure shear cell (Zougari et al., 2005, 2006), which was designed and built based on the Taylor-Couette (TC) flow principals, has been used to measure the deposition rate of waxes and asphaltenes from live fluids under turbulent flow conditions (Akbarzadeh and Zougari, 2008, Akbarzadeh et al., 2008, Zougari et al., 2006). By mimicking the pipeline flowing conditions the high pressure cell can create an environment similar to pipe flow. Although this device is a great tool in generating organic solids deposit under a wide variety of operating conditions, the main question is how the