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Full Length Article

High pressure micromechanical force method to assess the non-plugging potential of crude oils and the detection of asphaltene-hydrate mixed agglomerates

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ABSTRACT

A hydrate prevention strategy taking advantage of crude oil that exhibit hydrate non-plugging tendency is a viable option in oilfield production conditions, or during transient operations. For that reason, it is important to accurately evaluate crude oils for their potential as non-plugging oils in a small-scale apparatus, such as a High-Pressure Micromechanical Force (HP-MMF) system, before continuing to large-scale testing. HP-MMF is an interfacial method that has been applied to measure gas hydrate interparticle cohesive force to gain insight into the hydrate agglomeration tendencies of crude oils. Herein, methane/ethane hydrate cohesive force measurements in the presence of small concentrations of crude oil were performed in the HP-MMF. Direct observations from the HP-MMF revealed, for the first time, the appearance of asphaltene precipitates that interact with the gas hydrate particles to produce an asphaltene-hydrate mixed agglomerate. A new HP-MMF method has been developed that enables representative sampling and evaluation of the effect of crude oil samples on the cohesive force between two gas hydrate particles in the HP-MMF. The method has been tested with two crude oils, where lower cohesive force results are demonstrated by the presence of small concentrations (<5 vol% in model oil) of Crude A and C compared to the baseline system of pure model oil. Hence, indicating the presence of natural anti-agglomerants (AAs) that contribute to the non-plugging behavior of these crude oils. These studies show that the HP-MMF is a convenient tool to assess the non-plugging potential of crude oils at realistic (high pressure, low temperature) conditions, requiring only small oil sample volumes. The HP-MMF method developed in this work is demonstrated to be a unique tool that can be utilized for the detection of asphaltene-hydrate mixed agglomerates. These new findings provide important insights for asphaltene precipitation in the presence of gas hydrates, that can create catastrophic agglomeration in the flowlines.

1. Introduction

One of the major flow assurance issues that can occur during the operation of subsea oil and gas production facilities is the formation of gas hydrate plugs that are associated with severe safety, environmental, and economic risks [1,2]. Gas hydrates are crystalline structures that consist of guest molecules, such as methane or mixed of methane/ethane, encaged in a three-dimensional lattice of hydrogen-bonded water molecules [3]. Gas hydrates typically form at high pressure and low temperature conditions, which is the same condition as that in subsea oil and gas flowlines [4].

In oil-dominated flowlines where oil is the continuous phase, hydrates are formed when the emulsified water droplets in the oil phase are encrusted by hydrate films. These hydrate-encrusted water droplets then agglomerate, and can eventually form a hydrate plug [5]. Hydrate agglomeration is the key limiting factor for plug formation [6]. During agglomeration, hydrate particles interact via a small layer of water on the hydrate surface, which results in capillary bridge forces [7]. These interactions between hydrate particles lead to larger hydrate masses and plugging of the flowline [8].

One of the hydrate control strategies in the oilfields is to use low-dosage hydrate inhibitors, such as anti-agglomerants (AAs) that prevent hydrate particles from forming larger particles (i.e., agglomerates) that can eventually form a plug in the flowline [9,10]. AAs can be

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