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Predicting When and Where Hydrate Plugs Form in Oil-Dominated Flowlines

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Abstract

This work provides a means to predict when and where hydrate plugs will form in oil-dominated flowlines. The method was funded by DeepStar and is based on a hydrate kinetic model, CSMHyK, developed over the last six years, which is currently an addition to the transient multiphase program OLGA by SPT (Scandpower) Inc. The predictions show good agreement to data for hydrate formation in three flowloops with five oils.

Recent CSMHyK-OLGA workshops have been held in Houston and Oslo, and major companies are beginning to use the program in flow assurance to predict where and when hydrate plugs will form in flowlines.

Introduction

Gas and oil sub sea production and transportation are moving to deeper developments where the temperature and pressure conditions are well within the hydrate stability region. The subsequent increased risk of hydrate formation requires new strategies in flow assurance. Traditional methods of thermodynamic avoidance are impractical or uneconomic due to the large amounts of thermodynamic inhibitor (e.g. methanol or monoethylene glycol) required to prevent hydrates from forming under these conditions [1, 2]. Transient operations are particularly problematic due to the temporarily extreme subcoolings under these conditions. The prediction of hydrate formation rates in these conditions is a major challenge requiring knowledge of the kinetics of hydrate formation, rather than only hydrate thermodynamics. The ability to predict the rate of hydrate formation in sub sea flowlines under restart and shutdown conditions is extremely valuable in establishing new operating procedures during transient operations and in flowline design.

CSMHyK is a subroutine module for the OLGA (SPT Group) multiphase flow simulator. Researchers at CSM in cooperation with the SPT Group have been developing the module since 2003. The model predicts the rate of hydrate formation using a first-order rate equation based on the thermal driving force. The rate equation was originally proposed by Vysniauskas and Bishnoi [3] in the absence of mass and heat transfer limitations. In order to accurately simulate hydrate formation in flowloops, it was necessary to reduce the intrinsic kinetic constant by a factor of 500 [4]. The adjusted parameter accounts for mass and heat transfer limitations in the flowloops. The current model assumes that the hydrate particles convert directly from emulsified water droplets. Nucleation is assumed to occur instantaneously at a subcooling of 6.5°F, a parameter proposed by Matthews [5]. Once formed, the model assumes that these particles remain in the oil phase. The change in relative viscosity of this phase is then found from the Camargo and Palermo [6] correlation for steady state slurry flow. An overview of the current CSMHyK module and its integration into OLGA is shown in Figure 1.