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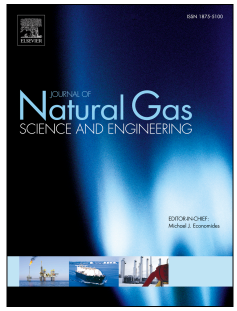


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# Modeling of hydrate layer growth in horizontal gas-dominated pipelines with free water

Zhiyuan Wang*, Jianbo Zhang, Litao Chen, Yang Zhao, Weiqi Fu, Jing Yu, Baojiang Sun*

*Offshore Petroleum Engineering Research Center, School of Petroleum Engineering, China University of Petroleum (East China), Qingdao 266580, China*

* Corresponding authors. Tel. /Fax: +86 0532 86981707 (BJ Sun), +86 532 86981927(ZY Wang).

E-mail address: sunbj1128@126.com (BJ Sun), wangzy1209@126.com (ZY Wang).

## Abstract

Flow is obstructed as hydrate layer grows on the wall of pipelines. In gas-dominated pipelines with free water, the gas–liquid–solid (hydrate) flow, gas–solid (hydrate) flow, and water-saturated gas flow may coexist at different locations of the pipeline. Current studies on hydrate layer growth largely focus on a single-flow pattern in gas-dominated pipelines. No studies have been conducted considering different flow patterns in pipelines simultaneously. Considering the flow pattern transition due to the variation in the contents of free water and hydrates in the gas phase, an integrated model is developed to quantitatively predict the hydrate layer growth in horizontal gas-dominated pipelines with free water. Based on the proposed model, the hydrate layer thickness distribution in horizontal gas-dominated pipelines is simulated and the sensitivity analysis of different factors is performed. The results show that the distribution of the hydrate layer thickness on the pipe wall along the pipeline is non-uniform. There exists a point in the flow that is most vulnerable to hydrate layer growth at a given point in time in the gas–liquid–solid flow. This study provides a theoretical basis for preventing hydrate blockage in submarine natural gas pipelines.

***Keywords*****:** Hydrate layer growth; Horizontal gas-dominated pipelines; Flow pattern transition; Prediction model; Non-uniform distribution

## 1. Introduction

Gas hydrates are crystalline inclusion compounds, which are formed by the contact of hydrocarbon gases (e.g., methane, ethane, etc.) with free water under particular pressure and temperature conditions (Sloan, 2003; Sloan and Koh, 2008). The formation and deposition of gas hydrates in oil and gas transmission pipelines lead to an increase in the flow resistance and may even cause hydrate blockage, thereby resulting in production delays, equipment damage, cost increase, and even human casualties (Jassim et al., 2010; Lee et al., 2013; Perfeldt et al., 2015; Rui et al., 2017b, 2017c; Rui and Wang, 2013; Sloan, 2005). With the exploitation of oil and gas in deeper water regions, it is significant to study the formation and deposition of hydrates in submarine pipelines (Norris et al., 2016; Song et al., 2017).

The reserve of natural gas in offshore is abundant, its production accounts for a gradual increase in global production (Rui et al., 2017a). The produced natural gas is transported to land via submarine pipelines,