Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 97 (2016) 310 – 317

Energy Procedia

European Geosciences Union General Assembly 2016, EGU
Division Energy, Resources & Environment, ERE

Effect of Fluid Saturation on Gas Recovery from Class-3 Hydrate Accumulations Using Depressurization: A Case Study of the Yuan-An Ridge Site in Southwestern Offshore Taiwan

Yi-Jyun Huang, Cheng-Yueh Wu, Bieng-Zih Hsieh*

Department of Resources Engineering, National Cheng Kung University, Tainan City, Taiwan

Abstract

This study focused on the effect of initial hydrate saturation on gas recovery from a depressurized Class-3 hydrate accumulation via a simulation study of the Yuan-An Ridge hydrate deposit located in southwestern offshore Taiwan. Our simulation results showed that the recovery factors for a 20-year operation time in the case of a 70% pressure decline were 0.37, 0.47, 0.49, 0.51, and 0.13 for initial hydrate saturations of 30%, 40%, 50%, 60%, and 70%, respectively. The depressurization is not suitable for hydrate deposits with a high hydrate saturation over 70% except when the formation permeability is higher than 2 Darcy.

Peer-review under responsibility of the organizing committee of the General Assembly of the European Geosciences Union (EGU)

Keywords: Gas hydrate; Depressurization; Numerical simulation

1. Introduction

Gas hydrates (GHs) are crystalline compounds in which guest gas molecules are trapped in host lattices of ice crystals under high pressure and low temperature conditions. Generally, one mole of gas is encapsulated by five to seven moles of water. When the gas hydrates dissociate, there will be 150 ~ 180 unit volumes of gas and 0.8 unit

* Corresponding author. Tel.: +886-6-275-7575; fax: +886-6-238-0421.
E-mail address: bzhsieh@mail.ncku.edu.tw

Peer-review under responsibility of the organizing committee of the General Assembly of the European Geosciences Union (EGU)
doi:10.1016/j.egypro.2016.10.006

volumes of water released [1].

Gas hydrates can be found in permafrost, deep marine sediments, and seabeds. The global resources of gas hydrates are estimated to be at least twice those of conventional fossil fuels [2]. Gas hydrates could serve as a clean energy source for the next generation because the combustion of the natural gas from hydrate dissociation produces lower greenhouse gas emissions than conventional fossil fuels.

Gas hydrate deposits can be divided into three major classes [3]. Class-1 GH deposits are a hydrate-bearing layer (HBL) accompanied by an underlying free gas zone. Class-2 GH deposits are a HBL accompanied by an underlying mobile water zone. Class-3 GH deposits are an isolated hydrate layer without an underlying zone of mobile fluids; the entire hydrate layer can be well within the hydrate stability zone covered by impermeable upper- and lower-burden rocks. The bottom of GH deposits can be recognized by the signals from a bottom simulating reflector (BSR), which occur because of a negative acoustic impedance contrast (i.e. higher acoustic impedance above and lower acoustic impedance below) when analyzing seismic data.

A disturbance to the phase stability of the gas hydrate can release natural gas from it. Gas hydrates exist in a high-pressure low-temperature environment, so depressurization and thermal stimulation are both useful methods to make gas hydrates dissociate. Depressurization creates a low-pressure environment, which is unfavorable for GH solid phase stability and triggers GH dissociation. Thermal stimulation uses heat to dissolve the gas hydrate and release natural gas. However, heat loss and energy consumption are issues for the thermal stimulation method as well as the extension of efficient heating zone. Therefore, depressurization is regarded as a more effective method to produce natural gas from the hydrate deposits.

The assessment of gas production performance and the observation of GH productivity from depressurization can be studied by numerical simulation. Moridis et al. [4] used TOUGH+ to simulate gas production of a Class-3 GH reservoir located in the Tigershark area by depressurization and thermal methods. The results demonstrated that depressurization leads to better performance than the thermal method. Zhou et al. [5] studied the Nankai Trough in Japan by using a simulator. Geomechanics issues in the depressurization method were studied with the simulator. Konno et al. [6] investigated gas production performance and key factors for Class-3 GH deposits in the Eastern Nankai Trough and the Gulf of Mexico by simulation (MH21-HYDRES). Su et al. [7] used TOUGH+ to investigate the potential of the site SH-3 in the Shenghu area of China.

For the depressurization method, the dissociation efficiency is controlled by the response of the hydrate to the propagating pressure disturbance. The pressure propagation is related to the fluid effective permeability, which is a function of the amount (or saturation) of the mobile fluid in the pore spaces of the hydrate layer. Therefore, the effect of initial hydrate saturation on the production performance should be studied. The purpose of this study was to investigate the effect of initial hydrate saturation on gas recovery from a depressurized Class-3 hydrate deposit. A simulation study of the Yuan-An Ridge hydrate deposit located in southwest offshore Taiwan was performed.

2. Geological setting

Significant efforts to evaluate the reserves of hydrates in Taiwan have begun recently. BSR investigations have identified large gas hydrate resources in southwestern offshore Taiwan. Because of the extremely low energy independence ratio (below 5%) of Taiwan, offshore gas hydrate resources could serve as an opportunity to improve the energy independence of Taiwan.

The Yuan-An Ridge hydrate deposit located in southwest offshore Taiwan was studied in this research (Fig. 1). The Yuan-An Ridge hydrate deposit was found through a BSR [8]. The studied site is a ridge-type gas hydrate deposit with a variable net-thickness measuring from 0.45 to 66.93 m. The investigated area is 2.56 km^2. Based on a geophysical investigation, the formation porosity is about 0.16 and the permeability is about 1 Darcy (1,000 mD). The best guess of the initial gas hydrate saturation is about 50% according to the seismic survey and the BSR analysis [9]. This reservoir is assumed to be a Class-3 GH deposit with two phases of hydrate and water. The formation pressure and temperature at the depth of the BSR (1520 m) were measured as 16.4 MPa and 17.2°C, respectively.