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Experimental Study on Steam Injection Method using Methane Hydrate Core Samples.

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ABSTRACT

Natural gas hydrate that exists in the ocean sediment is thought to constitute a large methane gas reservoir and is expected to be an energy resource in the future. In order to make recovery of natural gas from hydrates commercially viable, hydrates must be dissociated in-situ. Meanwhile, steam injection method is practically used for oil sand to recover heavy oil and recognized as a means that is commercially successful. In this study, the steam injection method for methane hydrate bearing sediments has been examined and discussed on an experimental basis. New experimental apparatus for steam injection has been designed and constructed. In-situ methane hydrate bearing sediments were simulated in laboratory scale. Using this apparatus, steam was successfully injected. And just after the depressurization, inner temperature at each area dropped down to approximately 0 deg C caused by the combination of endothermic reaction of hydrate dissociation and exothermic reaction of ice formation. Also, the phase transition from vapor water to liquid water in methane hydrate bearing sediments was observed. Obtained temperature profile suggested that phase transition from steam to liquid water occur at upstream area (from 25mm to 75mm from top of the core). Additionally, reaching point of steam moved back and forth around this area. From the gas production behavior, it can be concluded that roughly 44 % of total hydrate origin gas was produced after steam injection.

KEY WORDS: Natural gas; Hydrate; Exploitation; Core sample; Steam Injection; Dissociation.

INTRODUCTION

Natural gas hydrates are crystalline compounds that can contain a large amount of natural gas (Sloan, 1998). Owing to recent seismic exploration and geological research, it is widely known that natural gas hydrate that exists in the sediment constitutes a large natural gas resource and is expected to be an energy source in the future (Makogon, 1981; Brooks et al., 1986; Kvenvolden, 1988; Kvenvolden et al., 1993; Okuda, 1993; Gornitz and Fung, 1994; Sassen, 2001). To make recovery of natural gas from hydrates commercially viable, hydrates must be dissociated in-situ. The authors had studied about the inhibitor injection method combined with hot water injection for accelerate methane hydrate dissociation (Kawamura et al., 2005, 2006a, b). Meanwhile, steam injection method is practically used for oil sand to recover heavy oil and recognized as a means that is commercially successful (Butler, 1991; Polikar et al., 1995; Sasaki et al, 2001a, b; Chalaturnyk et al., 2004). In this study, the steam injection method for methane hydrate bearing sediments is examined and discussed on an experimental basis. New experimental apparatus for steam injection has been designed and constructed. In-situ methane hydrate bearing sediments were simulated in laboratory scale. From these approaches, the applicability of the steam injection method was discussed.

EXPERIMENTAL

Apparatus

A schematic of experimental set-up is shown in Fig. 1. This apparatus was designed to make steam injection for MH core sample possible. A high-pressure reactor is equipped with steam generator with maximum temperature of 300 deg C. The steam generator can inject steam with the maximum rate of 10 ml/min in liquid conversion. A high-pressure reactor is column-shaped and constructed with outer tube that is made of stainless steal (SUS 316) and inner tube that is made of zirconium. It is designed to minimize lengthwise thermal conduction through the tubes to achieve accurate thermal control. It also has jackets for thermal control from 0 deg C to 300 deg C. The jackets consist of 10 pieces from top to bottom of the reactor, and each piece has heater so as to control wide range temperature. This thermal control system achieved to make a thermal gradient around the core was equal to that of the core sample. In other words, the heat flow can be considered as one-dimensional neglecting the sideling heat loss. The artificial MH core sample is prepared in the column reactor. The diameter of core was 50 mm and the length was 500 mm. Steam, gas and liquid water can be injected into the core sample with given pressure, temperature and flow rate. Gas and water generated by MH dissociation are produced from outlet and the amounts of them are determined. The T-P conditions at inlet and outlet can be measured. The inner temperatures of the core were measured by 10 thermocouples located at 25 mm, 75 mm, 125 mm, 175 mm, 225 mm, 275 mm, 325 mm, 375 mm, 425 mm and 475 mm from the top of the core respectively. Also outer temperatures of the core were measured by 10 thermocouples located at same axial positions to inner thermocouples. The outlet pressure can be kept constant by backpressure regulator located at outlet of the reactor.