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Electrical Heating of Hydrate Sediment for Gas Production

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ABSTRACT

In-situ dissociation of natural gas hydrate is necessary to commercially recover natural gas from natural gas hydrate sediment. Thermal stimulation is considered an effective dissociation method, along with depressurization. In this study, we examined the efficiency of electrical heating of the hydrate core for gas production. To ensure safety and to avoid explosions, we investigated electrical heating of xenon gas hydrate sediment, instead of methane hydrate sediment. Alternating current (AC) heating with depressurization and additional electrode heating of hydrate sediment saturated with electrolyte solution was confirmed to enable gas production from sediment with less electric power.

KEY WORDS: permeability, hydrate, Xe, sediment, thermal stimulation method

INTRODUCTION

Methane hydrate deposited in sea floor sediment and permafrost is considered an unconventional methane resource (Collet, 1998). To commercially recover natural gas from natural gas hydrate sediment, in-situ dissociation of natural gas hydrate is necessary. The exploitation of methane hydrate and production methods of methane gas from methane hydrate (e.g., depressurization (Sakamoto, 2007a), thermal stimulation (Sakamoto, 2007b), and inhibiter injection (Kawamura, 2006)) have been proposed. With all methods, gas permeability and water permeability in the methane hydrate sediments are important factors to estimate the efficiency of production of methane gas. For depressurization, the gas production rate increased with increasing pressure drawdown. However, large pressure drawdown caused the sediment to cool to equilibrium temperature in proportion to equilibrium dissociation pressure because of the endothermic reaction of methane hydrate dissociation. The gas production rate then decreased as the sediment temperature decreased (Kamata, 2005a). For hot water of low temperature injection as a thermal-stimulated method, the pressure near the methane hydrate decomposed region increased, and decomposition of methane hydrate advanced on the equilibrium pressure and temperature. However, when the water temperature was above 20^{o}C higher than the equilibrium temperature, the temperature and pressure in the sample fluctuated in the equilibrium phase (Kamata, 2005b).

To solve this problem, an electrical heating method combined with depressurization has been developed to replace hot water injection. Generally, electrical heating is used to produce crude oil and natural gas from wells. Specifically, the Electric/Electromagnetic Enhanced Oil Recovery (EEOR) method has been applied for recovering heavy crude oil (Masters, 1987). It is a very effective method of direct heating of methane hydrate sediment by an electrical oven or an electric heater, whereas hot water injection involves indirect heating by using water. The principle of the EEOR method is advantageous because its simple system and operation of preferential heating with electrolyte solution causes less environmental pollution by using an electric network power supply. For crude oil production by the EEOR method, the main purpose of electrical heating is to decrease oil viscosity. For application to methane hydrate sediment, however, the EEOR method was developed for methane hydrate dissociation.

A patent has been registered in the United States for a method of producing natural gas from a subterranean formation (LaVerne, 1975). The patent description indicates that electrical heating could be performed by using connate water in methane hydrate sediment and that pressure, and consequently temperature, would be reduced due to gas production. However, we confirmed that it was impossible to heat methane hydrate sediment without additional injection of electrolyte solution and continued decomposition of methane hydrate under depressurization conditions.

In this study, we examined the efficiency of electrical heating of the hydrate core for gas production. To ensure safety and to avoid explosions, we investigated electrical heating for xenon gas hydrate sediment, instead of methane hydrate sediment. The efficiency of electrical heating of the hydrate core for gas production and problems with this method were analyzed. Furthermore, it was determined that several procedures enable gas production from sediment with less electric power (i.e., electric current and voltage).

EXPERIMENTAL

Figure 1 depicts a schematic diagram of the apparatus for electrical heating and measuring water permeability. The experiment apparatus consists of a temperature-controlled core holder, water and gas inlet-outlet lines with pressure gauges, and a data-recording system.