Experimental Study on Gas Production from Methane Hydrate in Porous Media by Huff and Puff Method in Pilot-Scale Hydrate Simulator

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ABSTRACT
Pilot-Scale Hydrate Simulator (PHS), a novel three-dimensional 117.8-L pressure vessel was developed to investigate the gas production from methane hydrate in porous media using the huff and puff method. In situ methane hydrate was synthesized in the pressure vessel with methane gas and deionized water in quartz sand with grain sizes between 300 and 450 μm. In the PHS, a 9-spot distribution of vertical wells, a single horizontal well and 49-spot distributions of the thermometers and resistance ports are respectively placed in three horizontal layers, which equally divide the vessel into four parts. During the experiment, the huff and puff stages, including the injection, the soaking and the production, are carried out for hydrate dissociation. A vertical well at the axis of the PHS was used as the injection and production well. The initial hydrate saturation before dissociation is 33.66% in volume, and the percentage of the hydrate dissociated could be approximately 94% after 15 huff and puff cycles. The experimental results indicate that with the constant hot water injection rate, the range of the thermal diffusion is restricted around the well, and depressurization rather than thermal stimulation is dominant for gas production. The decline of the cumulative gas produced during each cycle and the diminishing uptrend of the percentage of the hydrate dissociated indicate that the hydrate dissociation rate decreases over time. The gas production efficiency is improved by prolonging the hot water injection time, while this enhancement is limited by the stronger pressurization effect.

Keywords: hydrate dissociation, porous media, three-dimension, huff and puff, vertical well

NOMENCLATURE

- $M_{\text{inj}}$: cumulative volume of the injected water [L]
- $M_{\text{w}}$: cumulative volume of the produced water [L]
- $P$: pressure [MPa]
- $Q_{\text{avg}}$: average gas production rate [L/min]
- $Q_{\text{inj}}$: hot water injection rate [L/min]
- $R_{\text{GW}}$: cumulative gas to water production ratio [ST $m^3$ of CH$_4$ / $m^3$ of H$_2$O]

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