Optimization of Dissociation Front for Hydrate Development by Combining Depressurization and Hot Water Stimulation

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Abstract

In recent years, development of natural gas hydrate has attracted considerable interests as an alternative clean energy due to its great reserves as well as the depletion of conventional fossil fuels. Combination of depressurization and thermal stimulation is found to be a promising technique to develop both Class 2 and Class 3 hydrate reservoirs; however, it remains a challenging task to experimentally determine and theoretically optimize hydrate dissociation front. In this paper, techniques have been developed to optimize dissociation front for hydrate development by combining depressurization and hot water stimulation. Experimentally, hydrate dissociation is determined with a one-dimensional (1D) apparatus by gradually reducing the operational pressure. Gas production rate is continuously monitored and recorded during experiments. Theoretically, simulation techniques are developed to determine the decay rate by fitting the experimental measurements. The orthogonal design method is then used to perform sensitivity analysis and optimize operational parameters by maximizing energy efficiency as the objective function. The dominant parameters are found to be the flowing bottomhole pressure, water temperature, and injection time, while effect of injection rate is negligible at the same heat energy injected. When water with a temperature of 20°C is injected into the reservoir at 100 m^3/day for two years by lowering the following bottomhole pressure to 3 MPa, the energy efficiency reaches its maximum value of 17.4. Two dissociation fronts are formed separately near the producer and injector, while the depressurized dissociation front is found to move slower than that of the hot water stimulation due mainly to heat convection. In addition, hot water stimulation is not recommended for reservoirs with hydrate saturation equal to or higher than 60% because of abnormal pressure build-up.

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