Analytical and Numerical Studies of Gas Production from Hydrate Reservoirs

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Gas hydrates are being considered as an alternative energy resource of the future as they exist in enormous quantities in permafrost and offshore environments. However, gas production potential from hydrate reservoirs has not been fully investigated yet. In this work, we develop analytical and numerical models for studying gas production from hydrate decomposition in porous media by a depressurization method. We consider the heat transfer to the decomposing zone, intrinsic kinetics of hydrate decomposition and gas-water two-phase flow as the three primary mechanisms involved in hydrate decomposition in porous media. In the analytical study, the relative importance of these mechanisms is compared over a realistic range of the physical properties. It is shown that for the cases studied, the effect of two-phase flow is significantly smaller than the heat transfer and the intrinsic kinetics of hydrate decomposition.

Considering the rate-controlling mechanisms, an analytical model is developed to predict the performance of decomposition of gas hydrates in porous media. The model is used to perform sensitivity studies to investigate the feasibility of commercial gas production from hydrate reservoirs. The results suggest that significant quantities of gas can be produced from gas hydrate reservoirs where the hydrate overlies the gas zone. Such reservoirs have been found in the permafrost region of Siberia, Alaska and Canada.

Based on this motivation, a 2-D cylindrical simulator for gas production from hydrate reservoirs is developed. The model includes the equations of gas-water two-phase flow, conductive and convective heat transfer, and intrinsic kinetics of hydrate decomposition. The simulator is used to model a hydrate reservoir where the hydrate-bearing layer overlies a free gas zone. A well is drilled and completed in the free gas zone. Pressure reduction in the free gas zone leads to the decomposition of the overlying hydrate and subsequent production of the generated gas.

Using the simulator we investigate the effect of various parameters on gas production behavior. In particular, these parameters relate to formation properties, operating conditions, kinetic parameters etc. The cumulative gas generated and produced, pressure, temperature and saturation distributions are studied to investigate the sensitivity of results on individual input parameters. The potential of gas production from formations containing gas hydrates is analyzed using the results of the sensitivity study.