# Flow Dynamics in Gas Hydrate Reservoirs

The depletion of conventional oil and gas reserves has made unconventional reserves such as gas hydrates a popular choice for growing energy demands. This is also because methane is less polluting than other carbon rich fossil fuels. The large amount of energy stored in the methane hydrate reservoirs can be used to meet the energy demands by extracting methane gas present in these reservoirs which are distributed in deep oceanic sediments and the permafrost regions. The feasibility of the gas production from methane hydrate reservoirs is evident from several short-term field tests in the last decade; however, some crucial issues still exist challenging long- term production. Therefore, the production analysis requires the grasp of geological, technical, and economical factors controlling the methane production potential of these reservoirs. The objective of this work is to understand these reservoir complexities through numerical simulations using an in-house, 3-D finite volume, multi-phase, compositional, and thermal simulator.

In this work, the reservoir porosity, heterogeneity, confinement, and hydrate availability have been considered to strategize the gas production methodology. Different well placement and configurations have been explored for class-2 gas hydrate reservoirs which are the most common type of the hydrate reservoirs. For class-2 reservoirs, the size of the aquifer below the hydrate bearing layer governs the hydrate dissociation methodology. Large aquifers make depressurization ineffective and constrain the effectiveness of the injected warm water. How- ever, horizontal wells improve the effectiveness of the warm water injection. It is found that the injection well proximity to the aquifer improves the initial warm water circulation, hence improving the gas production in initial years.

The porosity and permeability in the reservoirs are correlated, therefore, porosity in the hydrate bearing layer and the aquifer layer has different effect on the gas production potential from the hydrate reservoirs. In homogeneous reservoirs the higher porosity leads to higher gas production. The simulations in this work show that the porosity distribution in the hydrate bearing layer should be considered while predicting the gas recovery from the unconfined hydrate reservoirs with large aquifers.

In moderately confined reservoirs, with lower porosity of the aquifer layer, the gas recovery potential is increased by 6-8 times when injector was placed away from the aquifer layer. The layers in the hydrate zone does not significantly impact the overall gas recovery in a highly unconfined reservoir. However, the injector placed in the high porosity hydrate layer in a moderately unconfined reservoir leads to more gas recovery. The injector location in both the unconfined and moderately unconfined reservoir needs to be selected carefully, however, the producer location does not significantly impact the overall gas recovery.

From above results, it can be seen that the uncertainty in reservoir properties will lead to different gas production outcomes. Therefore, the uncertainty quantification is necessary for these reservoir simulations. Using Monte-Carlo method for uncertainty quantification of gas recovery, it is found that porosity has huge effect on the gas production. A critical porosity point is found beyond which the gas production does not increase regardless of the increase in the reservoir porosity in a confined reservoir. This suggests that the hydrate dissociation is dependent on the heat availability in the reservoir for dissociation. The heat available does not change significantly with the porosity, therefore, after a critical porosity the gas production does not increase. The uncertainty in hydrate saturation leads to the less variations in the gas production.

Overall, this thesis contributes towards understanding the flow dynamic and the efficiently increasing the gas production along with the water handling during the methane gas production from gas hydrate reservoirs.