Numerical Study of Flux Models for CO2 - Enhanced Natural Gas Recovery and Potential CO2 Storage in Shale Gas Reservoirs

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Abstract

Introduction

Shale and sandstone reservoirs have always gained prime importance in development of technologies related to enhancing hydrocarbon recovery. Because of low porosity and ultra-low permeability, shale reservoirs often reach peak production in a very early stage when compared to sandstone reservoirs. Various attempts have been made to describe the fluid flow behavior in these reservoirs. Shale systems are more accurately defined using a dual porosity model as compared to a discrete fracture model (Jian et al., 2014). These systems consist of matrix, natural fractures and kerogen with organic carbon. Slip flow, surface and molecular diffusion, adsorption and Darcy flow mechanisms must be combined to accurately define flux propagation in the heterogeneous systems of tight reservoirs, such as shale and coal-beds. Slip flow, diffusion and adsorption/desorption are mainly considered as primary flow mechanisms in nano-pores while Darcy flow can be attributed for flow in natural fractures. These mechanisms are used in evaluating reservoir potential for enhanced gas recovery with CO2 injection and characterizing as a potential site for CO2 storage.

Liu and Smirnov (2007) described numerical modeling of CO2 sequestration in coal beds. Sun et al. (2013) and Guo et al. (2014) simulated fluid flow mechanisms in shale nano-pores using the COMSOL Multiphysics® software using the dusty gas model as the specie flux model.

Method

An attempt has been made to describe shale system of matrix and fracture in COMSOL. This incorporates production and injection wells. Multi-component adsorption isotherm and diffusion will be used to describe CO2-CH4 transport mechanism. Various flux models (Dusty gas model, Wilke-Chang model, Fick's model and Wilke-Bosanquet model) will be compared for the best fit to describe enhanced gas recovery and carbon storage.

Results

Shale matrix and fracture systems are modeled to simulate nano-pore flow with COMSOL. The model is characterized for multi-component species interaction, such as CO_2 - CH_4 system, in nano-pores. The results show dominance of diffusion and desorption in this pore throat size. Further extension is defined with using different flux models and comparing them to find the best fit.

Conclusions

This paper will broaden the simulation ability in subsurface modeling of tight gas reservoirs. Dusty gas model is more efficient to handle Knudesen diffusion, slip flow and boundary-dominated Darcy flow together as compared to other flux models. This model can also be extended to tight oil reservoirs or shale-sand reservoirs with low permeability.

Reference

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