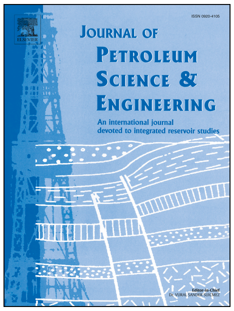

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PII: S0920-4105(17)30649-6
DOI: 10.1016/j.petrol.2017.08.033
Reference: PETROL 4196

To appear in: *Journal of Petroleum Science and Engineering*

Received Date: 20 April 2017
Revised Date: 25 July 2017
Accepted Date: 12 August 2017

Please cite this article as: Cao, C., Zhao, Q., Gao, C., Sun, J., Xu, J., Zhang, P., Zhang, L., Discrete fracture model with multi-field coupling transport for shale gas reservoirs, *Journal of Petroleum Science and Engineering* (2017), doi: 10.1016/j.petrol.2017.08.033.

Discrete Fracture Model with Multi-field Coupling Transport for Shale Gas Reservoirs

Cheng Cao [1], Qianping Zhao [1] ,Chao Gao [1] ,Jianbo Sun [1],Jie Xu [1],Peng Zhang[1], Liang Zhang[1].
1．Research Institute of Shanxi Yanchang Petroleum (Group) Co. Ltd, Xi’an, 710075, China

Abstract

In order to characterize the influence of fractures, multiple fields, and the differences between organic matter and inorganic matter on the transport of shale gas, a weighted coefficient is used to couple the transition diffusion model and Knudsen diffusion model to establish a permeability model of gas diffusion that is suitable for any Knudsen number. A gas flow model is established for organic matter considering diffusion, matrix shrinkage, stress sensitivity, and adsorption layer thickness; likewise, a gas flow model is established for inorganic matter considering diffusion and stress sensitivity. On this basis, the matrix grid in the discrete fracture model is further sub-divided into an organic matter grid and an inorganic matter grid, and the Galerkin finite element method is used to solve the discrete fracture model. The reliability of the established discrete fracture model is verified by comparing the proposed model to the BACA discrete fracture model. For validation, a shale gas well in the Yanan field in the Ordos basin is simulated using the proposed model. The results show that the effect of diffusion and matrix shrinkage on production can be ignored, but stress sensitivity and adsorption layer thickness have a moderate influence on production. Furthermore, neglecting the differences between organic matter and inorganic matter leads to errors. The errors are larger when there is less organic content or when the porosity ratio or pore diameter ratio are smaller. If hydraulic fracturing generates a larger number of fractures in the shale with relatively shorter half-lengths and bigger apertures, the production stabilization effects and the ultimate recovery rate will improve. For the shale gas well in the case study, the fitting error is approximately 74% if the dual-porosity model is used, but the fitting error decreases to less than 2% if the proposed discrete fracture model is used.

Keywords

Diffusion; shale gas flow model; discrete fracture model; organic matter; inorganic matter

1. Introduction

In recent years, the shale gas industry has benefitted from great breakthroughs and grown rapidly in the United States and throughout the world, but it lacks key production prediction technology for guiding the development of shale gas. Numerical simulation methods are a very important tool for the prediction of oil and gas production. At present, the double medium model is largely applied in shale gas reservoir numerical simulations. Bustin [1] established the double medium model for shale gas reservoir by considering desorption, diffusion, and flow of single-phase gas in matrix pores and Darcy flow for gas–water two-phase flow in fractures. Yan et al. [2,3] presented a new model that extended the double medium model to a beyond double model, wherein the shale pore system is divided into organic matter, inorganic matter, and natural fractures. Yao et al. [4] presented a dual medium model that considers viscous flow, Knudsen diffusion, and molecular diffusion in fractures and Kalantari-Dahaghi [5] proposed a numerical simulation method for shale gas based on Eclipse (Schlumberger); in this software, the matrix is further cut into matrix sub-grids to describe the flow exchanging from the matrix to fractures, and fracturing is modeled using the local logarithm encryption grid. Zhang et al. [6] also used Eclipse to perform numerical simulations of staged fracturing horizontal wells. Though these models can simulate fractured shale gas reservoirs, all are based on the double medium model, but for actual shale gas reservoirs, fractures do not exist in any one area, which certainly exaggerates the role of fractures. Furthermore, the fracture orientation is related to the direction of the grid in the