Geophysical Research Abstracts
Vol. 19, EGU2017-6739, 2017
EGU General Assembly 2017

A Realistic Gas Transport Model with application to Determining Shale Rock Characteristics

Iftikhar Ali and Nadeem Malik

King Fahd University of Petroleum & Minerals, Department of Mathematics & Statistics, P.O. Box 5046, Dhahran 31261, Saudi Arabia (namalik@kfupm.edu.sa)

A nonlinear transport model with pressure-dependent parameters for the flow of shale gas in tight porous media, accounting for important physical processes such as continuous flow, transition flow, slip flow, Knudsen diffusion, surface diffusion, adsorption and desorption in to the rock material, and also including a nonlinear Forchheimer correction term for high flow rates (turbulence), has been developed [1,2]. The transport model is an advection-diffusion type of partial differential equation with pressure dependent model parameters and associated compressibility coefficients, and with nonlinear pressure-dependent apparent convective velocity $U(p, p_x)$ and apparent diffusivity $D(p)$ where p is the pressure field. The transient one-dimensional model without gravity and without external source is,

$$\frac{\partial p}{\partial t} + U\frac{\partial p}{\partial x} = D\frac{\partial^2 p}{\partial x^2} \tag{1}$$

where,

$$D = \frac{\rho}{\mu}\frac{FK_a}{\rho\phi\zeta_1 + (1-\phi)\zeta_2} \tag{2}$$

$$U = -D\zeta_3\frac{\partial p}{\partial x} \tag{3}$$

and, ρ is the fluid density, μ is the fluid viscosity, K_a is the apparent rock permeability, ϕ is the rock porosity, and $\zeta_1(p),\ \zeta_2(p),\ \zeta_3(p)$ are various pressure dependent compressibility factors, and F is a factor incorporating the effects of high flow rates – see [1, 2] for details.

The steady-state 1D model was used to determine the shale rock charcateristics by history matching the pressure distribution across a shale rock core sample obtained from pressure-pulse decay tests for different inflow pressure conditions [3]. The best results were obtained when the high flow rate Forchheimer correction term is included in the model; the estimates for the porosity and permeability are then much more realistic than previous models [4], which is a notable achievement. In the case considered, the porosity was determined to lie in the range, $0.1 < \phi < 0.104$, and the rock intrinsic permeability was determined to lie in the range, $106 < K < 111$ nD.

This work is important because it demonstrates that a realistic transport model must incorporate all of the important physical transport sub-processes in the porous system, and that all model parameters and associated compressibility coefficients should be kept pressure dependent throughout the numerical procedure. A Forchheimer correction term for high flow rates is very important for good estimation of rock characteristics. In the future, the second phase of this work is to incorporate this model in to a new model for gas transport through fractured media such as fractured tight shale rocks.

[1] Ali I. A Numerical Study of Shale Gas Flow in Tight Porous Media Through Nonlinear Transport Models. PhD Dissertation, King Fahd University of Petroleum & Minerals, Saudi Arabia, 2016.

[2] Ali I. & Malik N. A. A realistic transport model with pressure dependent parameters for gas flow in tight porous media with application to determining shale rock properties. *Submitted 2017.*

[3] Pong K., Ho C., Liu J., Tai Y. Non-linear pressure distribution in uniform micro-channels. ASME Fluids Eng. Div. (FED) Vol. 197, 51–56, (1994).

[4] Civan, F., Rai, C.S., Sondergeld, C.H. Shale-gas permeability and diffusivity inferred by improved formulation of relevant retention and transport mechanisms. Transport in Porous Media 86, 925-944, (2011).