World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Sphere in Cube Grid Approach to Modelling of Shale Gas Production Using Non-Linear Flow Mechanisms

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Abstract : Shale gas is one of the most rapidly growing forms of natural gas. Unconventional natural gas deposits are difficult to characterize overall, but in general are often lower in resource concentration and dispersed over large areas. Moreover, gas is densely packed into the matrix through adsorption which accounts for large volume of gas reserves. Gas production from tight shale deposits are made possible by extensive and deep well fracturing which contacts large fractions of the formation. The conventional reservoir modelling and production forecasting methods, which rely on fluid-flow processes dominated by viscous forces, have proved to be very pessimistic and inaccurate. This paper presents a new approach to forecast shale gas production by detailed modeling of gas desorption, diffusion and non-linear flow mechanisms in combination with statistical representation of these processes. The representation of the model involves a cube as a porous media where free gas is present and a sphere (SiC: Sphere in Cube model) inside it where gas is adsorbed on to the kerogen or organic matter. Further, the sphere is considered consisting of many layers of adsorbed gas in an onion-like structure. With pressure decline, the gas desorbs first from the outer most layer of sphere causing decrease in its molecular concentration. The new available surface area and change in concentration triggers the diffusion of gas from kerogen. The process continues until all the gas present internally diffuses out of the kerogen, gets adsorbs onto available surface area and then desorbs into the nanopores and micro-fractures in the cube. Each SiC idealizes a gas pathway and is characterized by sphere diameter and length of the cube. The diameter allows to model gas storage, diffusion and desorption; the cube length takes into account the pathway for flow in nanopores and micro-fractures. Many of these representative but general cells of the reservoir are put together and linked to a well or hydraulic fracture. The paper quantitatively describes these processes as well as clarifies the geological conditions under which a successful shale gas production could be expected. A numerical model has been derived which is then compiled on FORTRAN to develop a simulator for the production of shale gas by considering the spheres as a source term in each of the grid blocks. By applying SiC to field data, we demonstrate that the model provides an effective way to quickly access gas production rates from shale formations. We also examine the effect of model input properties on gas production.

Keywords : adsorption, diffusion, non-linear flow, shale gas production
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020