Impact of Fracture Design Parameters on the Production Performance in Hydraulically Fractured Shale Gas Reservoir

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ABSTRACT

Effective hydraulic fracturing along with characterization of flow and reservoir properties is an important parameter for a successful shale gas development. In this study, a sensitivity analysis was conducted to evaluate the impact of fracture design parameters on the well performance in a hydraulically fractured shale gas reservoir using a simulation model. Gas recovery was higher when considering secondary fracture growth in shale gas reservoirs which have high natural fracture conductivity or low primary fracture conductivity.

KEY WORDS: Shale gas; fracture design parameter; multistage fracturing of horizontal wells; sensitivity analysis.

NOMENCLATURE

\[ A \] Porosity exponent
\[ b \] Langmuir’s constant, psi\(^{-1}\)
\[ C \] Gas concentration in kerogen, lb/ft\(^3\)
\[ D_D \] Diffusion constant, md/s
\[ d_s \] Secondary fracture spacing, ft
\[ k \] Permeability md
\[ k_{app} \] Apparent permeability of matrix, md
\[ k_0 \] Permeability at reference stress level md
\[ L \] Length of sample, ft
\[ L_{cf} \] Half width of fracture network, ft
\[ M \] Molecular mass, lb/mol
\[ p_i \] Initial reservoir pressure, psia
\[ p_k \] Pressure of gas dissolved in kerogen bulk, psi
\[ p_x \] Pressure of free gas in nanopore, psi
\[ R \] Gas constant, 8.314 J/molK
\[ r_s \] Pore radius, ft
\[ T \] Temperature, °F
\[ t \] Time, s

\[ X_{pf} \] Primary fracture half length, ft
\[ z \] Gas compressibility factor
\[ \mu \] Gas viscosity, cp
\[ \rho_s \] Bulk density of shale at initial reservoir pressure, lb/ft\(^3\)
\[ \rho_{NTP} \] Gas density at normal T and p condition, lb/ft\(^3\)
\[ \phi \] Porosity, fraction
\[ \phi_0 \] Porosity at reference stress level, fraction

INTRODUCTION

For successful development of shale gas, it is necessary to maximize productivity by analyzing the flow characteristics, reservoir properties, and a fracture treatment design which influence well performance. The fracture design parameters are important to optimize the production of shale gas. When a low-permeability reservoir is hydraulically fractured, a fracture network system is formed comprising primary and secondary fractures. The fracture network should be considered when evaluating production performance of a shale gas reservoir.

To investigate the correlation between fracture design parameters and production performance in a shale gas reservoir, Li et al. (2013) carried out a simulation using multistage fracturing of horizontal wells. It was verified that the peak production was changeable according to the stimulated reservoir volume (SRV) and secondary fracture density. However, since the sensitivity analysis was implemented by only designing simple parameters, the impact of secondary fracture on the production performance for a reservoir with various properties could not be clearly evaluated.

In this study, sensitivity analysis was implemented to evaluate the impact of fracture design parameters on gas well performance using CMG’s module, GEM. The shale gas reservoir model was established using the properties of a Barnett shale which was well-known in reservoir properties. The sensitivity analysis was carried out in terms of primary and secondary fracture in the model. For advanced analysis, an additional simulation was also performed with a wide range of reservoir conditions. Based on the results, the determination of whether to increase or decrease secondary fracture growth is required to improve gas recovery.