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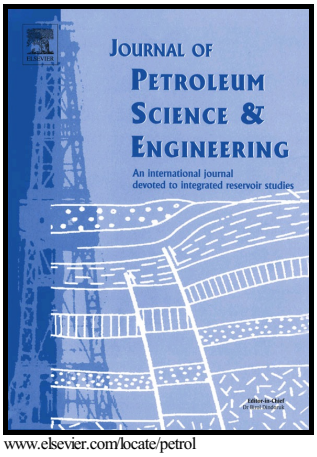

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A Comprehensive Productivity Equation for Multiple fractured Vertical Wells with Non-linear Effects under Steady-State Flow

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Abstract

In Ordos Basin low-permeability reservoirs, taking large-scale fracturing (LSF) measures on vertical wells is being a common practice. Thus, it is a significant problem that should be solved urgently about how to estimate productivity of those wells. During the LSF treatments, micro-seismic monitoring (MSM) strongly shows multiple fractures (MF), with arbitrary length and arbitrary angle, develop along the wellbore. However, most of published works on the productivity of vertically fractured wells assumed that the wells contained a single fracture, and few work has been done to focus on MF.

In this paper, a comprehensive steady-state productivity equation for a multiple fracture vertical well (MFVW) is proposed under a constant pressure drawdown. First, a mathematical model of the MFVW is established with consideration of multiple factors including stress-sensitivity effect of permeability (SEP), threshold pressure gradient (TPG), fracture angle asymmetry (FAA), fracture length asymmetry (FLA), and fracture conductivity asymmetry (FCA). Then, using conformal mapping and Pedrosa's perturbation, the productivity equation of MFVW is solved. After that, based on real cases from Ordos Basin reservoir, error analysis of the proposed equation is performed. Equation validation is also conducted by comparing the proposed equation with those of conventional wells in literatures. Finally, the effects of some critical parameters on productivity of MFVW are analyzed.

Equation validation shows there are good agreements between the proposed productivity equation and those of conventional wells. The results from sensitivity analysis demonstrate the productivity of MFVW increases with the increase of fracture length, fracture conductivity, fracture number, and degree of FLA; it decreases with the increase of TPG value, SEP coefficient, degree of FCA, and degree of FAA.

It provides significant references for reservoir engineers in productivity estimations as well as fracturing evaluations of vertically fractured wells in the low-permeability oil reservoirs.

Graphical Abstract

Micro-seismic fracture imaging strongly shows multiple fractures (MF), with arbitrarily length and arbitrarily angle, can develop along the wellbore during large-scale fracturing (LSF) measures. However, most of published works on the productivity of vertically fractured wells assumed that the wells contained a single fracture, and few work has focused on MF. To fill this gap, in this paper, a