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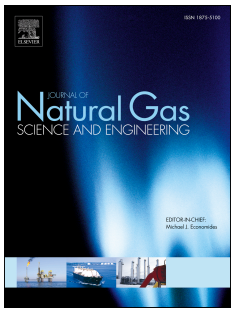

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Transient Pressure Analysis of Horizontal Well with Nonorthogonal Transverse Fractures and Drainage Volume Characterization Using Fast Marching Method

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Abstract

Horizontal well drilling and multistage hydraulic fracturing are essential to economic recovery of unconventional tight/shale reservoirs. Multiple transverse fractures are ideally supposed to be perpendicular to the minimum stress direction, but nonorthogonal transverse fractures might be seen in practice, which might bring a better connection between wellbore and fractures. However, for the same fracture half-length, the stimulated reservoir area might be less. Thus, the well performance with these nonorthogonal transverse fractures is full of uncertainty. Little research work is currently conducted on the nonorthogonal transverse fracture scenario.

Our transient pressure analysis of horizontal well performance with nonorthogonal transverse hydraulic fractures utilizes the concept of rate-normalized pressure and transient productivity index. The novel Fast Marching Method (FMM) is adopted to characterize the drainage volume evolution for multi-stage horizontal wells and validate the proposed methodology. Sensitivity studies contrast transient pressure behavior and productivity index for azimuth angles from 15 to 90 degrees, e.g. from nearly longitudinal to truly transverse fracture angles. Additionally, transient pressure behavior and long-term reservoir performance of horizontal well for different scenarios are investigated, such as reservoir anisotropy and different proppant allocation strategies under the constraints of given horizontal well spacing and total proppant amount.

Contrast to what we are usually expecting, results show that for the same fracture spacing, and the same total proppant amount, the well with nonorthogonal transverse fractures will have a higher productivity index than that for truly transverse fractures. Different from productivity index, the long-term reservoir performance, however, turns out to play a different game, given specific horizontal well spacing and the same total proppant amount. Reservoir performance for horizontal well with nonorthogonal transverse fractures can be significantly improved by optimally allocating the proppant and designing hydraulic fracture placement strategies through this research.

Keyword

Nonorthogonal Transverse Fracture; Transient pressure analysis; Drainage Volume; Fast Marching Method

Introduction

Hydraulically fractured horizontal well has become a common technique applied for the low permeability tight/shale reservoirs. Economical production from these reservoirs normally requires large reservoir contact per well, which can be achieved through multiple transverse fractures. Therefore, horizontal wells and transverse hydraulic fractures together provide the opportunity to effectively improve the productivity. The hydraulic fracture initiation and propagation for horizontal wells are