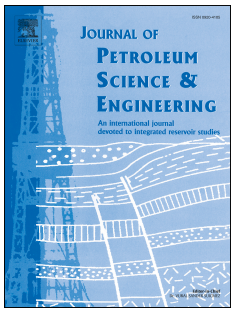
Accepted Manuscript



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PII: S0920-4105(17)30696-4

DOI: 10.1016/j.petrol.2017.08.071

Reference: PETROL 4234

To appear in: *Journal of Petroleum Science and Engineering*

Received Date: 30 March 2017

Revised Date: 28 August 2017

Accepted Date: 30 August 2017

Please cite this article as: Wang, J., Xu, J., Wang, Y., Li, H., Liu, T., Wen, X., Productivity of hydraulically-fractured horizontal wells in tight oil reservoirs using a linear composite method, *Journal of Petroleum Science and Engineering* (2017), doi: 10.1016/j.petrol.2017.08.071.

Productivity of hydraulically-fractured horizontal wells in tight oil reservoirs using a linear composite method

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Abstract: In tight oil reservoirs, horizontal wells log analyses indicate properties of reservoirs, such as permeability and porosity, are unequal along the horizontal wells' direction, those heterogeneity of reservoirs bring huge challenges in productivity predicting and hydraulic fracturing designing. This paper focuses on describing such heterogeneity, analyzes its effects on productivity and optimization of hydraulic fractures' parameters. The heterogeneous reservoir is concluded as a linear composite system, the reservoir is divided into two-zone along horizontal well's direction and each zone' permeability and porosity are different. Then a new rigorous mathematic method to predict the productivity is derived based on volumetric source idealization. The new method is verified through the commercial numerical reservoir simulator (Eclipse). Comparing with cumulative productions of a hydraulically-fractured horizontal well in Xinjiang Oilfield Company, the difference is $95m^3$ for heterogeneous model but raises to $1750m^3$ for homogeneous model, which show heterogeneous model have better predicting ability and two-zone assumption has enough accuracy in application. Parameters study show the difference between the simulated results of homogeneous and heterogeneous model could be 15%, and the degrees will be more serious when length of high permeability zone becomes shorter, reservoir's average permeability becomes lower, or contrast of two zones' permeability becomes bigger. Optimizing hydraulic fractures' parameters can be processed by employing homogeneous model with average permeability, but design more and longer hydraulic fractures in high permeability zone will have significant effect on productivity in early stage, and hydraulic fractures with even space and length would be better for long time production.

Key words: tight oil reservoirs; heterogeneity; hydraulically-fractured horizontal wells; volumetric source model; linear composite system

1 Introduction

Long horizontal well drilling and hydraulic fracturing technologies have been widely applied on developing tight oil reservoirs. The performance of hydraulically-fractured horizontal well is affected by various factors mainly including uncontrollable reservoir's and controllable fracturing parameters (Root, 1978; Osorio and Lopez, 2009). In general, uncontrollable parameters, such as permeability and porosity, are unequal along the horizontal well. The inherent heterogeneity of tight oil reservoirs brings challenges in productivity predicting and hydraulic fracturing designing.

Composite systems have been utilized to present actual systems where flow is moderated and observed on pressure signatures. For the heterogeneous reservoirs that values of permeability and porosity are unequal along the horizontal wells' direction, a linear composite system is suitable to present such properties. Bixel et al. (1963) firstly introduced a linear composite model to analyze pressure behavior of a well located near a linear discontinuity, the value of permeability, viscosity, compressibility and porosity are assumed to be different. Then the conception is generalized into different situations, such as semi-permeability barrier cases with different boundary conditions (Yaxley 1987; Ambastha and Abraham1987), naturally fractured reservoir case (Kikani and Walkup Jr 1991) and varied thickness case (Zhang et al. 2010). Beyond the limitation of two-dimensional or two zones assumptions, flow models of three zones (Bourgeois et al. 1996) and n-zone (Kuchuk and Habashy 1997) composite systems are investigated; a three-dimensional model in a closed and box-shape reservoir with two zone composite system is also proposed (Ambastha and Ghaffari 1998). Most researches are focused on vertical wells; only Ezulike and Igbokoyi (2012) have turned to study horizontal wells. Flow models of hydraulically-fractured horizontal wells, such as analytical linear flow models (Brown et al. 2009; Hasan 2010; Stalgorova and Mattar 2013; Li et al. 2014), semi-analytical point source models (Lian et al. 2012; Lin and Zhu 2012), semi-analytical volumetric source models (Amini 2007; Wang et al. 2015), are mostly derived in homogeneous or dual media reservoirs. Although reservoir simulation technique could be employed to evaluate the performance of the hydraulically-fractured horizontal wells in heterogeneous reservoirs (Gilbert and Barree, 2009), the process has to face higher computational expense due to the finer Local Grid Refinement (LGR) and will be more time-consuming.

This paper focuses on productivity of hydraulically-fractured horizontal wells in heterogeneous tight oil reservoirs and derives a new two-zone linear composite model to predict the productivity. The