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A NEW WELL TEST MODEL FOR STRESS-SENSITIVE AND RADIALLY HETEROGENEOUS DUAL-POROSITY RESERVOIRS WITH NON-UNIFORM THICKNESSES*

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Abstract: This article presents a new well test model for stress-sensitive composite dual-porosity reservoirs based on the concept of permeability modulus, where the rock and fluid properties as well as the formation thickness vary in the radial direction. An analytical solution in the Laplace space for the pressure-transient behavior for a line-source, constant-rate well of this type of reservoir is obtained with the Laplace transformation and the perturbation technique. The pressure and its derivative in the reservoir and the effects of relevant parameters on the pressure-transient response are obtained. The model as well as the corresponding type curves may be used in predicting the production performance or analyzing the production data for this type of reservoir.

Key words: non-uniform thickness, stress-sensitive, composite dual-porosity, well test model, type curve

Introduction

Naturally fractured reservoirs are composed of fractures with high flow and low storage capacity and a matrix with high storage and low flow capacity. The composite systems of this type of reservoirs can be encountered as a result of non-uniform fracture distribution, drilling, secondary or tertiary recovery projects, and stimulation programs. In general, a composite reservoir system is made up of two or more regions, with its own rock and fluid properties in each region.

In the past 26 years, a considerable number of theoretical studies were devoted to describe the pressure behavior of this specific type of reservoir[1-4]. In 2006, based on the previous studies, Huang and Liu[5] extended the radial composite dual-porosity model to the multi-zone condition and presented an analytical solution to describe the transient pressure behavior of a composite dual-porosity oil reservoir with non-uniform thickness and lateral heterogeneity. Zhang et al.[6] proposed a well testing interpretation model for naturally fractured reservoirs with consideration of stress sensitivity and starting pressure gradient. However, the model was only numerically solved without obtaining its analytical solution. Shan et al.[7] established a relaxation model to describe the unsteady flow of non-Newtonian visco-elastic fluid in dual-porosity media by introducing fractional order derivatives into the seepage flow. More recently, Zheng et al.[8] established mathematical models for dual porosity reservoirs with infinite outer boundary, constant pressure outer boundary and closed outer boundary, and the similar structure of the solutions in the three kinds of outer boundary conditions was analyzed. In 2009, Cai and Huang[9] presented an analytical model to describe the pressure behavior of a vertical fracture well completed in a dual-porosity composite reservoir. In 2010, with consideration of changes of the permeability modulus of fracture and using the concept of the effective stress in a pressure-sensitive dual-porosity medium, Wang et al.[10,11] developed a mathematical model of well testing for the stress-sensitive dual-porosity reservoir. In 2010, Tao et al.[12] proposed a radial composite

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