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THE INVESTIGATION OF NUMERICAL SIMULATION SOFTWARE FOR FRACTURED RESERVOIRS

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Abstract. Based on percolation mechanism of fractured reservoirs and simulation technique, the numerical simulation software of fractured reservoirs has been developed on PC-Linux environment, which is on the basis of DQHY simulator of three dimensions and three phases. It can treat dual-porosity/single-permeability and dual-porosity/dual-permeability model. The results of examples indicate that the performance of fractured reservoirs could be simulated with the software.

Key Words. the numerical simulation, fractured reservoirs, DQHY simulator, PC-Linux, dual-porosity.

1. Introduction

The concept of dual-porosity media was put forward by Barenblatt, G.I in Russian when he studied single-phase flow crossing fractured porous media in 1960. Later this concept was applied into fractured reservoir simulation, and popularized to multiphase flow.

The use of the dual-porosity approach for the modeling of naturally fractured reservoirs has become widely accepted in the oil industry. In this approach, it is assumed that fractured porous media can be represented by two collocated continua called matrix and fracture. The original idealized models assumed that the fracture is the primary conduit for flow whereas the matrix acts as distributed sources and sinks. Since the introduction of idealized model into the petroleum literature some 40 ago, so several improvements and refinements have been proposed. For example, the dual-permeability model was introduced when it become evident for some fractured reservoirs, the continuity of the matrix is very important consideration. Much of the recent works on dual-permeability modeling are directed towards the more accurate representation of matrix-fracture transfers for porosity model.

There are natural and artificial fractures in periphery oil field of Daqing, such as Fuyang oil layer, Putaohua layer and Toutai oil field, there are also fractures since old oil wells was fractured in interior of Daqing oil field. In order to improve waterflood recovery and development level of periphery oil field at late period of high water-cut, Daqing oil field requires the support of numerical simulation technique for fractured reservoirs.

Based on mature percolation mechanism of fractured reservoirs inland and overseas, the numerical simulation software of fractured reservoirs has been developed on PC-Linux environment, which is on the basis of DQHY simulator of three dimensions and three phases.

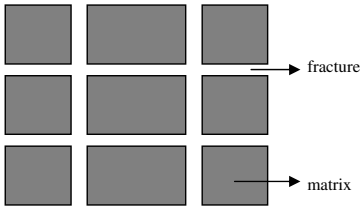

FIGURE 1. Dual porosity system.

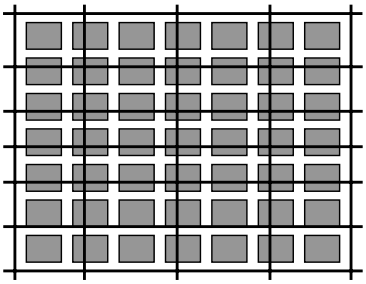

FIGURE 2. Partition of grids for dual porous media.

2. General theories

In order to describe fractures, it is first assumed that there is an ideal fractured system with only vertical and horizontal fractures in reservoir (for 2-D problem), showed by FIGURE 1, the matrix is surrounded by fractures, so dual porous media consists of the fractured system (grid) and the matrix. In general, the most fluids exist in matrixes for reservoirs, the volume of fracture is very small, there is only a small quantity of fluids in it, but the conductive capability of the fracture is much better than the matrix. Therefore the matrix blocks only acts as distributed sources and sinks, the fracture is the primary conduit in the idealized dual porosity model.

The flow equations can be described by the following mathematical modeling when multiphase fluids are flowing through the ideal media above [1]:

$$\begin{cases} \dfrac{\partial}{\partial t}(\dfrac{\Phi S_\alpha}{B_\alpha})_f = \bigtriangledown \cdot [\dfrac{KKr_\alpha}{\mu_\alpha B_\alpha}(\bigtriangledown P_\alpha - \rho_\alpha g \bigtriangledown D)]_f - \tau_{\alpha maf} + q_{\alpha f}, \\ \dfrac{\partial}{\partial t}(\dfrac{\Phi S_\alpha}{B_\alpha})_{ma} = \tau_{\alpha maf}, \end{cases} \tag{1}$$

where the subscripts f and ma refer to the fracture and matrix respectively, the $\tau_{\alpha maf}$ is the matrix-fracture transfer term and has the form:

$$\tau_{\alpha maf} = \sigma V_b (1 - \Phi_f) \lambda_\alpha (\varphi_f - \varphi_{ma})_\alpha, \tag{2}$$

where σ is the shape factor, λ_α is the phase mobility of phase α, Φ_f is the fracture porosity and φ is flow potential.

We can obtain different fractured model if we choose different $\tau_{\alpha maf}$, such as: the gravity model, the subdomain model, pseudo function method and dual permeability model or any combination above, etc..