SIMULATION OF FLOW IN NATURALLY FRAC TURED PETROLEUM RESERVOIRS

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Abstract
This paper describes two models for simulating flow in naturally fractured petroleum reservoirs, one for single phase flow of a fluid of constant compressibility, and the other for two-phase, incompressible, immiscible flow. Both models are based on the dual porosity concept. In each model the flow in an individual matrix block is simulated using the standard equations describing flow in unfractured media, and the matrix/fracture interaction is based on the imposition of proper boundary conditions on the surface of the block. The models are presented in an easily parallelizable form.

Introduction
Double porosity models of flow through a naturally fractured petroleum reservoir were first described by Barenblatt, Zheltov, and Kochina1 and Warren and Root2; their models were for single phase flow under the assumption of quasi-steady state flow in the matrix blocks. Kazemi3 and de Swaan 4 considered the fully unsteady model. In this paper a somewhat more general single phase model will be considered, along with a model for two-phase, incompressible flow. Thomas et al.5 have studied a different double porosity model of this problem.

The fractured reservoir $\Omega$ will be idealized as a porous medium having a regular geometric pattern of fractures separating the medium into matrix blocks $\Omega_i$. The diameter of each $\Omega_i$ is supposed small in comparison to that of $\Omega$. The fracture system and each matrix block will be considered to be distinct, coupled porous media. The flow in each matrix block will be treated in a standard manner, based on a proper form of Darcy's law and conservation of mass. Similarly, the flow in the fractures will be modeled through the same physics, except that a (distributed) source term is induced by the flow between the blocks and the fractures. No direct flow between blocks (i.e., without passing through the fractures) will be permitted; thus, each matrix block interacts, through proper boundary conditions, with the surrounding fractures, but with no other block. For convenience in the models formulated below, it will also be assumed that the blocks are not directly affected by external sources or sinks.

The Single Phase Model
In addition to the assumptions described above, assume that the single phase fluid is of constant compressibility; i.e.,

$$\rho^{-1} \Delta P = c \delta, \quad \rho^{-1} \Delta \rho = c \rho,$$

where $c$ is a positive constant, in the entire system. (Capital letters generally denote fracture quantities, small letters the corresponding matrix quantities.) Gravitational terms will be linearized.

References at end of paper.