TWO-FLUID MATHEMATICAL MODEL FOR COMPRESSIBLE FLOW IN FRACTURED POROUS MEDIA

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***Abstract*— A three-dimensional isothermal transient compressible two phase flow of liquid and gas in a low permeability fractured porous media model has been developed from the general mass and momentum balances using volume averaging techniques. The emphasis of the paper is on the available analytical and semi-empirical correlations and closure relations. The interfacial mass and momentum transfer terms in the averaged formulation are explained. The assumptions used in the model's formulation are that a condition of capillary equilibrium exists throughout the media, momentum transfer between mobile fluid phases is negligible in the porous media and exists in the fracture, and fluid phase change has been neglected. The pore size distribution of the studied porous media was represented by three mean pore diameters: liquid pore network, gas pore network, and fractures. An average pore diameter and length for each network were determined using the gamma distribution function. The model was validated and solved for a hypothetical porous media and fractured domain.**

***Keywords*— Two-Fluid; Fractured; Porous Media; Capillary Pressure; Transient; Compressible Flow, Isothermal, Mass, Momentum Transfer.**

I. INTRODUCTION

The increased sophistication of oil/gas recovery technologies has brought with it increased operating and material costs and therefore a greater demand for sound process designs. Mathematical models of fluids flow in petroleum and gas reservoirs have become key tools by which reservoir engineers develop and implement these designs. Using mathematical models together with various characterizations of the rock-fluid system being modeled, the engineer can test various operating strategies, compare different recovery technologies, and formulate hypotheses in diagnosing the performance of ingoing projects.

It is impossible to specify the microstructure in a realistic porous medium completely. Porous media can be characterized without specifying the porous geometry in all its details. The well-known approach of doing so is by constructing a simplified geometric model, like bundle of capillary tubes, grain models, network models, and percolation model, for each specific porous medium of interest.

Most of the models describing the flow through fractured porous media, such as (Thomas *et al.*, 1983; Evans, 1982; Guzman and Khaled., 1992; Fung, 1993; Warren and Root, 1963; Zekai, 1988; Nitao, 1990; Arbogast, 1993; Celis *et al.*, 1992; Lee and Tan, 1987; Alder and Thovert, 1999; Panfilov and Panfilov, 2000) were based on Zheltov's model (Zheltov *et al.*, 1960), and used his concept of dual-porosity dual-permeability region. They differentiate between two flow regions, one representing the discrete matrix where the other represents the continuous fracture network. Based on that, they considered mainly two types of equations: the equations describing flow in fracture system and equations describing flow in the matrix.

The main objective of the manuscript is the development of a mathematical model which predicts the flow phenomena in low permeability fractured porous media. It is rather impossible to apply conservation laws directly to each pore in porous medium and to find a possible numerical or analytical solution. Instead a semi-empirical approach has been used where some constitutive equations are needed, and a set of equations are developed based on flow through the entire medium.

It is known in reservoir engineering that the productive strata (producing formation or beds) could be made up of rocks described by the following characteristics and properties; porosity, permeability, granulemetric composition, elasticity, resistance to rupture, compression, deformation and saturation. Using these characteristics and properties, the conditions of oil and gas fields' development can be determined.

Pore structure of reservoir rocks is very complex. In the case of fractured porous media, the porosity can be placed into two classes:

1- Primary porosity, which is highly interconnected and can be correlated with permeability, this could be the porosity of the homogeneous rocks. This region always has high resistance (low permeability) to flow.
2- Secondary porosity, formed by a fracture, usually this porosity is the product of geological movements, hydraulic fracturing and chemical processes. Although it does not contain a fraction of fluid reserve as large as that of the first class, it greatly affects the flow. Moreover, it has low resistance to flow compared to the primary porosity region.

For the case of low permeability fractured porous media a network model is developed, the simultaneous existence of two phases of water and gas is considered.