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ORIGINAL PAPER

The impact of the spatial and temporal variability of physical and petrophysical properties on conventional reservoir performance

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Abstract
The paper focuses on the impact of the spatial and temporal variability of permeability and viscosity, as well as the mobility ratio on the flow behavior of reservoir fluid. The motivation of the study is to eliminate the uncertainty that could be raised from the assumptions of the constant values for these parameters. In the current study, computational fluid dynamics (CFD) is used to simulate reservoir fluid flow in the porous media considering time- and space-variant permeability, viscosity, and mobility ratio. For this purpose, different analytical models of the three parameters have been used. The models adopted a linear distribution of the three parameters with distance from the wellbore to the outer boundaries of the reservoir. After introducing these models to the CFD simulator, reservoir fluid velocity and the pressure distribution are predicted. Based on the velocity and pressure distribution, the effects of the three parameters on reservoir production capacity are calculated. Moreover, a comparison between the velocity, pressure, and production behavior based on the variable parameters and those of constant value parameters is presented in this study. The study has reached several conclusions and observations summarized as follows: (1) The spatial changes in the viscosity, permeability, and mobility may have an impact on the velocity, pressure, and oil productivity index, compared to the constant values approach. (2) The permeability may have more impact than the viscosity in the oil reservoirs especially close to the wellbore where the damage or stimulated conditions could exist. (3) The greatest impact is seen near the wellbore at early production time when the transient flow is dominant. (4) Radial flow regimes are more affected by the spatial changes of the permeability and viscosity, whereas pseudo-steady-state flow regime is less affected by the spatial changes.

Keywords Conventional reservoir · Physical and petrophysical properties · Numerical analysis · Computational fluid dynamic

Introduction

Substantially, all reservoir engineering studies require a comprehensive understanding of the fluid flow characteristics. As it is well documented, many parameters affect fluid flow in the porous media such as reservoir petrophysical properties and reservoir fluid physical properties. For the sake of simplicity and ease of the simulation implementations, some of the reservoir petrophysical and physical properties is frequently taken as a constant. In reality, their actual behaviors may vary with the production time, reservoir pressure, or the location in the porous media. The current study investigates the impact of the changes in the petrophysical properties of reservoir rock and physical properties of reservoir fluid with the location in the porous media, i.e., the distance from the wellbore and time on the reservoir performance.

Permeability is one of the petrophysical properties while viscosity is one of the physical properties that could play a great role in the fluid flow pattern, pressure distribution through the reservoir, and the total production represented by the productivity index. The permeability physically is defined as the porous media's indicator for the ability to

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