

Please read as supplementary text to lectures. Please focus on the discussions of physical behavior. Sections on reservoir simulation are not relevant for this course

Dual Porosity, Dual Permeability Formulation for Fractured Reservoir Simulation

K. Uleberg and J. Kleppe, Norwegian University of Science and Technology (NTNU), Trondheim
RUTH Seminar, Stavanger 1996

Abstract

This study reviews key physical mechanisms and calculation methods for modelling of fluid flow in North Sea fractured reservoirs. The main matrix-fracture fluid exchange mechanisms described are gravity drainage, capillary imbibition and molecular diffusion. Important issues such as capillary continuity between matrix blocks, re-infiltration of fluids from higher to lower blocks and effect of block shape on flow processes are also addressed.

Simulation studies of water-flooding in fractured reservoirs are reported for the purpose of identifying the effects of gravity and capillary forces on oil recovery. Included are studies of effects of capillary continuity and degree of wetting. The results show that for intermediately wetted systems, such as the Ekofisk reservoir, capillary continuity has a major effect on oil recovery.

Laboratory processes involving high pressure gas injection in fractured systems have been studied by compositional simulation. The results show that changes in interfacial tension caused by diffusion, may have dramatic effects on oil recovery.

Computational aspects of fluid exchange processes are discussed, including conventional dual porosity formulation, use of matrix-fracture transfer functions, and detailed numerical calculation. The only solution to more representative modelling of flow in fractured reservoirs is more detailed calculations. A multiple grid concept is proposed which may drastically increase the detail of the simulation.

Introduction

Based on the theory of fluid flow in fractured porous media developed in the 1960's by Barrenblatt *et al.*¹, Warren and Root² introduced the concept of dual-porosity models into petroleum reservoir engineering. Their idealized model of a highly interconnected set of fractures which is supplied by fluids from numerous small matrix blocks, is shown in Fig. 1. Kazemi *et al.*³ were the first to incorporate the dual-porosity concept into a numerical model, with application to fluid flow on a large scale.

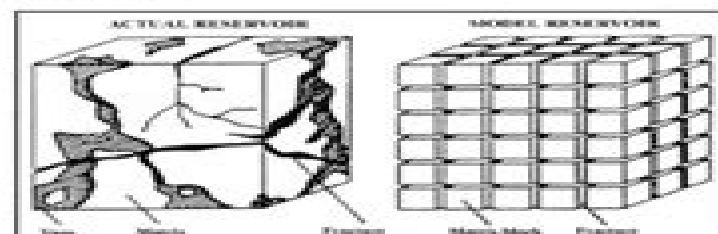


Fig. 1 Idealization of a fractured system (from Warren and Root²)

Since that time, numerical modelling of naturally fractured reservoirs using dual-porosity models has been the subject of numerous investigations. In the dual-porosity and dual-porosity/dual-permeability formulations most commonly used to model fractured reservoirs, proper representation of imbibition and gravity drainage is difficult. In some formulations, attempts have been made to represent correct behavior by employing a gravity term, and assuming a simplified fluid distribution in the matrix.⁴⁻⁶ Several authors⁷⁻¹⁰ have made use of capillary pressure pseudofunctions for the matrix and/or the fracture that employ matrix fluid distributions obtained through some type of history matching with a fine-grid model of a single

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Uncertainty Analysis and Reservoir Modeling Y. Zee Ma, Paul R. La Pointe, 2011-12-20

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Design and Construction of an Experiment for Two-phase Flow in Fractured Porous [i.e. Porous] Media Rafael E. G. Ayala, 1993

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Efficient Simulation of Thermal Enhanced Oil Recovery Processes Zhouyuan Zhu, 2011 Simulating thermal processes is usually computationally expensive because of the complexity of the problem and strong nonlinearities encountered In this work we explore novel and efficient simulation techniques to solve thermal enhanced oil recovery problems We focus on two major topics the extension of streamline simulation for thermal enhanced oil recovery and the efficient simulation of chemical reaction kinetics as applied to the in situ combustion process For thermal streamline simulation we first study the extension to hot water flood processes in which we have temperature induced viscosity changes and thermal volume changes We first compute the pressure field on an Eulerian grid We then solve for the advective parts of the mass balance and energy equations along the individual streamlines accounting for the compressibility effects At the end of each global time step we account for the nonadvective terms on the Eulerian grid along with gravity using operator splitting We test our streamline simulator and compare the results with a commercial thermal simulator Sensitivity studies for compressibility gravity and thermal conduction effects are presented We further extended our thermal streamline simulation to steam flooding Steam flooding exhibits large volume changes and compressibility associated with the phase behavior of steam strong gravity segregation and override and highly coupled energy and mass transport To overcome these challenges we implement a novel pressure update along the streamlines a Glowinski scheme operator splitting and a preliminary streamline finite volume hybrid approach We tested our

streamline simulator on a series of test cases We compared our thermal streamline results with those computed by a commercial thermal simulator for both accuracy and efficiency For the cases investigated we are able to retain solution accuracy while reducing computational cost and gaining connectivity information from the streamlines These aspects are useful for reservoir engineering purposes In traditional thermal reactive reservoir simulation mass and energy balance equations are solved numerically on discretized reservoir grid blocks The reaction terms are calculated through Arrhenius kinetics using cell averaged properties such as averaged temperature and reactant concentrations For the in situ combustion process the chemical reaction front is physically very narrow typically a few inches thick To capture accurately this front centimeter sized grids are required that are orders of magnitude smaller than the affordable grid block sizes for full field reservoir models To solve this grid size effect problem we propose a new method based on a non Arrhenius reaction upscaling approach We do not resolve the combustion front on the grid but instead use a subgrid scale model that captures the overall effects of the combustion reactions on flow and transport i e the amount of heat released the amount of oil burned and the reaction products generated The subgrid scale model is calibrated using fine scale highly accurate numerical simulation and laboratory experiments This approach significantly improves the computational speed of in situ combustion simulation as compared to traditional methods We propose the detailed procedures to implement this methodology in a field scale simulator Test cases illustrate the solution consistency when scaling up the grid sizes in multidimensional heterogeneous problems The methodology is also applicable to other subsurface reactive flow modeling problems with fast chemical reactions and sharp fronts Displacement front stability is a major concern in the design of all the enhanced oil recovery processes Historically premature combustion front break through has been an issue for field operations of in situ combustion In this work we perform detailed analysis based on both analytical methods and numerical simulation We identify the different flow regimes and several driving fronts in a typical 1D ISC process For the ISC process in a conventional mobile heavy oil reservoir we identify the most critical front as the front of steam plateau driving the cold oil bank We discuss the five main contributors for this front stability instability viscous force condensation heat conduction coke plugging and gravity Detailed numerical tests are performed to test and rank the relative importance of all these different effects

Proceedings ... SPE Annual Technical Conference and Exhibition Society of Petroleum Engineers (U.S.). Technical Conference and Exhibition, 1994 **Simulators International XIII** Maurice Ades, Ron Griebenow, 1996 **Proceedings** Society of Petroleum Engineers of AIME. California Regional Meeting, 1988 **SPE Reservoir Evaluation & Engineering**, 2010 **Shale** Thomas Dewers, Jason Heath, Marcelo Sánchez, 2019-09-16 Advances in theories methods and applications for shale resource use Shale is the dominant rock in the sedimentary record It is also the subject of increased interest because of the growing contribution of shale oil and gas to energy supplies as well as the potential use of shale formations for carbon dioxide sequestration and nuclear waste storage Shale Subsurface Science and Engineering brings together

geoscience and engineering to present the latest models methods and applications for understanding and exploiting shale formations Volume highlights include Review of current knowledge on shale geology Latest shale engineering methods such as horizontal drilling Reservoir management practices for optimized oil and gas field development Examples of economically and environmentally viable methods of hydrocarbon extraction from shale Discussion of issues relating to hydraulic fracking carbon sequestration and nuclear waste storage Book Review I D Sasowsky University of Akron Ohio September 2020 issue of CHOICE CHOICE connect A publication of the Association of College and Research Libraries A division of the American Library Association Connecticut USA Shale has a long history of use as construction fill and a ceramic precursor In recent years its potential as a petroleum reservoir has generated renewed interest and intense scientific investigation Such work has been significantly aided by the development of instrumentation capable of examining and imaging these very fine grained materials This timely multiauthor volume brings together 15 studies covering many facets of the related science The book is presented in two sections an overview and a second section emphasizing unconventional oil and gas Topics covered include shale chemistry metals content rock mechanics borehole stability modeling and fluid flow to name only a few The introductory chapter 24 pages is useful and extensively referenced The lead chapter to the second half of the book Characterization of Unconventional Resource Shales provides a notably detailed analysis supporting a comprehensive production workflow The book is richly illustrated in full color featuring high quality images graphs and charts The extensive index provides depth of access to the volume This work will be of special interest to a diverse group of investigators moving forward with understanding this fascinating group of rocks Summing Up Recommended Upper division undergraduates through faculty and professionals

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