PEGN 620A: Naturally Fractured Reservoirs:
Engineering & Reservoir Simulation
Fall 2009

http://www.mines.edu/~hkazemi

Thursdays: 9:00 am- 11:50 am

Instructor

Dr. Hossein Kazemi, Chesebro' Distinguished Chair in Petroleum Engineering

Office: AH 229

Phone: (303) 384-2072

E-mail: hkazemi@mines.edu

Web Page: http://www.mines.edu/~hkazemi

Office hours: Tuesdays and Thursdays 1:30 pm – 2:45 pm

Course objectives

More than fifty percent of the petroleum reservoirs are in carbonate rocks. In the Middle East, it is estimated that this number increases to seventy percent. A great number of these reservoirs are naturally fractured, e.g., Ghawar field, in Saudi Arabia, Cantarell field in Mexico, and Yates field in the USA. These are three of the largest fields in the world. The interest in such fields has grown tremendously.

Description

The course covers reservoir engineering, well testing, and simulation aspects of naturally fractured reservoirs. Specifics include: fracture description, connectivity and network; fracture properties; physical principles underlying reservoir engineering and modeling naturally fractured reservoirs; local and global effects of viscous, capillary, gravity and molecular diffusion flow; dual-porosity/dual-permeability models; multi-scale fracture model; dual-mesh model; streamline model; transient testing with non-Darcy flow effects; tracer injection and breakthrough analysis; geomechanics and fractures; compositional model; coal-bed gas model; oil and gas from fractured shale; improved and enhanced oil recovery in naturally fracture reservoirs.

Course Syllabus

- Fractures and Naturally Fractured Reservoirs (two weeks)
    - Fracture description, connectivity and network
    - Fracture properties
- Physical Principles and Flow Models (six weeks)
    - Single-phase Flow
    - Multi-phase Flow
    - Multi-component Flow
    - Dual-porosity/dual-permeability models
    - Multi-scale Fracture Model
    - Dual-mesh Model
- Transient Testing (two weeks)
    - Single-well tests
    - Multi-well test
    - Non-Darcy Flow Effects
- Tracer Injection and Breakthrough Analysis (two weeks)
    - Tracer Transport Model
    - Breakthrough Analysis
    - Streamline Simulation
- Geomechanics and Fractures (two weeks)
    - Oil and gas production from fractured shale
    - Tight gas reservoir production
- Compositional Modeling, IOR and EOR (two weeks)
    - Multi-component Model
    - Coal-bed Gas Model
    - Relevant Laboratory Experiments

Requirements

- PENG 513 or equivalent.
- Strong reservoir engineering background.
- Basic computer programming knowledge.

Exams

- Two tests and a final.

Homework Policy

Homework problems will be assigned throughout the semester. They are designed to facilitate student's understanding of the course material and its application to real world situations. The T.A. will post homework problems on the web page after each lecture. The student is to submit his/her typed homework on time to the T.A. Homework will be considered late after T.A. has posted the solution on the web page. Points will be taking off when homework is late, not typed, or the computer code is not submitted.

Collaboration Policy

Discussions of the assignments are encouraged; however, students must write their own code. Generally linear solver subroutines will be provided, but other than that, all other work submitted should be entirely of student's own creation.

TAs

Sarinya Charoenwongsa
Office: AH 224
School E-mail: scharoen@mines.edu
Office hours: TBA

Jeffrey Brown
Office: AH 230
School E-mail: jsbrown@mines.edu
Office hours: TBA

Mojtaba Kiani
Office: AH 230
School E-mail: mkiani@mines.edu
Office hours: TBA

Grading

Homework: 30%
Three tests: 30%
Project: 30%
Class contribution: 10%

References

Adibrata, Bob Wikan H., Hurley, and Neil F.: "Flow-Unit Modeling Using Neural Networks, Logs, and Core in a Vuggy Dolomite Reservoir, Dagger Draw Field, New Mexico," SPWLA 44th Annual Logging Symposium, June 22-25, 2003.

Alkobaisi M., Kazemi H., Ramirez B., Ozkan E. and Atan S.: "A Critical Review for Proper Use of Water-Oil-Gas Transfer Functions in Dual-Porosity Naturally Fractured Reservoirs – Part II," IPTC 11778, to be presented at IPTC 2007, Dubai, U.A.E.

Atan, S., Al-Matrook, M., Kazemi, H., Ozkan, E., and Gardner, M.: "Dual-Mesh Simulation of Reservoir Heterogeneity in Single- and Dual- Porosity Problems," SPE 93294, Reservoir Simulation Symposium, Jan. 2005 Houston, TX.

Aziz, K. and Settari, A.: Petroleum Reservoir Simulation, Applied Science Publishers Ltd (1979).

Caers, Jef: Petroleum Geostatistics, SPE (2005).

Dickey, P. A.: Petroleum Development Geology, PennWell Books (1986).

Ertekin, T., Abou-Kassem J. H. and King, G.R.: Basic Applied Reservoir Simulation, SPE Textbook Series Vol. 7 (2001).

Kazemi, H. and Gilman, J. R.: "Multiphase Flow in Fractured Petroleum Reservoirs," Chapter 6 in Flow in Contaminant Transport in Fractured Rocks, Academic Press (1993) pp 267-323.

Kazemi, H., Atan, S., Al-Matrook, M., Drier, J., and Ozkan, E.: "Multilevel Fracture Network Modeling of Naturally Fractured Reservoirs," SPE 93053, Reservoir Simulation Symposium, Jan. 2005 Houston, TX.

Kazemi, H. and Gilman, J. R.: "Engineering Aspects of Fracture Characterization and Analysis," to be published.

Laudon, Robert C.: Principle of Petroleum Geology, Prentice Hall (1996).

Mattax, C.C. and Dalton R.L.: Reservoir Simulation, SPE Monograph Volume 13 (1990).

Narr, Wayne, Schechter, D. W. and Thompson, L. B.: Naturally Fractured Reservoir Characterization, Society of Petroleum Engineers (2006).

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Pereira, C. A., Kazemi, H., and Ozkan, E.: "Combined Effect of Non-Darcy Flow and Formation Damage on Gas Well Performance of Dual-Porosity and Dual-Permeability Reservoirs," SPE 90623, ATCE, Sept. 28, 2004, Houston, TX.

Ramirez B., Kazemi H., Alkobaisi M., Ozkan E. and Atan S.: "A Critical Review for Proper Use of Water-Oil-Gas Transfer Functions in Dual-Porosity Naturally Fractured Reservoirs – Part I," SPE 109821, to be presented at ATCE 2007, Anaheim, CA.

Van Golf-Racht, T. D.: Fundamentals of Fractured Reservoir Engineering, Elsevier (1982).

Waite, M., Johansen, S. and Betancourt, D.: "Modeling of Scale-Dependent Permeability Using Single-Well Micro-Models: Application to Hamaca Field, Venezuela," SPE 86967, SPE Heavy Oil Symposium, March 16-18, 2004, Bakersfield, California, U.S.A.