Reservoir Management of Shale Oil and Gas

Instructor: Prof. Arash Dahi Taleghani
Level: Intermediate-Advanced
Duration: 5 days

Course Objectives and Description
The main objective of the course is to transfer the knowledge for management and development of shale oil and shale gas resources starting with geology and petrophysics of unconventional reservoirs. Because of the significance of natural fractures in economic production from these reservoirs, a special attention is given to natural fractures characterization. In the second day of the course, we discuss rock mechanics followed by a brief introduction about hydraulic fracturing operations as the main solution for economic production from these resources. The role of geomechanics in these reservoirs and mechanics governing hydraulic fracturing will be discussed in the afternoon. The third day of the course is designated to drilling and completion in Shale oil and gas reservoirs specially for horizontal wells and techniques to assess integrity of these wells before fracturing and refracturing treatments.

Fractured well productivity analysis and decline curve analysis in unconventional shale reservoirs for production forecast will be introduced, then we will review available techniques for reserve estimated in Shales. Field examples and case histories from unconventional shale systems around the world will be presented. Numerous exercises on various topics will be conducted in the class to enhance the transfer of course knowledge and learning of participants on horizontal well fracturing technologies and their economic significance. Quality control measurements will be introduced in the form of post-treatment assessments such as rate transient analysis and flowback analysis in the following day. Injection tests and Nolte-Smith analysis will be introduced for mapping fractures. These tests are critical to determine parameters such as in situ stresses, rock mechanical properties, leakoff for a proper field development and fracture design. The course will end with an overview of emerging technologies such as refracturing and EOR techniques for shale oil reservoirs.

Learning of the Course
- To introduce petrophysics and geology of shale formation and their economic significance.
- To review principles governing hydraulic fracturing propagation and their implication on treatment design.
- To learn the impact of natural fractures on development of shale oil and gas reservoirs and associated characterization techniques.
- To learn about injection tests and how to benefit from these tests for field development plans.
- To assess fracturing treatment using realtime data to determine fracture parameters and improve frac treatment design.
- To assess and discuss real frac jobs implemented in the field and prepare recommendations to improve future treatments in a specific field including its complete design.
- To conduct post-closure pressure decline curve analysis and flowback analysis to estimate induced fracture geometry, fluid efficiency and effective formation permeability for production engineering analysis.
- To identify well spacing and pad locations more accurately, to place wells and extract hydrocarbons at a lower cost and with a greater overall success rate by incorporating economic factors.

**Target Audience**
Drilling/completion engineers, exploration and development geologists, petrophysicists and geophysicists, production engineers and reservoirs engineers with some previous exposure to hydraulic fracturing operations.

Other personnel with prior oil and gas industry background who desire to improve their understanding of petroleum business can also benefit from this course.

**Course Content**

**DAY 1. GEOLOGY AND PETROPHYSICS**

Geology of Unconventional reservoirs
- Tight sand, shale gas, shale oil, gas hydrate etc.
- Current status of development of unconventional resources
- Significance of unconventional resources on future of energy markets

Petrophysical properties of Shale gas and shale oil
- TOC concept and Passe calculations
- Basic models for fluid flow in shales

Natural fractures and their role in unconventional reservoirs
- Fracture characterization, length and width distribution
- Interaction of Hydraulic fractures with naturals fractures
- Examples

**DAY 2: GEOMECHANICS AND HYDRAULIC FRACTURING**

Rock Mechanics and Elasticity principles
- Stress/strain definitions
- Concepts of fracture mechanics
- In situ stress and rock mechanical properties
- Calculation of stress
- Hoop stress in vertical, inclined and horizontal wells
- Rock mechanics experiments
- Exercise
Introduction to hydraulic fracturing treatment
- Concepts and field equipment
- Why fracturing works
- Types of fracturing from conductivity?
- Horizontal and multilateral completions
- Road map for a comprehensive fracture analysis
- Examples
- Exercises

Hydraulic Fracture Mechanics and Geometry
- Fracture initiation and propagation
- PKN, KGD and radial fractures models
- Perforation design
- Fracture height prediction
- Fluid Leak-off models
- Lab experiments and their reliability
- Examples
- Hands on exercises

DAY 3 DRILLING AND COMPLETION IN SHALES
Drilling and Completion in Horizontal Wells
- General considerations and standards
- Horizontal and deviated well fracturing
- Stress interference/shadowing between fractures
- Fluid flow in horizontal wells
- Perforation design for multi-clustered treatments
- Illustrative examples

Cementing and Well Integrity
- Significance of well integrity in unconventional reservoirs
- Cementing horizontal wells
- Technique to assure well integrity

Proppant and Fracture Fluid
- Proppants
  - Proppant types
  - Proppant properties
  - Factors affecting fracture conductivity
  - Proppant placement in multi-fractures
- Fracturing Fluid
  - Water-based, oil-based and hybrid fracture fluids
  - Additives/breakers/crosslinker/polymers
  - Surfactant, Biocides, Buffers and Clay stabilizers
- Exercise on Proppant

Pre-frac Injection Tests Analysis
• Stress injection tests
• Pressure fall-off (or DFIT) Test Analysis and Interpretation
• Microfrac test
• Step rate, step down test
• Example calculation of the closure pressure and fracture pressure

DAY 4 POST-FRAC ASSESSMENT AND PRODUCTION ANALYSIS
Quality Assurance and Quality Control
• Quality control system, QC documentation
• Wellbore integrity tests
• Health, safety, environment (EPA studies)

Monitoring
• Microseimics, Myths and reality
• Tiltmeter analysis
• Image logs
• Examples

Hydraulic Fracture Evaluation
• Diagnostics issues
  – Nolte-Smith analysis
  – Before closure transient analysis techniques
  – After closure analysis techniques
  – Pressure decline analysis of frac treatment
• Examples
• Hands on Exercises

Well Performance Assessment
• Fold of increase (FOI)
• Discussions on dimensionless fracture conductivity
• Recovery Factor Exercises for Unconventional Reservoirs
• Effective Frac length exercises for conventional reservoirs
• Example

Production rate Transient Analysis (RTA) Methods
• Type-curves
• Straight line methods
• Flow simulation
• Empirical methods

DAY 5 WELL DESIGN AND FIELD DEVELOPMENT PLANS; CASE STUDIES
Design issues for Field Development
• Integrated design
• Tip and near-wellbore screen-outs
• Fluid banking vs. fluid support approach
• Field example
• Practical considerations to enhance successful execution
• Exercise

Field Performance Analysis and Economic Aspects
• Cost-benefit analysis
• History-matching a shale gas well: Barnett Shale
• History-matching of a shale oil well; Bakken shale
• Landscape of shale developments and its economic impacts

Recent Trends on Shale Oil and Gas Development
• Foam fracturing
• Hydraulic fracturing using slick water and other fluids
• High-pressure high-temperature fracturing fluids
• Re-fracking and re-completion trends
• Flow back operations
• IOR/EOR Potential for Shale Gas/Oil Wells

Field Case Studies
• Case study 1: Horizontal well in tight sand formation (what went wrong?)
• Case study 2: Horizontal well in shale formations (typical job)
• Case study 3: Horizontal well in shale formations (Abundant natural fractures)
• Case study 4: Field development plan for a shale oil reservoir (well layout, trajectories and pad placement)

• Analysis of Participant’s Hydraulic Fracture cases and Reservoir Management in Shale Oil and Shale Gas Reservoirs