N484: Reservoir Management for Unconventional Oil and Gas Resources

Format and Duration
Classroom - 4 Days

Instructor(s): Yucel Akkutlu

Summary

This course is designed to familiarize practicing subsurface professionals with unconventional oil and gas resources as reservoirs, including topics related to the evaluation and development aspects of unconventional oil and gas fields. The emphasis is on tight gas/oil formations and organic-rich source rocks, in particular shale. It provides in-depth discussions on fluid storage, phase change, and transport for reservoir evaluation and development. Hydrocarbon in-place calculations are presented, including new pore-scale considerations, and a new method is introduced to assess the liquid potential of the reservoir. Laboratory techniques are discussed for the characterization of unconventional formations. The course will help engineers to understand transient flow regimes associated with horizontal wells completed with hydraulic fractures and to analyze the production data using various analytical and simulation techniques. Field case studies will be introduced to discuss tight gas reservoir- and shale oil/gas reservoir development, including economic and environmental evaluation of horizontal wells with multi-stage fracturing.

Business Impact: Application of the learnings of this course will empower participants to better explain the unconventional reservoir physics and improve their business performance by developing more accurate reservoir models.

Learning Outcomes

1. Assess, characterize and classify unconventional resources.
2. Recognize the impact of organic matter maturation and hydrocarbon generation on the resource assessment.
3. Assess oil and gas storage mechanisms for unconventional reservoirs.
4. Assess the transport mechanisms in unconventional reservoirs.
5. Design pressure transient (fall off) tests for wells in unconventional reservoirs.
6. Develop a shale gas/oil apparent permeability model for simulation using petrophysical data.
7. Perform rate transient analysis for unconventional wells and predict total fracture surface area contributing to production.
8. Evaluate the relative accuracies of unconventional reserve estimates.
9. Evaluate production rate decline characteristics of unconventional wells.
10. Formulate a field development plan for an unconventional resource.
11. Categorize similarities and differences between tight gas, shale gas, and CBM.
12. Propose an integrated use of geoscience, engineering, and advanced technology in exploitation on unconventional reserves.

Training Method

This is a classroom or virtual classroom consisting of lectures with worked examples, hands-on exercises, and discussion. Presentations by participants are encouraged.

N484: Reservoir Management for Unconventional Oil and Gas Resources

Format and Duration
Classroom - 4 Days

Instructor(s): Yucel Akkutlu

Who Should Attend

The course is designed for mid to senior level engineers and engineering managers that have some familiarity with unconventional reservoirs.

Course Content

Introduction

- Unconventional oil and gas resources:
  - Tight gas characteristics
  - Source rock (CBM, organic-rich shale) characteristics
- Unconventional resources in North America, their oil/gas production trends, and reserves
- What is shale and what makes shale a hydrocarbon resource?
- Resource-reservoir duality and the concept of reservoir creation

Fundamentals

- Source rock burial, diagenesis, catagenesis, and metagenesis
- Multi-scale pore structure development in source rocks
- Multi-scale oil and gas storage mechanisms in shale
- Occurrences of hydrocarbons in organic and inorganic pore networks in source rocks
- Phase change and capillarity in nanopores
- Volumetric calculations for shale: gas, wet-gas, condensate, and oil
- Material balance calculations for CBM and shale gas wells
- Flow and other mass transport mechanisms for shale gas and oil reservoirs
- Stress-dependent shale permeability
- Stress-dependent fracture permeability models
- Flow calculations using Wasaki's permeability model for organic-rich shale
- Multi-phase flow considerations in source rocks

Reservoir Evaluation and Characterization for Resource Shale

- Reservoir sample analysis
- Special core analysis
  - Pore-size distribution, capillary pressure, relative permeability, wettability
  - Geomechanical properties
  - Organic and inorganic material characterization
- Organic matter classification: bitumen vs. kerogen
- Kerogen type and maturity
- Hydrocarbons recovery potential from kerogen
- Integration of core-data and log-data
  - TOC estimation

    - Free and sorbed-phase fraction analysis
- Examples on shale core measurement data and analysis
- Exercise on predicting shale gas and shale oil permeability

Drilling and Completion Techniques for Shale Formations

- Fundamentals of directional and horizontal drilling
- Considerations on rotary steerable systems (RSS)
- Designing bit weight for the vertical section, build section, and the lateral section
- Major drilling challenges in shale
- Overbalanced, underbalanced, and managed pressure drilling
- Drilling-induced transverse fractures and formation damage mechanisms
- Completion techniques
    - Cased and cemented hole completion
    - Open hole completion
- Example comparison of the Eagle Ford wells completion data

Multi-stage Hydraulic Fracturing in Shale Wells

- Fundamentals of hydraulic fracturing operation
- Effective fracture length
- Re-fracking and re-completion considerations
- Tip screenout process
- Hydraulic fracturing using “plug and perf” and “sliding sleeve”
- Impact of fracturing fluid damage on production during flow-back
- Example simulation of the fracturing fluid invasion and flow-back
- Exercise on treatment of fracture skin

Monitoring

- Micro-seismic monitoring of hydraulic fractures
    - Downhole monitoring
    - Surface monitoring
- Tilt meter and its applications in monitoring near well fractures
- Image logs and their application in monitoring near well fractures
- Example fractures identification using tiltmeter
- Example fractures identification using wellbore image logs

Pre-frac Injection Test Analysis

- Pressure fall-off (or DFIT) Test Analysis and Interpretation
    - Typical pressure transient and its signatures
    - Breakdown pressure, instantaneous shut-in pressure, fracture closure pressure
    - Analysis of the pressure fall-off data for flow capacity, leak-off type, and presence of fractures

- Example calculation of the breakdown pressure
- Example calculation of the overburden stress using Eaton's equation

Geomechanics

- Fracture evolution in ductile and brittle formations
- Griffith's theory of brittle rock failure
- Laboratory measurements
- Stress-strain diagrams
- Popular geo-mechanical concepts for stimulation decisions
- Example decision making on vertical locations for perforations in cased-cemented hole
- Exercise on calculation of the four elastic moduli using uniaxial test data

Transient Flow Regimes and Production Analysis

- Reservoir flow regimes and flow patterns
- Pressure evolution during transient flow
- Production rate transient signatures in flow patterns
    - Vertical wells with hydraulic fracture
    - Horizontal wells with and without hydraulic fracture
    - Horizontal well with multiple hydraulic fractures
- Production rate transient analysis (RTA) methods
    - Type-curves
    - Straight line methods
    - Flow simulation
    - Empirical methods, e.g. Arps, Duong, stretched exponential decline
- Total fracture surface area calculations using RTA with dynamic matrix permeability
- Workflow for engineering analysis of horizontal wells with hydraulic fractures
- Example type-curve analysis

Recent Trends on Shale Oil and Gas Development

- How to deliver efficiency during surface operations, i.e., surface efficiency
- How to remove waste from operations
- How to reduce footprint
- Closed loop drilling and water conservation
- Low energy drilling
- Wellbore integrity challenges due to shale lamination and fissility
- 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

    - Miscible hydrocarbon gas injection
    - Carbon dioxide injection using huff and puff
    - Micro-emulsion injection during hydraulic fracturing or re-fracking
- Examples of CO2 injection and molecular interactions using Grand Canonical Monte Carlo simulation

Case Studies

- A tight gas field case study in Canada
- Single-well fracture interference study using Barnett data
- Single well fracture surface area calculations using rate transient analysis (RTA)
- History-matching Marcellus shale gas well
    - Impact of the number of transverse fractures on future recovery
- History-matching Eagle Ford shale gas well
- History-matching Bakken shale oil well
- A shale gas well completion optimization
    - Procedure of calculating hydraulic fracture economics: NPV, IRR, DROI
    - Number of fracture stages/clusters
    - Transverse fracture spacing
    - Fracture propped-length