N555: Transforming 60-years of CO2-EOR Experience into Shale Oil Recovery and CO2 Sequestration

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Format and Duration

Classroom - 3 Days
Virtual - 6 Sessions

Summary

This course provides clear, concise and practical information for understanding and implementing the CO2 enhanced oil recovery into unconventional reservoirs. The recovery discussions will be complemented with technical discussions on the depleted wells for CO2 sequestration and carbon credit. Pilot projects and case studies are used to demonstrate evaluation and predictive techniques using experimental, analytical and numerical methods. Operational aspects including transportation, injection, separation, reinjection and corrosion are discussed.

Business Impact: Application of the learnings of this course will empower participants to improve their unconventional oil and gas production performance by developing new CO2 injection-based EOR and carbon sequestration operations in the field.

Learning Outcomes

Participants will learn to:

1. Determine why unconventional wells production rate decline so fast.
2. Interpret what net-zero production means for the participant's company.
3. Calculate how carbon tax credit is earned as CO2 is injected to reach the net-zero targets.
4. Implement EOR screening.
5. Characterize the nature of miscible and immiscible processes.
6. Select laboratory tests and screening for pilot design.
7. Assess minimum miscibility and injection pressure of a CO2 injection operation.
8. Perform volumetric calculations for primary and enhanced recoveries estimation.
9. Estimate recovery efficiency of CO2 injection using volumetric methods and using simulations.
10. How to optimize a CO2 injection operation using simulations for EOR and sequestration.
11. Evaluate and address operational aspects of CO2 projects.

Training Method

This is a classroom or virtual classroom course comprising a mixture of lectures, discussion, case studies, and practical exercises.

Who Should Attend

The course is designed for mid- to senior-level engineers and engineering managers that have familiarity with unconventional reservoirs and looking for a detailed understanding of EOR processes applicable to the unconventional reservoirs.

Course Content

The U.S. National Petroleum Council recognized the potential for CO2-enhanced oil recovery and initiated the first laboratory investigations on CO2 flooding in 1950s. Since then, a significant body of knowledge has developed, which led to numerous field-applications globally. Currently, CO2 flooding

makes up the largest proportion of the total EOR projects in the US. The major reasons for the success in CO2-EOR are (1) high efficiency of CO2 in mobilizing crude oils with a wide range of API under the reservoir conditions, (ii) difficulty in injecting water (and water with chemicals) into deep oil reservoirs and (iii) low efficiency of thermal recovery methods with deep light oil reservoirs.

Currently the unconventional oil and gas industry is under economic and social pressure to (i) maintain low-cost production from shale gas/oil wells, (ii) reduce the environmental footprint during the field operations, and (iii) reach to net-zero targets. CO2-injection has the potential to play an important role in reaching these targets. Firstly, the unconventional reservoirs are the most suitable for mobilization of oil: high pressure reservoirs with high API gravity oil. However, the existing knowledge on CO2-EOR requires conscious transformation from flooding in well patterns of injectors and producers into the unconventional well settings: horizontal wells with long laterals drilled into ultra-tight formation and hydraulically-fractured densely. In this new environment the flooding operation occurs only through the fracture network and the recovery of oil from the tight matrix may need large soaking times.

Topics Covered:

- Introduction
  - Quick review of Enhanced Oil Recovery (EOR) Techniques: what is available out there?
  - Status of EOR projects in the US
  - What are the technical reasons for the increase in CO2 injection operations in the US.
  - Why shale gas wells could be alternative locations for giga-ton-level CO2 sequestration
- CO2 Process Facilities
  - Oil production and processing facilities
  - Corrosion management in oil production and processing operations
  - Gas gathering systems
  - CO2 surface facilitie
- CO2 Injection Considerations
  - Locating the source
  - Sub-critical and super-critical CO2
  - Horizontal well completion
  - Re-fracking and re-completion
  - Well testing
- CO2 Injection Methods
  - Single-well cyclic stimulation (huff-and-puff)
  - Injector-producer well patterns and flooding
  - Water-alternating-gas (WAG)
- Case Study
  - Each participant brings in one shale well info (depth, oil API gravity, saturations, TOC, porosity and permeability, well completion, etc.) into class and learn how to screen his/her well for selection of an EOR method (chemical, gas, thermal) and for the injection method.
  - Evaluation of shale well for CO2 sequestration
- Fundamentals of Miscible Oil Recovery

  - First-contact and multiple-contact (dynamic) miscibility
  - Ternary-diagrams; condensing and vaporizing gas drive processes
  - Molecular level discussions on CO2-oil interactions in shale reservoirs
- Laboratory Tests for Measuring CO2 Injection and Sequestration Efficiency
  - Hele-Shaw experiments
  - PVT analysis and CO2-hydrocarbon phase behavior predictions
  - Slim-tube experiments
  - Core soaking/flooding experiments using shale samples
- Review of the Existing Pilot Projects
  - Huff-and-puff gas injection projects in Bakken.
  - Huff-and-puff gas injection projects in the Eagle Ford.
  - PVT analysis and CO2-hydrocarbon phase behavior predictions
- Case Study – Volumetric Calculations
  - How to use primary production Rate Transient Analysis (RTA) data to calculate the Stimulated Reservoir Volume (SRV) of a shale well
  - How to perform volumetric calculations to estimate initial hydrocarbon in-place, primary hydrocarbon recovery, CO2-enhanced hydrocarbon recovery.
  - How to estimate CO2 sequestration capacity of a shale gas well based on its SRV
  - How to estimate CO2 sequestration capacity of a shale oil well based on its SRV
  - Carbon tax credit calculations
- Simulation Based CO2 Enhanced Oil Recovery and Sequestration
  - How to develop a reservoir flow simulation model for a shale well
    - Single-fracture well models
    - Fracture cluster well models
    - Simulation of well interference during production and injection
  - Case Study 1
    - Analysis of the primary-stage oil production data for EOR using History-matching and Optimization
    - Implementation of multi-stage CO2 huff-n-puff
  - Case Study 2
    - CO2 sequestration in shale gas wells and geomechanical considerations
- Workflow for CO2-EOR using shale wells
  - Workflow to be presented including the following factors:
    - Geological, geochemical and petrophysical data evaluation
    - Well and completion data evaluation
    - Primary production data evaluation
    - Pilot project considerations for EOR and CO2 sequestration
    - Field-scale expansion considerations EOR and CO2 sequestration