Co-optimization of CO2-EOR and Storage Processes under Geological Uncertainty

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Abstract

This paper presents an integrated numerical framework to co-optimize EOR and CO2 storage performance in the Farnsworth field (FWU), Ochiltree County, Texas. The framework includes a field-scale compositional reservoir flow model, an uncertainty quantification module, and a neural network optimization process. The reservoir flow model has been constructed based on the field geophysical, geological, and engineering data. A laboratory fluid analysis was tuned to an equation of state and subsequently used to predict the thermodynamic minimum miscible pressure (MMP). A history match of primary and secondary recovery processes was conducted to estimate the reservoir and multiphase flow parameters as the baseline case for analyzing the effect of recycled produced gas, infill drilling and water alternating gas (WAG) cycles on oil recovery and CO2 storage. The final objective was to ensure sufficient CO2 recovery, such performance to assist in future oil recovery projects.

Geological Model

The stratigraphic column shows a type log at FWU with formations included in the static model. The structural model is shown at the right.

Simulation & Optimization Models

The stratigraphic column shows a type log at FWU with formations included in the static model. The structural model is shown at the right.

Property Modeling

FWU Reservoir Fluid Analysis

A fluid sampled from the FWU was analyzed and calibrated to the equation of state to assist in compositional modeling. A slim tube simulation experiment was used to compute the MMP and compared to lab estimation.

Simulation & Optimization Models

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Development Strategy (Baseline & Optimized Case)

• Convert all injectors to WAG wells (25 wells) using both purchased and recycled CO2
• Purchase a constant 10,000 Mscf of anthropogenic CO2 per month until 2024
• Systematically decrease volume of purchased CO2 from 2024 to 2030

Additional constraints include:

• Compressor capacity = 30,000 Mscf/d
• Production well tubing pressure = 900 psi
• Injection well tubing pressure = 2500 psi
• Maximum Production target = 3000 bbl/d
• Injection target = CO2 purchased volume + recycled volume

Conclusion

• A real time reservoir performance has been developed by using fast proxy methodology which can reduce computational cost without compromising on accuracy
• The use of a complex multi-objective function resulted in optimum operational variables that yielded 94% of CO2 storage and more than 25% incremental of OOIP oil recovery beyond waterflood at FWU
• This work, and ongoing efforts, will serve as a blueprint for future CO2-EOR projects in the Anadarko basin or geologically similar basins around the world

Motivation for this Work

• Ampomah et al 2016 (SPE-179528) presented a scenario based model to study different injection strategies effects on oil recovery and CO2 storage
• Their work resulted in about 75% of CO2 storage which is used as the baseline case for this study
• This work seeks to use advanced optimization with uncertainty procedure with multi-objective function to improve prediction of CO2 storage and/or oil recovery

FWU Reservoir Production History

• First discovery well drilled by Unocal in October 1955
• Initial reservoir pressure at datum of 4900 ft was 2203 psig
• Original bubble point pressure was 2059 psig
• OOIP = 120 MMSTB
• Secondary recovery started 1964
• Tertiary recovery started 2010

Summary of uncertainty associated with CO2 storage at different confidence levels

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