Development and Optimization of Gas-Assisted Gravity Drainage (GAGD) Process for Improved Light Oil Recovery

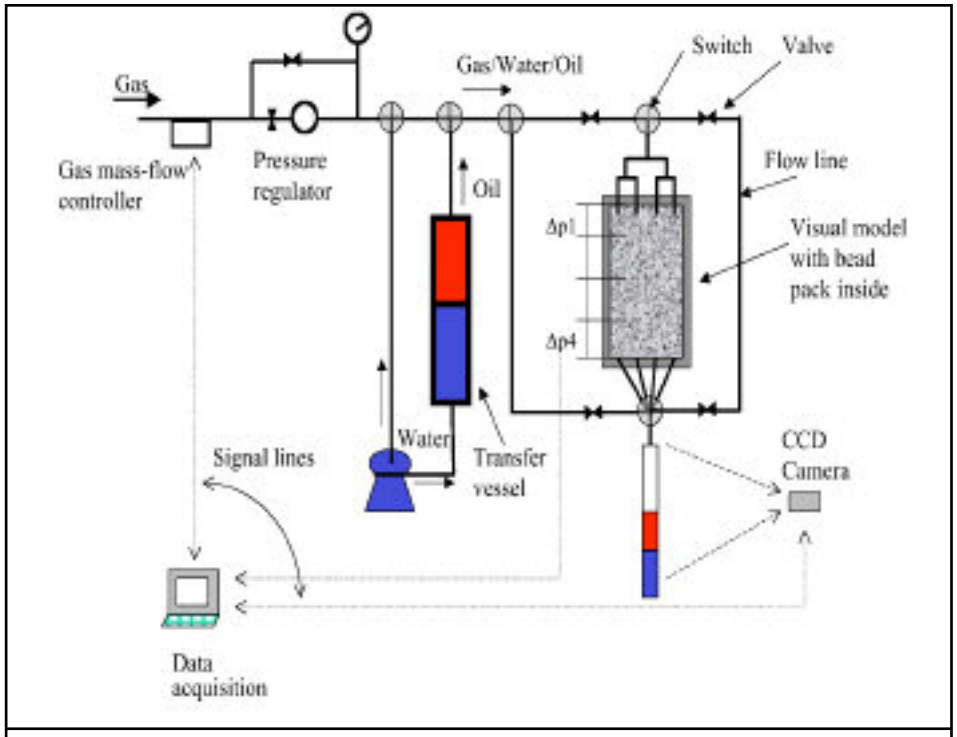
DE-FC26-02NT15323

Goal

The main objective of this project was to develop a new gas-injection enhanced oil recovery process, called Gas-Assisted Gravity Drainage (GAGD), to recover large amounts of oil trapped in reservoirs subsequent to primary recovery and secondary waterflood techniques. This new process consists of placing a horizontal producer near the bottom of the pay zone and injecting gas through the existing vertical wells used in prior waterfloods.

Performer

Louisiana State University (LSU)
Baton Rouge, LA



Schematic of GAGD physical model experimental apparatus.

Results

The important dimensionless groups operating in gravity-stable field projects were identified using the dimensional analysis approach. These dimensionless numbers were successfully utilized to capture and characterize the operational forces from field-gas injection projects for the laboratory physical model experiments.

The gas-oil interfacial tension measurements were conducted at elevated pressures and temperatures using the standard gas-oil systems of known miscibility conditions. The miscibilities determined from the vanishing interfacial tension (VIT) technique agreed well with the reported miscibilities for all the standard fluid systems used. This indicates the sound conceptual basis of the VIT technique for accurate, quick, and cost-effective determination of miscibility conditions for miscible gas injection improved oil recovery applications.

Laboratory corefloods of relevant reservoir rock and fluids showed the performance of the GAGD process to be superior to almost all presently practiced commercial modes of gas injection. This study has identified important multiphase mechanisms and fluid dynamics operational in the GAGD process. The GAGD process has been found to be largely immune to the deteriorating effects of reservoir heterogeneity, and the results indicate that the presence of vertical fractures possibly aids the GAGD performance.

Benefits

The oil recoveries from currently practiced water-alternating-gas (WAG) horizontal gas injection processes are low, about 5-10 percent of original-oil-in-place (OOIP). The newly developed GAGD process can improve the overall efficiency of gas injection projects and hence will be of immediate interest to the US oil industry. Gas-oil miscibility conditions can be determined using the VIT technique in an easy and cost-effective manner. There is also the possibility of developing new miscibility correlations and computational models and the potential benefit of sequestering large quantities of CO_2 in oil reservoirs.

Background

After the application of primary and secondary oil recovery technologies, more than 60 percent of the OOIP remains unrecovered in America's oilfields. This remaining oil amounts to a staggering 377 billion barrels in the known oilfields of the United States.

In spite of several ongoing U.S. WAG floods, their incremental oil recoveries have been disappointing. By comparison, oil recoveries were much better—15-40 percent of OOIP—in the gravity-stable vertical gas floods conducted in pinnacle reefs and dip-ping reservoirs. These field results indicate the benefits of working with nature by making use of the buoyancy rise of injected gas to displace oil downwards. This led to the conceptual basis of this project: injecting the gas in a gravity-stable mode at the top of the pay zone in order to drain the oil downwards to a horizontal producer.

Summary

The project consisted of three main tasks:

- Task 1 involved the design and development of a scaled physical model to identify the optimum parameters for GAGD process performance.

- Task 2 called for further development of the VIT technique to determine miscibility between the injected gas and crude oil for GAGD process optimization.

- Task 3 entailed corefloods using reservoir rocks and fluids to investigate the effects of various multiphase mechanisms and fluid dynamics operational in the GAGD process. Researchers accomplished the following:

- Construction and experimentation with physical models to visualize the drainage and displacement phenomena in the

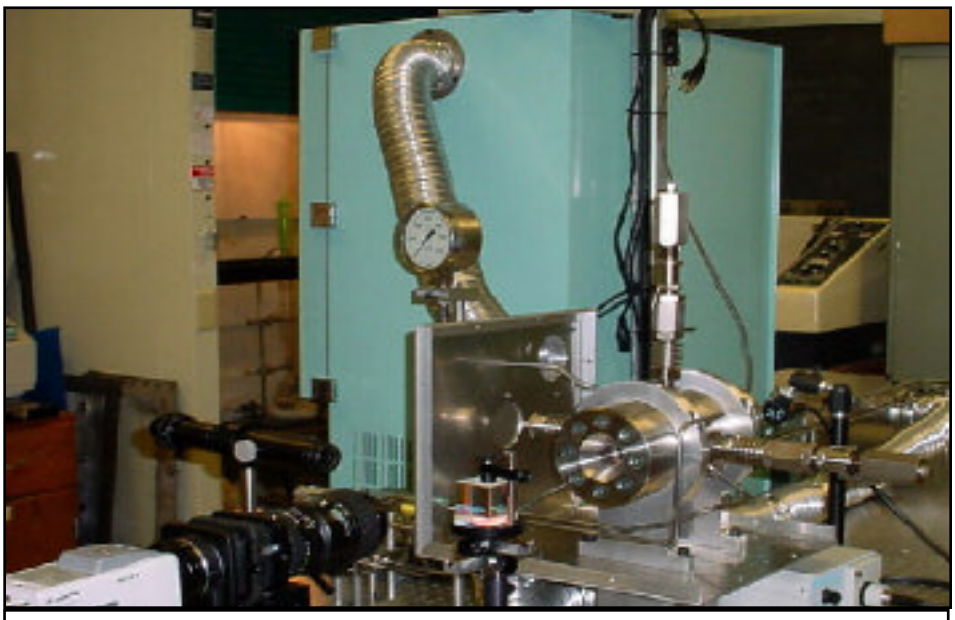
GAGD process.

• Design and assembly of a high-pressure, high temperature VIT experimental system for gas-oil interfacial tension measurements at reservoir conditions.

• Completion of VIT experiments with model fluid systems of known phase behavior conditions to determine gas-oil miscibility conditions.

• Completion of GAGD corefloods and comparative evaluation against horizontal WAG and CGI using the high-pressure, high-temperature 6-foot coreflood assembly.

• Correlation of laboratory results against field performance characteristics using a dimensionless gravity number (ratio of Bond to capillary number).



Apparatus used for gas-oil interfacial tension measurements at elevated pressures and temperatures.

Current Status (June 2006)

Discussions between LSU and an independent operator have resulted in a sponsored program (LSU Research Agreement No. 19499) for the field-testing of the GAGD process in a depleted U.S. oilfield. As a part of the contract, extensive geological, petrophysical and reservoir engineering analysis of several oilfields are being conducted at LSU to identify a suitable GAGD application candidate reservoir.

Funding

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