Design and Implementation of Energized Fracture Treatment in Tight Gas Sands

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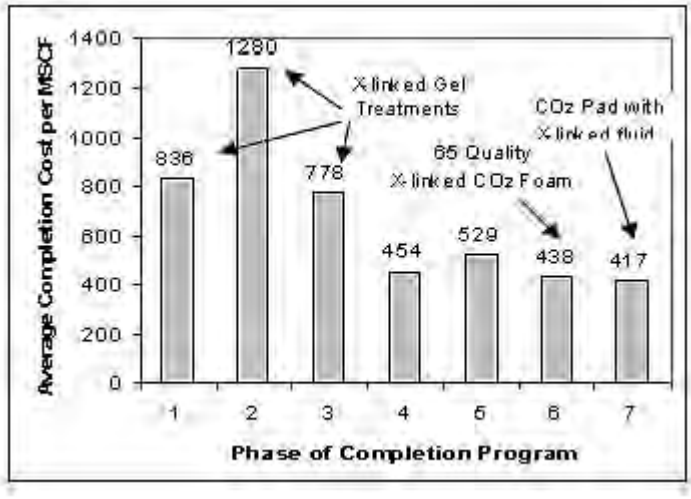
Goal

The goal of this project is to develop methods and tools that can enable operators to design, optimize, and implement energized fracture treatments in a systematic way. The simulator that will result from this work would significantly expand the use and cost-effectiveness of energized fracs and improve their design and implementation in tight gas sands.

Performer

University of Texas at Austin
Austin, TX



Energized treatments using carbon dioxide can be more cost-effective than conventional gel treatments.

Results

Two graduate (PhD) students have started work on this project. The students have completed a review of the literature to develop a better understanding of the problem. Some of the important papers reviewed carefully are listed in the publications section.

The mechanics and fluid flow issues associated with energized fluid fracturing are similar to traditional fracturing. This is why researchers are using UTFRAC-3D, an existing 3-D hydraulic fracturing model developed at the University of Texas, as a starting point. The code already incorporates fluid balances and fracture mechanics that will not need much modification when different fluids are used. Also, the rheological parameters on energized fluids can easily be implemented because of the general way rheology is modeled in UTFRAC. Making both the new students familiar with UTFRAC is a key early step.

The first step in building the new model is to incorporate thermal effects. An energy balance was formulated and implemented in the existing program. This allows researchers to compute the temperature profiles in the wellbore and in the fracture. These will be used later to perform phase behavior calculations. Temperature also affects fracture growth by changing the stresses in the rock.

The composition of the fluid will ultimately affect fluid properties, i.e., the ability of the fluid to propagate the fracture and carry proppant. A compositional model has been formulated but not implemented. The composition of the fluid will have to be coupled with the phase behavior of the fluid that can be modeled using an equation of state, EOS (in this case, a Peng-Robinson EOS). Researchers are currently formulating the ideal method to make sure the phase behavior of the fluid can be computed efficiently and accurately.

Benefits

By adding thermal and compositional capabilities to 3-D hydraulic fracture models, operators will be able to design and optimize energized fracture stimulation treatments in a systematic way. Such improvements will help operators better develop underpressurized reservoirs, many of which are water-sensitive and will require energized treatments to be produced effectively. The resulting improvement in development approach will result in fewer unnecessary wells being drilled and fewer completion or recompletion attempts being required to achieve a satisfactory level of natural gas production, reducing costs. In addition to the energy supply and economic benefits flowing from a more cost-effective way to boost domestic energy supply, the reduction in the number of wells and overall activity through improved efficiency also means less impact on the environment.

Background

A significant portion of U.S. natural gas production comes from unconventional gas resources such as tight gas sands. Tight gas sands account for 58 percent of the total proved natural gas reserves in the United States.

As many of these tight gas sand basins mature, an increasing number of wells are being drilled or completed into nearly depleted reservoirs. This includes infill wells, recompletions, and field-extension wells. When these activities are carried out, the reservoir pressures encountered are not as high as the initial reservoir pressures. In these situations, where pressure drawdowns can be less than 2,000 psi, significant reductions in well productivity are observed, often due to water blocking and insufficient clean-up of fracture-fluid residues. In addition, many tight gas sand reservoirs display water sensitivity—owing to high clay content—and readily imbibe water due both to very high capillary pressures and low initial water saturations.

This sensitivity to water-based fracturing fluids means that a large proportion of the re-fracs and infill well fracturing operations in many U.S. tight sand basins will most likely be conducted using energized fracture stimulation technology. This approach avoids many of the problems listed above by "energizing" the fracturing fluid through the addition of carbon dioxide or nitrogen. None of the 3-D hydraulic fracture models available today for simulating and designing hydraulic fracture treatments have the capability to adequately simulate energized fracture treatments. These

models are not capable of accounting for the changes in fluid composition and phase behavior during injection and flowback after the energized fracture treatments.

Summary

Starting two good graduate students on the project is an important step in getting the project goals accomplished. Both students have been taking the required courses (finite elements, geo-mechanics etc.) to get themselves up to speed with the mathematical and engineering tools needed to implement the project. They have made good progress in formulating the new models needed to simulate energized fractures.

The formulation and development of the model is on pace with the proposed tasks and activities. To date, researchers have developed:

- An understanding of the existing model, UTFRAC-3D.
- A model predicting the temperature of the fluid during fracturing that was implemented in the program.
- Formulations for the component balance and phase behavior.

In addition, a subcontract agreement has been sent to Anadarko Petroleum Corp., The Woodlands, TX, for signature.

Current Status (January 2007)

Currently, the focus is on adding compositional effects into the program. Using the compositional results—and temperatures already solved for—the phase behavior program can be added this summer.

Publications

Colwell, D.A.F., O'Brien, C.G.J., and Gates, T.D., "Evolution of Completion Practices in the Wild River Tight Gas Field," SPE 89719, presented at the SPE Annual Technical Conference and Exhibition, September 26-29, 2004, Houston, TX.

Gabris, S.J., and Taylor III, J.L., "The Utility of CO_2 as an Energizing Component for Fracturing Fluids," SPE 13794, SPE Production Engineering, September 1986, pp. 351-358.

Warnock Jr., W.E., Harris, P.C., King, D.S.,"Successful Field Application of CO_2-Foam Fracturing Fluids in the Arkansas-Louisiana-Texas Region," SPE 11932, Journal of Petroleum Technology, 1985, pp. 80-88.

Valko P., and Economides, M.J., "Volume Equalized Constitutive Equations for Foamed Polymer Solutions," Journal of Rheology, 36(6), August 1992, pp.1033-1055.

Tulissi, M.G., May, R.E., "A Comparison of Results of Three Different CO_2 Energized Frac Fluids: A Case History," SPE 75681, presented at the SPE Gas Technology Symposium, April 30–May 2, 2002, Calgary, AB, Canada.

Mazza, R.L., "Liquid-Free CO_2/Sand Stimulations: An Overlooked Technology—Production Update," SPE 72383, presented at the SPE Eastern Regional Meeting held in Canton, OH, October 17-19, 2001.

Antoci, J.C., Briggiler, N.J., and Chadwick, J.A., "Crosslinked Methanol: Analysis of a Successful Experience in Fracturing Gas Wells," SPE 69585, presented at the SPE Latin America and Caribbean Petroleum Engineering Conference, March 25-28, 2001, Buenos Aires, Argentina.

Harris, P.C.,"Dynamic Fluid-Loss Characteristics of CO_2-Foam Fracturing Fluids," SPE Production Engineering, May 1987, pp. 89-94.

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Anticipated DOE Contribution: $694,366
Performer Contribution: $785,414 (53 percent of total)

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