Design and Implementation of Energized Fracture Treatment in Tight Gas Sands

DE-FC26-06NT42955

Progress Report for Period 4/1/07-6/31/07

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.

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, re-completions, 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 due to high clay content and readily imbibe water due to both 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.

Performer

University of Texas-Austin

Locations

Austin, TX
Carthage and Ozona fields, Texas

Potential Impact

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 under-pressurized 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 re-completion 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 number of wells and overall activity through improved efficiency also means less impact on the environment.

Results

A compositional balance was formulated and implemented so that composition of the frac fluid in the fracture can be determined. The composition of energized fluids can change by 3 mechanisms: leak-off, phase behavior, and multi-phase flow effects. Leak-off changes occur when one phase, rich in one component, is lost to the formation at a higher rate compared to the others. Phase behavior changes in the fracture because of pressure and temperature changes. Lastly, multi-phase flow may occur when two or more phases travel together in the fracture. All 3 mechanisms, in their own way, will cause compositional separation.

Fluid composition will change the fluid rheology, therefore, effecting fracture propagation and proppant placement. Each of the mechanisms mentioned above are taken into account in the balance. In most cases, the leak-off will cause the most dramatic change in fluid composition. An example of this is shown in the figure below where the leak-off of the water phase is larger than the leak-off in the gas phase.

Summary

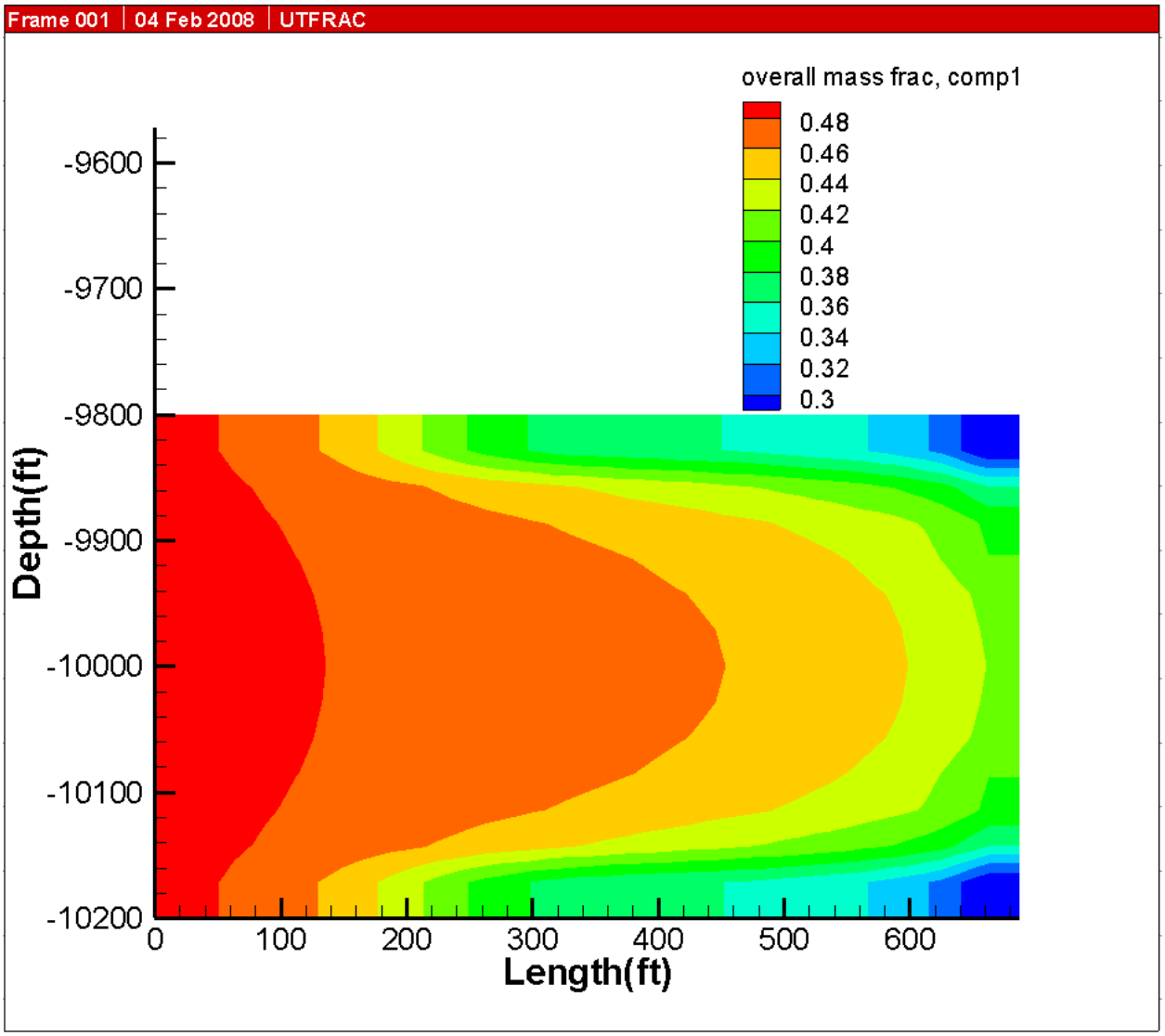
A compositional model for energized fluids has been completed. This compositional balance has been coded together with the fracturing code previously created. Runs were made to show compositional changes during fracturing for simple cases.

Accomplishments

- Understanding of how composition of the fluid may change during fracturing
- Formulation and implementation of compositional balance into fracturing code
- Compositional balance verified for simple cases.

Current Status (July, 2007)

Currently we are focused on completing the compositional balance in the fracture code. We plan to couple the effects of phase behavior in this code this fall.



Shows overall mass fraction of water changing down the fracture when the leak-off of the water phase is higher than the leak-off of the gas phase.

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Project End: September 30, 2009

DOE Contribution: $694,366
Performer Contribution: $785,414

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