A Novel Approach to History Matching and Optimization of Shale Completions and EUR - a Case study of Eagle Ford Well

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Summary

A simulation study was carried out to simulate a multi-stage hydraulic fracturing conducted in Eagle Ford. Both the historical injection and production periods were history matched. A prediction run was conducted to estimate the ultimate recovery. A few sensitivities and optimizations runs were also carried out to evaluate cluster efficiency, cluster spacing and stage spacing. Based on the history match process, the following can be concluded:

1. The entire pumping fracture length does not contribute to production. Whereas a fracture length of ~250ft was generated during injection, only 60ft contributed during production.
2. The SRV half-length developed during injection was ~250ft but only 190ft contributed in the production implying that the well drains to a distance of only 190ft away from the well.
3. Pressure dependent permeability functions adequately capture the overall permeability variation in the reservoir for the injection and production.
4. Analytical models for production analysis provided valuable insights into the hydraulic fracture properties. They give a good first hand estimate of fracture half-length and SRV residual permeability.
5. Injection and production scenarios must be modeled in tandem to get better insights into the flow physics rather than simulating them separately.

Introduction

The objective was to use a novel integrated reservoir/geomechanics modeling technique to build a highly realistic and comprehensive model of a typical Eagle Ford well in the Dimmit County, Texas. The modeled well had a large suite of data, including microseismic and fiber data. The model was history matched (HM) against all available data from pre-frac to long term production, used to learn about, and optimize, the completion/production process, and ultimately provided guidelines for improving EUR by changes to current practices.

Theory and/or Method

The study used the reservoir and geomechanical modeling techniques previously developed by us for tight gas and extended them for shale reservoirs. Both the completion (injection) and historical production periods are matched using the same integrated model. The key new ingredients are the gridding techniques allowing to represent accurately all fractures, and the method of computing the development of the SRV and its permeability enhancement during pumping as well as the loss of it after closure and during production. This approach is capable of modeling a number of aspects of the treatment and production, which are extremely difficult to capture by other methods.

Examples

The work shows how the integrated reservoir/fracturing/geomechanics modeling can be used to optimize completions and EUR for shale wells. The method is capable of modeling hundreds of fractures and SRVs and of modeling the entire history of the well. The results show the importance of this integrated approach and give insight into many issues, such as perforation efficiency (linked to seismic reservoir characterization and fiber measurements), cluster and stage spacing and well spacing.

Conclusions

The HM process showed that injection and production scenarios must be modeled in tandem to get better insights into the flow physics rather than being simulated separately, and the real sequence of fracturing must be modeled. Pressure (as opposed to stress) dependent permeability functions adequately capture the permeability variation both for injection and production. Only a fraction of the created fracture and SRV lengths contribute to production. Whereas fracture half-lengths of ~250 ft were generated during injection, only about ¼ of fracture and ¾ of SRV contributed to production. Effect of completion efficiency was also investigated. It was shown that the assumption of only 2 perf clusters per stage is not plausible while assuming some other scenarios offers good HM and prediction very similar to uniform efficiency. Optimization work considered several scenarios. Cases with larger cluster or stage spacing with the same pumped volume are not desirable. However, the use of double cluster spacing gives slightly higher production, and could offer significant completion cost savings. Use of current injection volumes and current well spacing (500 ft) leaves significant reservoir volume undrained, which is a target for well spacing optimization.

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