July Newsletter

Request for Proposals Update

The faculty members of the Crisman Steering Committee received 18 proposals from faculty for evaluation by member company representatives of the Crisman Steering Committee. The proposals were sent to company representatives on 18 July. They will evaluate them and return their recommendations by 17 August. The faculty members will then collate the responses and compute an overall ranking for the proposals per those evaluations. Highly ranked proposals will be funded to begin new Crisman projects for the Fall of 2012. New project awards will be made on 24 August, with projects to begin on 1 September.

We realize this is yet another request for time out of the member company representatives’ already busy schedules, so we have attempted to structure the evaluation process to minimize the time required. And we encourage the representatives to share the effort with colleagues as they are able. Feel free to go to your organization’s representative member and offer to help. We greatly appreciate all efforts on this and look forward to having a high percentage of company member participation in evaluating this round of proposals.

Please let us know if you need contact information for your company’s Crisman Steering Committee member.

Best regards,

Bob Lane, Deputy Director

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Objective
The objective of this work is to determine transport properties, such as permeability and fracture characteristics, in very low permeability rocks, such as tight gas sandstone and shale. Further, we will characterize stress-induced changes in permeability in low permeability rocks.

Approach
The project has been performed with two primary goals:

- to simulate the hydraulic fracturing process; and
- to determine the effect of fracturing in permeability improvement.

To achieve the goals, the injection fracturing system was set and the acoustic emission (AE) testing system was used to inspect the rock inner structure change during the rock fracturing process.

Accomplishments
It was found that the main frequency spectrum of AE is between 100 kHz and 1 MHz. Thus, the crystals were designed to detect the acoustic wave of frequency 1 MHz and lower. Signals with the frequency range less than 100 kHz were filtered by preamplifier.

The 1x2-in. Berea sandstone specimen was set up to perform the compression fracturing test under 1000 psi confining pressure. During the failure process, the AE signal was obtained to calculate the hypocenters of each event. Fig. 1 shows the AE activity during the compression. The specimen was loaded up until the volumetric strain started to decrease. The events are nucleated and aligned along the plane where the signals have high amplitude.

Future Work

Noise filtering—since the AE system is very sensitive to electric noise, it is not possible to obtain meaningful low-amplitude signals. The filtering and grounding process will be done to minimize the noise.

Injection fracturing test on low permeability rock—the hydraulic fracturing test on low permeability rocks will be performed with the AE measurement.

Permeability measurement on different failure type—failure type of rocks which strongly depend on the pressure condition are important factors for permeability enhancement. The injection fracturing test will be performed under various pressure conditions and the permeability will be measured before and after the fracturing process.
Reducing the Risk of Cement Failure in HPHT Rock Mechanics Aspects through Analytical and Finite Element Method Approaches

Introduction

There have been many experimental investigations on the mechanism of fatigue failure of structures like buildings and bridges but the fatigue behavior of well cement is still relatively unknown to engineers.

Cement sheath is very important to maintaining wellbore integrity in high pressure, high temperature (HPHT) wells and steam injection wells. Due to the HPHT cycles experienced in the process of hydraulic fracturing, production, and steam injection, the failure probability of low cycle cement fatigue is high in these wells and is likely to cause failure of the zonal isolation and increase the casing failure probability.

Objectives

This research gives a better understanding of cement fatigue and failure. Based on the experimental data, we will develop equations specific to well cement from experimental data; develop new failure mechanisms, crack initiation, propagation and failure theories; and then predict the fatigue life of cement related to HPHT gas wells.

Approach

An experiment was set up to simulate conditions under which cement low cycle fatigue failure could occur. In the test, the casing was applied with zero-based cyclic pressure to study the cement failure characteristics. The cement mechanical properties were measured at 14 days curing time under three different conditions: (1) room conditions; (2) 167°F, 14.7 psi; and (3) 212°F, 2610 psi. The results were used as the input data for finite element method analysis.

Accomplishments

The cement elastic strain and plastic strain developed in the experimental test were calculated by finite element method, thereby the cement cycles to failure can be predicted based on the strain-cycle relationship. As the confining pressure increased, the cement showed more plasticity and could hold more pressure cycles. At temperatures below 300°F, the temperature had minor effect on the cement low cycle fatigue. The cement with higher Poisson’s ratio and lower Young’s Modulus showed better low cycle fatigue behavior.

The results of strain-cycle relationship were applied in HPHT gas wells in South Texas to predict the cement fatigue failure under different operations. This research proposes the low cycle fatigue failure envelope that can help reduce the cement failure and improve the cement design in HPHT wells and steam injection wells.

Future Work

More investigations need to be carried out to verify the cement fatigue behavior at confining pressures above 10,000 psi and temperatures above 300°F. Beyond 300°F, the temperature may have an effect on cement low cycle fatigue. Below 300°F, the temperatures may have an effect on the high cycle cement fatigue. However, more lab tests need to be done to study this behavior.

References


Introduction

Characterization and modeling of subsurface flow and transport properties is critical for modeling production prediction in hydrocarbon reservoirs. History matching is typically applied to infer reservoir flow properties from available static and dynamic measurements. Data sparsity and nonlinearity of production data with respect to reservoir model parameters often result in significant uncertainty and non-unique history matching solutions. Stochastic methods have become increasingly popular for robust history matching and uncertainty quantification. In particular, the ensemble Kalman filter (EnKF) has been widely applied for stochastic characterization reservoir properties from dynamic field measurements. For large-scale reservoir models, the computational cost of the forward simulation severely constrains the number of model realizations that can be included in ensemble predictions. Consequently, the statistics computed from a limited-size ensemble become spurious, making the resulting EnKF model updates unreliable.

Localization and local analysis methods have been introduced to mitigate the effect of spurious correlations by reducing or removing the unphysical numerical correlations between model parameters and observations at distant locations. While these methods have proven useful, they require prior tuning of localization parameters and do not address the impact of small ensemble size approximations on the existing physical correlations between parameters and close-by observations.

Objectives

In this project, we are developing an alternate approach to localization by approximating the correct statistics from computationally efficient surrogate models.

Approach

We propose an efficient streamline-based pseudo forecast method for approximating the first and second order statistics needed for EnKF-based model calibration. We accomplish this by first performing fast streamline simulation for a large ensemble of models, which we cluster into a small number of groups based on their flow responses. We then perform full simulations

Fig. 1—(a) The true permeability field in parts of the SPE10 benchmark model shown with the well configuration; the 3rd layer of the model along with a summary of the estimation results for different calibration methods are shown in (b) a sample realization, (c) the ensemble mean, and (d) the ensemble variance maps.

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with the representative models in each cluster (i.e., cluster centroids) and use them to develop correlations between the forecasts obtained from streamline and full simulations. We use these correlations to adjust streamline-based forecasts for all realizations, which are in turn used to compute the second order sample statistics needed for the EnKF updates.

To motivate our proposed pseudo forecast approach, we use the first 5 layers of the SPE-10 benchmark in a black oil simulation with secondary production using water and gas injection, and apply our method to update the permeability field from the simulated production measurements obtained from the synthetic true model. We first apply EnKF with 200 realizations and full finite difference simulation in the forecast step to obtain our performance benchmark for comparison with our approximate method. We then apply the EnKF with 20 realizations to emphasize the effect of small ensemble size on the EnKF performance. In addition, we obtain the EnKF forecasts from the streamline simulation alone to show the effect of streamline simulation errors on EnKF performance. Finally, to evaluate the performance of our proposed method, we combine the streamline simulation with a small number of full simulations to examine the performance of our fast forecast proposed method. The results for the investigated cases are depicted in Fig. 1 and 2.

As illustrated, the EnKF with small ensemble size tends to collapse (very small variance map). Also, the use of streamlines alone in the forecast step of EnKF results in over- and under-estimation of the permeability field. On the other hand, the proposed pseudo forecast method results in similar performance as that obtained from forecast obtained from the full-blown simulations with 200 realizations. This is particularly important to emphasize, as the contribution of this part of our research is the reduced computational complexity of the developed approach without compromising the accuracy of the history matching solution (relative to results from full simulation).

**Fig. 2**—Plots of (a) BHP, and (b) oil rate observation forecasts with final replicates obtained from different data calibration methods.