Analysis of Best Hydraulic Fracturing Practices in the Golden Trend Fields of Oklahoma

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ABSTRACT
In the past decades, several hundred stimulation procedures have been performed in the Golden Trend fields of Oklahoma. The outcome of these stimulation jobs has not been the same for all wells. The effectiveness of the stimulation is a function of several factors including reservoir quality, completion and stimulation techniques. Completion and stimulation techniques can be further itemized as completion type such as open hole versus cased hole, type and amount of fluids and proppant and the rate at which they are pumped into the formation.

This project was supported by DOE and GTI in connection with the DOE’s Preferred Upstream Management Practices (PUMP) project. The project was implemented in three fields in the Golden Trend in Oklahoma. Detailed production and completion data analyses revealed that the most influential controllable parameter effecting the production rate and ultimate recovery was fracture stimulation, and as such, the bulk of efforts were focused on determination of optimized hydraulic fracturing procedure. Detailed stimulation data from more than 230 wells in the Golden Trend fields of Oklahoma operated by three independent operators were collected and analyzed using a new best practices analysis methodology.

The study was performed for gas and oil bearing formations. Among the findings of this comprehensive study were the best stimulation practices in carbonate formations that are primarily gas producing, and clastic formations, from which both oil and gas are produced. During his study authors were able to identify the best type of fluid, the most optimal injection rate and proppant concentration for both types of formations.

In this paper application of a new methodology that was used to perform the best practices analysis on the Golden Trend fields of Oklahoma is presented.

METHODOLOGY
Intelligent Best Practices Analysis (IBPA) is a two-step process. It consists of a descriptive and a predictive analysis. During the descriptive analysis the productivity of the wells in the database is divided into several fuzzy sets and fuzzy-averages of this controllable parameter effecting the production rate and ultimate recovery determination of optimized hydraulic fracturing procedure. During the full field analysis we identify the best practices based on all the wells in the database. We then divide wells into groups, based on different criteria, and look at each group more closely and either, verify, refine or dispute the best practices that were identified during full field analysis. The last step of the predictive analysis is working with individual wells and using the results of past two steps as a guide to enhance the production of an individual well. We showed that although the best practices that were identified during the full field and groups of wells analysis work for most of the wells (since that is how they were identified), there will be wells in the database (or new wells) that would not necessarily follow the identified trends as expected. This makes refining of the design by individual analysis a highly recommended exercise.

CONCLUSIONS
Wells in the Golden Trend are completed in several formations. The formations that are present in almost all of the wells can be divided into two major categories, clastic (oil & gas production) and carbonate (only gas production). Clastic and carbonate formations in the Golden Trend respond positively to different types of hydraulic fractures. Therefore, it is highly recommended that the clastic and carbonate formations be isolated prior to stimulation jobs in order to achieve the best results.

It was identified that the recommended main fracturing fluid for the clastic formations in the Golden Trend is “Diesel Oil”. This seems to be due to the presence of certain amount of clay that is contributing to damage of the reservoir near the well bore by developing hydration spheres, a process that seem to be reversible as long as the water saturation in the reservoir is not at irreducible saturation. On the other hand it was identified that “acid fracs” and not “acid jobs” are the stimulations that should be performed in these formations.

In the case where each record in the database represents a well in a field (as the case in this application) the classification of the wells can be based on any predetermined classifier such as well quality, operating company, well locations, geology, reservoirs involved, or any other classification that makes sense. In cases that such native (natural) classifier is not present in the database, k-mean clustering or fuzzy c-mean clustering can be used in order to cluster the records in the database. For this study wells were once grouped base on their quality, and once based on the operator. Three operators had participated in this study.

The predictive analysis is based on a neural network model that is developed from the data available in the database. Figures on left and the next column highlights the identification of best practices in the Golden Trend.

Upon completion of the full field analysis the wells in the database are classified and the process is repeated for each class (category or cluster) of the wells. The classification can be based on several criteria. If there is a class indicator in the database (natural or native classifier) it can be used as the basis for the classification.

It is recommended to use average injection rates of less than or equal to 0.2 BMP per foot of pay thickness while stimulating the formations in the Golden Trend.

The analysis (in all cases) is performed for single parameters and for multiple parameters in a combinatorial fashion as shown in these figures.

The recommendation matrix at the top of this column is then generated. All the recommendations that are the results of the analysis is presented in the recommendation matrix.

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