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Optimization of Completion Design and Well Spacing with Complex Fracture Modeling and Machine Learning Techniques

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ABSTRACT AND OBJECTIVES

Completion efficiency is determined by stimulated reservoir volume (SRV), fracture sizes, and geometry. These factors are mainly controlled by the completion design such as cluster spacing, clusters per stage, and stage length, pumping rates etc. Studies so far on completion efficiency and well spacing in unconventional reservoirs have been majorly based on simple models such as a single cluster model or models with the same fracture length and geometry at every stage, related to rate transient analysis. However, complex fracture modeling can predict production more realistically because both pumping and production data are used for history matching analysis, considering heterogeneous geomechanical properties (Ajisafe et al. 2017). This work seeks to present a method utilizing data-driven machine learning techniques to optimize design components to maximize productivity of a single well while also presenting surrogate models with the ability forecast the cumulative production of a single well with real world data-set.

VALUE

- **With a history-matched reservoir model, the right completion strategy for a single well can be predicted in a shorter period.**
- **With an optimized completion strategy for the parent well, the right spacing for child well can be determined.**
- **Most important inputs out of all possible completion design components are identified. It is used to develop a proxy model to estimate the productivity and fracture growth with a small number of cases.**

METHOD

Two wells are selected from a field in the Southern Midland Basin. Only a segment of the geo-model is used. There are three steps:

- **Two, history matching processes are performed for hydraulic fracturing and production. Specifically, hydraulic fracturing simulation is performed, matching real pumping data. After the history-matched hydraulic fractures are created, reservoir simulation is performed, matching real production data (Fig. 1).**
- **Various scenarios of the development plan for a single well are generated by changing parameters of completion design (using Random for use in the ML algorithm. Total of 90 cases were found sufficient. (Fig. 2)**
- **LSTM based learning algorithm is trained to predict Geometry and Cumulative production. The algorithm is chosen for its general utility in dealing with time series data as well as stationary data for regression tasks (shown in Fig. 3). Training Parameters:**
  - ✓ **Dataset size: 90 (75-15-10 split between training, validation and test sets).**
  - ✓ **Epochs : 500**
  - ✓ **Learning Rate : 0.01**
  - ✓ **Batch Size: 10**

Fig. 4 summarizes the entire process used in this study.

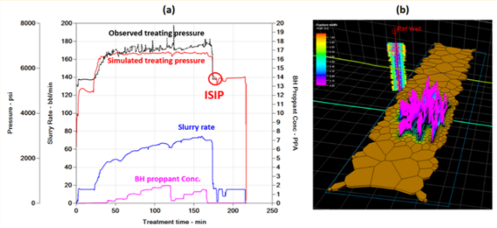


Figure 1. (a) History-matched results between pumping data and hydraulic fracturing simulation. (b) Hydraulic fracture geometry and history-matched pressure profile after 6 months production.

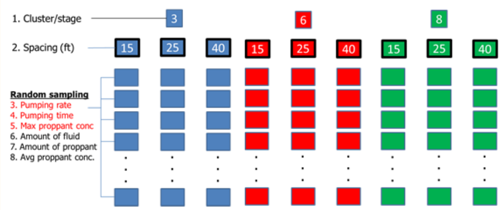
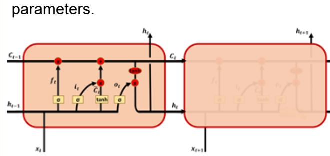


Figure 2. Random-sampling based combinations for completion parameters.



$$
\begin{aligned}
&\text{Input gate:} && i_t = \sigma(W^{(i)}\tilde{x}_t + W^{(hi)}h_{t-1})\\
&\text{Forget gate:} && f_t = \sigma(W^{(if)}\tilde{x}_t + W^{(hf)}h_{t-1})\\
&\text{Output gate:} && o_t = \sigma(W^{(io)}\tilde{x}_t + W^{(ho)}h_{t-1})\\
&\text{Process input:} && \tilde{C}_t = \tanh(W^{(iC)}\tilde{x}_t + W^{(hC)}h_{t-1})\\
&\text{Cell update:} && C_t = f_t * C_{t-1} + i_t * \tilde{C}_t\\
&\text{Output:} && y_t = h_t = o_t * \tanh(C_t)
\end{aligned}
$$

Figure 3. LSTM Model

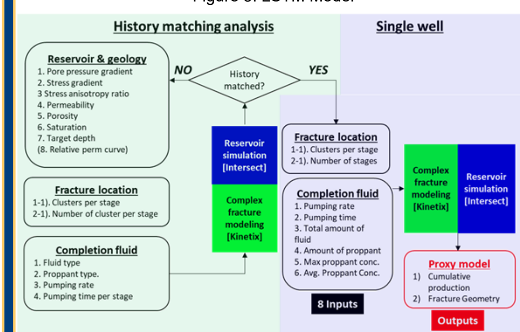


Figure 4. Workflow Diagram

RESULTS

- **Fracture Geometry: Results are shown in Fig. 5. Average Model error:**
  - ✓ **Fracture Length : ~4.0%**
  - ✓ **Fracture Surface : ~5.0%**
  - ✓ **Fracture Height : ~3.0%**

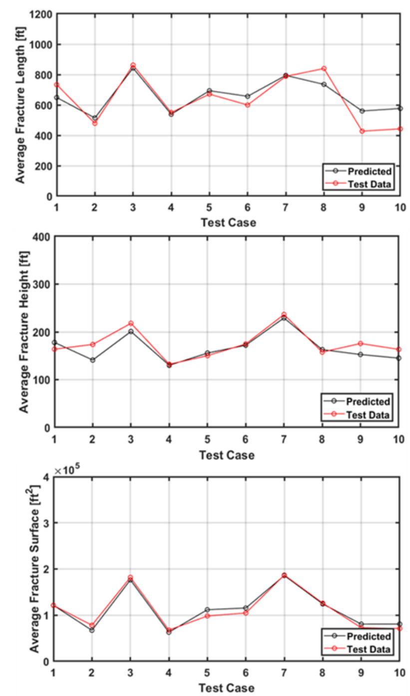


Figure 5. Results Comparison (a) Fracture Length. (b) Fracture Height. (c) Fracture Surface Area

- **Cumulative Production:**
  Results are shown in Fig. 6. Model error: ~4.0%

SUMMARY AND CONCLUSIONS

The proposed workflow can be used for optimization of completion design by integrating hydraulic fracture modeling, reservoir simulation and machine learning, which can test many completion designs numerically before real field development.

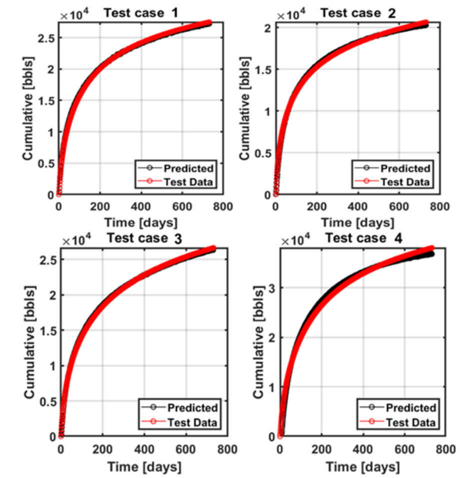


Figure 6. Results Comparison Cumulative Production

Thus, it can expedite the decision-making process of the field development plan without repeating computationally-expensive procedures. Eventually, we can increase efficiency and reduce costs. The Site-Specific Single Well Proxy Model is able to predict Fracture Parameters (Length, Height and Surface Area) as well as Productivity with accuracy while taking major completion parameters into consideration

REFERENCES

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