Data Driven Models Using Machine Learning Methods to Predict Well Productivity in Montney Formations

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Summary

With the commercial development of the unconventional tight and shale reservoirs, data on geology, well completion and production are also accumulating rapidly. In this work, data-driven models are built for Montney formation to predict the first-year cumulative production and optimize the fracturing parameters, such as the proppant tonnage and the fracturing fluid volume. Data of a total of 4790 horizontal wells in the Montney formation were firstly collected. General data visualization and statistical data analysis are conducted to qualitatively and quantitatively interpret the relationships between the stimulation design strategy and the 12 months well production. Then, 6 features are identified as the most important variables for fractured well performance by using the recursive feature elimination with cross validation (RFECV) method. Based on these features, four supervised learning approaches including random forest (RF), adaptive boosting (AdaBoost), support vector machine (SVM), and neural network (NN) are evaluated to predict the first-year oil production in the Montney Formation. Results show that 88.6% of observations fall into the 90% prediction intervals, indicating that the developed production forecasting model is reasonable and robust for further fracture stimulation design. Furthermore, the newly developed prediction models are successfully used to identify the optimal range for the mass of proppant and volume of fracturing fluid. The AI-based fracture design system is of practical useful for reservoir engineers to design the hydraulic fracturing process when drilling a new horizontal well in Montney Formation. Furthermore, such AI-based system can also be used to design fracturing parameters for other formations by feeding corresponding data sets into the system and re-training the models.

Unconventional tight or shale reservoirs are becoming important hydrocarbon resources with the successful application of advanced horizontal well drilling and multi-stage hydraulic fracturing techniques. Optimizing completion and stimulation strategies is critical to maximize the well productivity and/or oil and gas recovery of unconventional formations, while minimizing the water usage and operation footprints. With the rapid development of unconventional reservoirs, the amount of data related to petroleum exploitation and production is increasing rapidly and continuously. It is of practical interest for reservoir engineers to develop a reliable and fast well performance analysis and prediction model based on the knowledge extracted from the available data.

Theory / Method / Workflow

A comprehensive data mining process is performed on the Montney field data. The dataset not only contains well information such as well locations, true vertical depth, well lateral length, and wellbore direction, but also provides detailed stimulation information including number of fracture stages, total volumes of fluid and proppant, and fracturing fluid type. General data visualization and statistical data analysis are firstly carried out to qualitatively interpret the relationship between the stimulation design and first-year well production. Then, recursive feature elimination method is used to evaluate the importance of features in constructing the prediction models. After removing redundant and uncorrelated features, four commonly used supervised learning approaches including random forest, adaptive boosting, support vector machine, and neural network are evaluated to predict the first-year well production in Montney tight reservoirs. Finally, the newly developed prediction model is used to optimize the fracture stimulation strategies (e.g., the mass of proppant and volume of fracturing fluid) for field cases.

Results, Observations, Conclusions

The data used in this work comes from horizontal wells drilled in Montney Formation. Montney Formation is the primary oil and gas producing layers in western Canadian sedimentary basin (WCSB) located in southwest Alberta. It is estimated that more than 4000 multi-stage fractured horizontal wells were drilled or licensed in Montney Formation since 2005. A total of 4790 horizontal wells were obtained from the well completion and fracture database. Two kinds of features were used in this work: the geological properties of formation and well completion/stimulation parameters.

Novel/Additive Information

This work has shown how to comprehensively analyze the fracture stimulation design in unconventional reservoirs by using general data visualization, statistical data evaluation, and advanced machine learning algorithms. The data analytics results found that horizontal wells with NW/SE wellbore direction and transverse fractures are more preferred in Montney Formation. The average cumulative production of wells with multiple perforation clusters is 28.6% higher than that without clusters. Using the RFECV method, 6 features are identified as the most important variables: well latitude, longitude, well TVD, proppant pumped per well, well lateral length, and fluid injected per well. Four commonly used supervised learning approaches including RF, AdaBoost, SVM, and NN are compared in this work. It is found that the RF performs the best in terms of prediction accuracy in comparison with other three methods. Finally, the newly developed prediction models are successfully used to optimize the fracture stimulation strategies for field cases. These data-driven models are found to be very useful for reservoir engineers when designing the hydraulic fracture treatments in unconventional tight formations.

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