

HYDRAULIC FRACTURING CANDIDATE-WELL SELECTION USING ARTIFICIAL INTELLIGENCE APPROACH

Agus Aryanto^{1,a}, Sugiatio Kasmungin^{2,b}, Fathaddin^{2,c}

¹Master Degree of Petroleum Engineering Department Trisakti University

²Lecture of Master Degree of Petroleum Engineering Department Trisakti University

^aagus.aryanto258@gmail.com, ^bsugiatio_ftke@trisakti.ac.id, ^cmuh.taufiq@trisakti.ac.id

Abstract. Hydraulic fracturing is one of the stimulation method that aimed to increase productivity of well by creating a high conductive conduit in reservoir connecting it to the wellbore. This high conductivity zone is created by injecting fluid into matrix formation with enough rate and pressure. After crack initiate and propagate, the process continue with pumping slurry consist of fracturing fluid and sand. This slurry continues to extend the fracture and concurrently carries sand deeply into formation. After the materials pumped, carrier fluid will leak off to the formation and leave the sand holds the fracture created. TLS Formation in X and Y Field is widely known as a formation that have low productivity since it has low permeability around 5 md and low resistivity 3 Ohm-m. Oil from TLS formation could not be produced without fracturing. This formation also have high clay content, 20 – 40 % clay. Mineralogy analysis also shown that this formation contains water sensitive clay such as smectite and kaolinite. Hydraulic fracturing has been done in this field since 2002 on around 130 wells. At the beginning of hydraulic fracturing campaign, the success parameter is only to make the wells produce hydrocarbon in economical rate. As the fractured wells become larger in number, several optimization is also been done to increase oil gain. Later on, the needs of conclusive analysis to evaluate well performance after hydraulic fracturing rise up due to sharp decrement of crude oil price. Accurate analysis and recommendation need to be conducted to assess the best candidate for hydraulic fracturing to maximize success ratio. Even though a common practice, candidate-well selection is not a straightforward process and up to now, there has not been a well-defined approach to address this process. Conventional methods are not easy to use for nonlinear process, such as candidate-well selection that goes through a group of parameters having different attributes and features such as geological aspect, reservoir and fluid characteristics, production details, etc. and that's because it is difficult to describe properly all their nonlinearities. In that matter, Artificial Intelligence approach is expected to be an alternative solution for this condition.

Keywords. *Hydraulic Fracturing, ANN, ANFIS.*

Abstrak. *Fraktur hidrolik merupakan salah satu metode stimulasi yang bertujuan untuk meningkatkan produktivitas sumur dengan menciptakan saluran konduktif tinggi di reservoir yang menghubungkannya dengan sumur bor. Zona konduktivitas tinggi ini dibuat dengan cara menyuntikkan cairan ke dalam formasi matriks dengan tingkat dan tekanan yang cukup. Setelah retak memulai dan merambat, proses dilanjutkan dengan bubur pemompaan terdiri dari fraktur fluida dan pasir. Bubur ini terus memperpanjang fraktur dan secara bersamaan membawa pasir ke dalam formasi. Setelah bahan dipompa, cairan pembawa akan bocor ke formasi dan membiarkan pasir menahan fraktur yang tercipta. Formasi TLS di Lapangan X dan Y secara luas dikenal sebagai formasi yang memiliki produktivitas rendah karena memiliki permeabilitas rendah sekitar 5 md dan resistivitas rendah 3 Ohm-m. Minyak dari formasi TLS tidak bisa diproduksi tanpa rekahan. Formasi ini juga memiliki kadar tanah liat yang tinggi, tanah liat 20 - 40%. Analisis mineralogi juga menunjukkan bahwa formasi ini mengandung tanah liat peka seperti smektit dan kaolinit. Rekahan hidrolik telah dilakukan di lapangan ini sejak tahun 2002 di sekitar 130 sumur. Pada awal kampanye rekahan hidrolik, parameter keberhasilannya hanya membuat sumur menghasilkan hidrokarbon dalam tingkat ekonomis. Sebagai sumur retak menjadi lebih besar jumlahnya, beberapa optimasi juga telah dilakukan untuk meningkatkan perolehan minyak.*

Nantinya, kebutuhan analisis konklusif untuk mengevaluasi kinerja baik setelah fraktur hidrolik meningkat karena penurunan tajam harga minyak mentah. Analisis dan rekomendasi yang akurat perlu dilakukan untuk menilai kandidat terbaik untuk rekah hidrolik untuk memaksimalkan rasio keberhasilan. Meskipun praktik umum, seleksi kandidat-baik bukanlah proses yang mudah dan sampai sekarang, belum ada pendekatan yang tepat untuk menangani proses ini. Metode konvensional tidak mudah digunakan untuk proses nonlinier, seperti seleksi kandidat-baik yang melewati sekelompok parameter yang memiliki atribut dan fitur berbeda seperti aspek geologi, karakteristik reservoir dan fluida, rincian produksi, dll dan itu karena sulit dilakukan. untuk menggambarkan dengan benar semua nonlinearitas mereka. Dalam hal ini, pendekatan Artificial Intelligence diharapkan bisa menjadi solusi alternatif untuk kondisi ini.

Kata kunci. *Fraktur Hidrolik, JST, ANFIS.*

Introduction

Currently, Hydraulic Fracturing candidate wells are classified as “Tier 3” candidates, that have more challenges from operation, while having less identified potency. More than 90% fractured wells candidates are work over change layer, with no further potency from previous layer.

As asserted in the literature, even though a common practice, candidate-well selection is not a straightforward process and up to now, there has not been a well-defined approach to address this process. Conventional methods are not easy to use for nonlinear process, such as candidate-well selection that goes through a group of parameters having different attributes and features such as geological aspect, reservoir and fluid characteristics, production details, etc. and that’s because it is difficult to describe properly all their nonlinearities. However, it is believed that advanced methods such as artificial neural network (ANN) could be better decrease the uncertainty existed in candidate-well selection

Literature Review

Various investigations show that the success of hydraulic fracturing operation mainly acquired by better candidate-well selection. It could be say that candidate-well selection is the process of choosing or recognizing well that have potential for higher production and better return of investment after stimulation job. In order to successfully performing hydraulic fracturing treatment, the selection of the first well through well-defined methodology is of particular importance. The objective not only saves money and time but also will establish this technology as a proper stimulation method. So, the need for accurate hydraulic fracturing candidate-well selection to eliminate possible failures becomes very important.

Besides reservoir quality and completion, the effectiveness of the hydraulic fracturing of three critical parts, which are trying together: candidate-well selection, treatment design, and field operation. Actually, they are the triangle success factors that must link together. Applying the best treatment design and field procedures to the wrong candidate-well will results in a failure of the whole operation. In other words, all of the three factors should perform well to guarantee the success of hydraulic fracturing treatment.

Two methods for hydraulic fracturing candidate-well selection could be presented; conventional and advanced approaches. Being familiar with the conventional methods in candidate-well selection that mainly deals with engineering, geological, etc aspects in decision making process, is of particular importance in order to increase the performance of the advance techniques that mainly utilized Artificial Intelligence methods.

Methodology

To give graphical guide for developing this study, there are 4 regions that represent the state of working procedure, namely Data Preparation, Data Processing, Network Modeling and Calculation, and Result and Evaluation

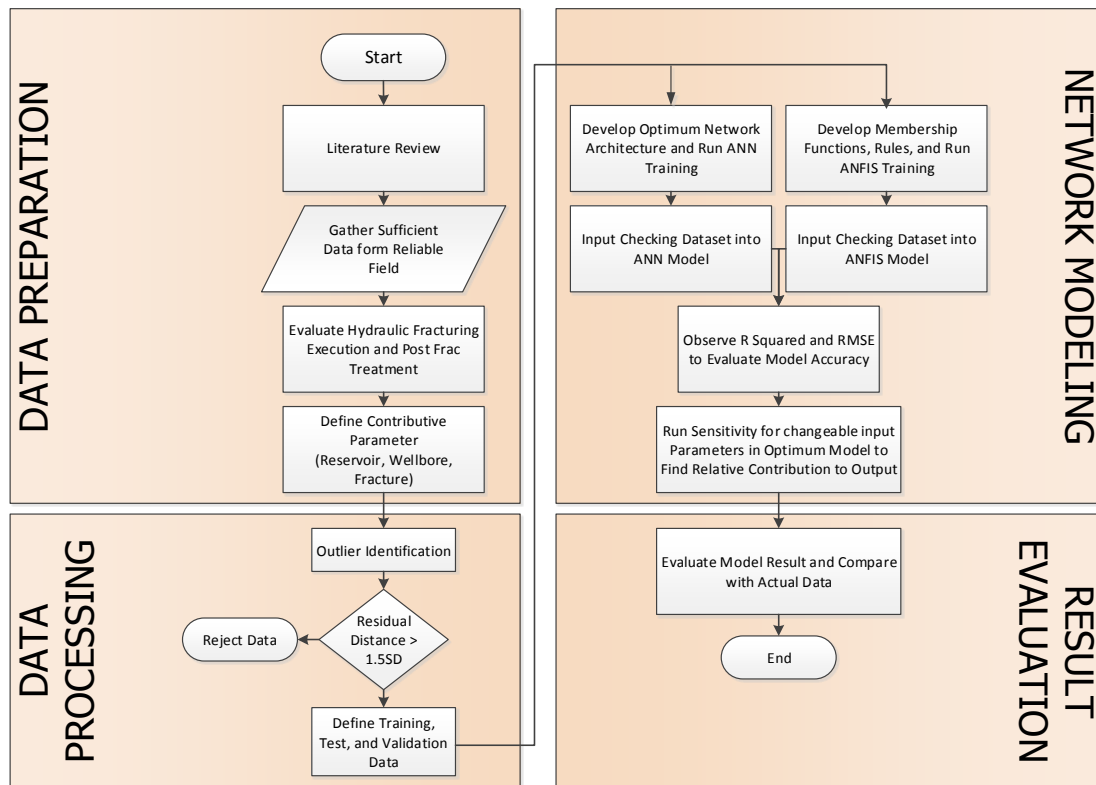


Figure 1. Flowchart of study

1. Data Preparation

Source of data and its measurement method is summarized as follows:

Input

- Porosity, Resistivity, Lithology, Water Saturation and Thickness are petrophysical data and obtained from formation measurement using logging tools and interpreted by Petro physicists.
- Permeability. There are some possible way to obtain permeability, such as transient test, core analysis (porosity-permeability correlation), and well modeling. In this study, permeability is obtained from well modeling as well test is very rare and permeability from porosity-permeability in many wells seems lack of realism that show extreme high and low of permeability.
- Reservoir Pressure. To give conclusive understanding for modeling purpose, reservoir pressure will be expressed as a pressure gradient. Bottomhole Pressure measurement itself is obtained by using EMR.
- Fracture half-length, Fracture Conductivity and Proppant Volume are hydraulic fracturing parameters that being obtained from net pressure matching and field measurement.

Output

- Average Fluid Production rate has been selected as output variable due to it affection in PI calculation, and not dependent by water cut.

2. Data Processing

To ensure the data set is representative, as it is very crucial in data modeling, data set screening is performed by simply observed the output and input variables. Each of variables are sorted for maximum and minimum values for recruitment of training data. Total 34 data sets was used to build a network model.

3. Network Modelling

Artificial Neural Network

The first step to build the ANN model is to import input data (input parameters) and target Data (output parameter) into the data manager, then a create a network which has a single or more hidden layer with sigmoid hidden neurons with output neurons and then choose the best model or the most suitable network architecture. This kind of network can fit multi-dimensional mapping problems arbitrarily well, given consistent data and enough neurons in its hidden layer. The best network in this study will be the model with a combination of low Mean Squared Error (MSE) and high Regression (R) value of testing data. The construction of the ANN model is implemented in ANN Software (Alyuda Neuro Intelligence).

Alyuda Neuro Intelligence provides set of possible network architecture, and algorithm to choose best network to be activated. Manual selection can also be done as shown on Figure III-16 Network selection is based on error prediction, and data fitness, thus made the architecture of 10-14-1 is chosen.

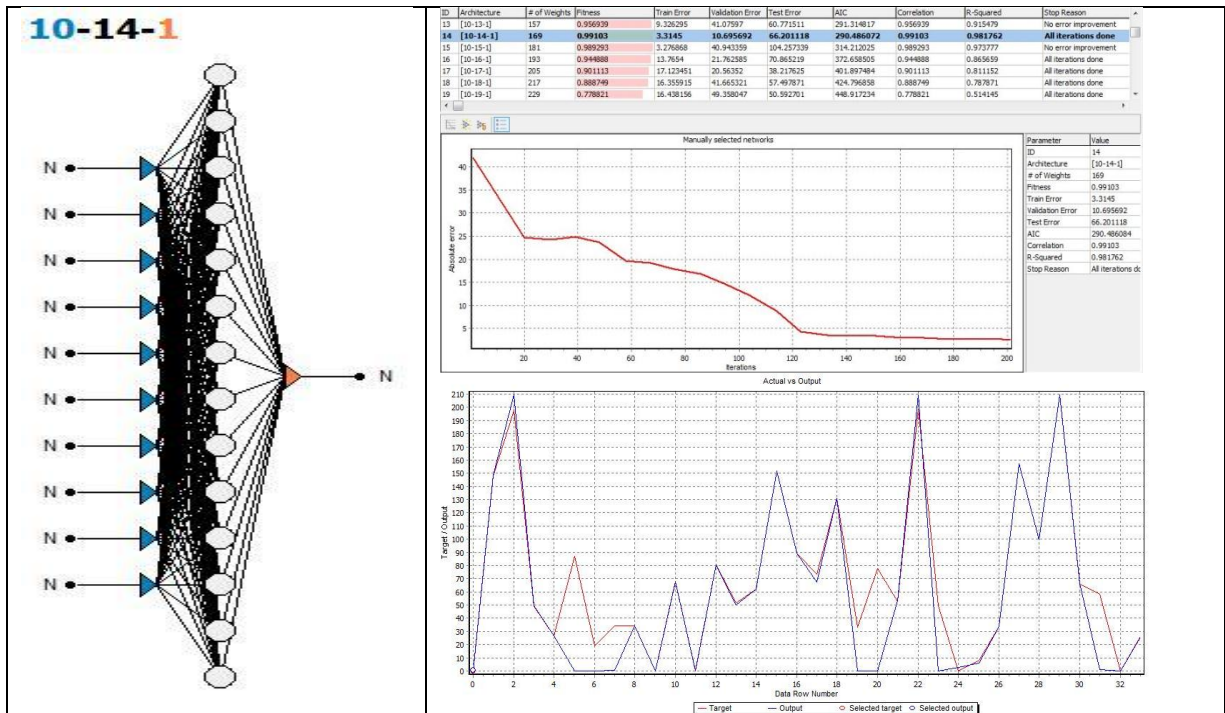


Figure 2. ANN Modeling Process

Adaptive Neuro FIS

ANFIS is applied for estimating the parameters of significant variables in order to examine the effects of these parameters on the cumulative oil production. The ANFIS model categorizes the input space into Fuzzy subspaces and maps the output using a set of linear functions. Using a learning process, ANFIS can determine the mapping relation between an input and output data set in order to identify the optimal distribution of membership functions; the relation involves a premise and a consequent part.

The construction of the ANFIS model is implemented in MATLAB, which comprises fuzzification by determining the type and the number of membership functions. The subtractive clustering method will be used to partition the universe of discourse for input variables and then to generate the Fuzzy inference system. The number of Fuzzy rules required for FIS construction and their associated membership parameters is minimized

using the subtractive clustering method for three rules. The next step is training of the inputs to minimize the RMSE and to adjust the shape of the membership functions. The hybrid learning algorithm will be used to develop the ANFIS model. This algorithm consisted of back propagation for the input parameters associated with input membership functions and least squares estimation for the parameters associated with output membership functions. The learning process stops when a maximum number of training iterations (epochs) is achieved. The best ANFIS model is selected based on a lower RMSE for both training and checking data sets, where the RMSE is under control and not increasing.

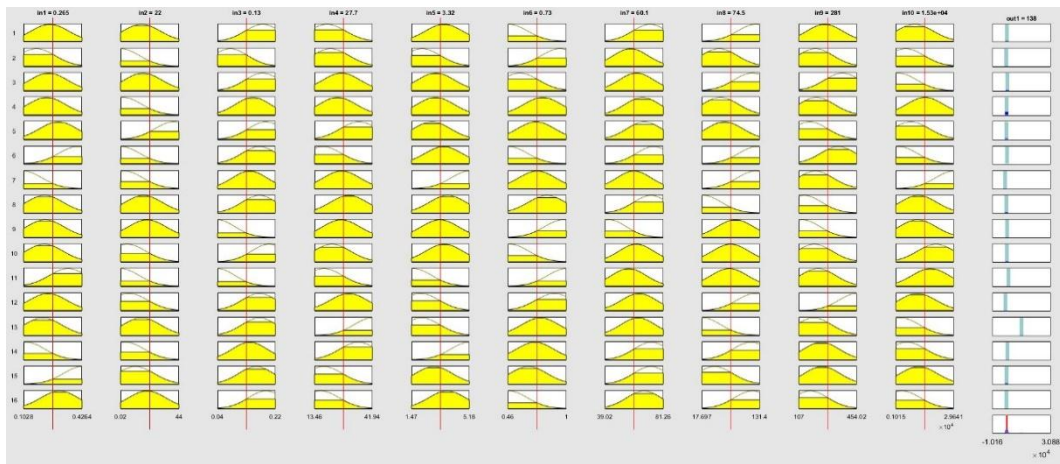


Figure 3. Generated ANFIS rules

Result and Analysis

As a measurement to prediction accuracy, the model generated through learning process using training data is validated using checking data, by entering the input in checking data into ANN regression coefficient and ANFIS rules, and compare the calculated output to observed output (average liquid production). The output and statistical validation can be seen in Figure.

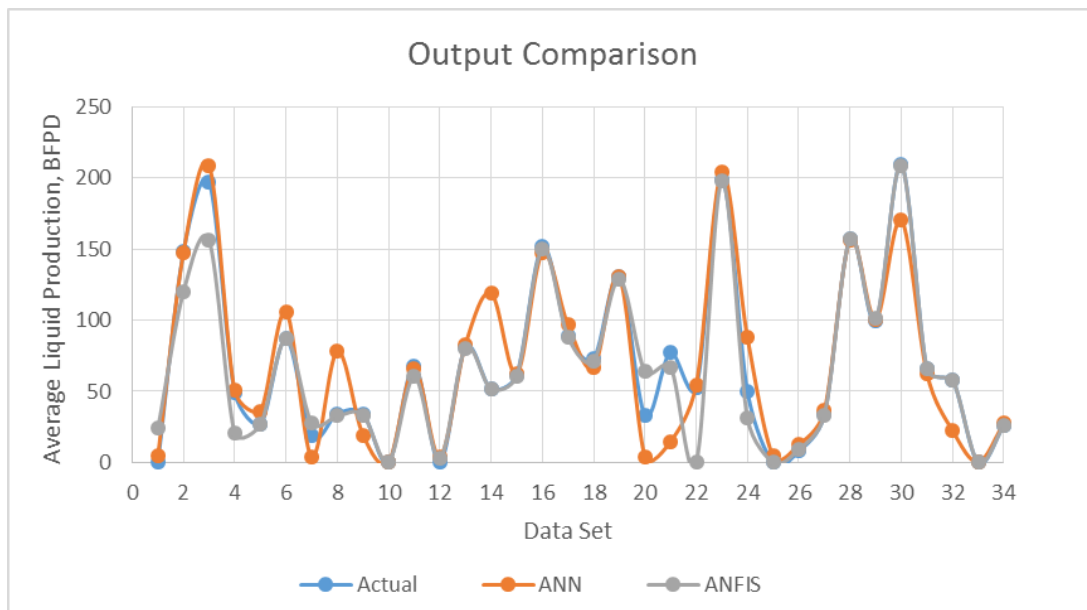


Figure 4. ANN and ANFIS output comparison

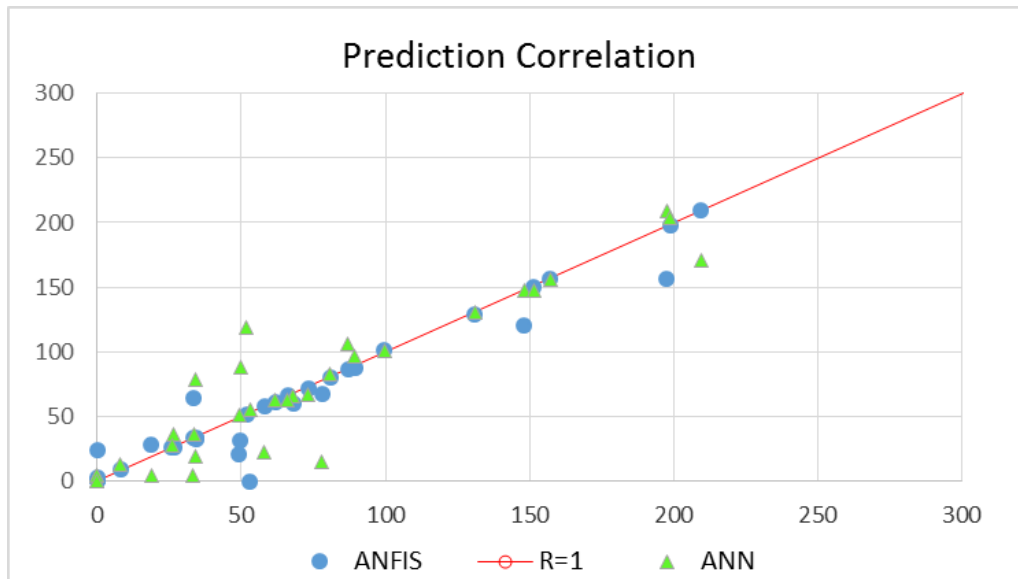


Figure 5. Prediction Correlation

Table 1. ANN and ANFIS Model Validation

Network Model	RMSE	R	R ²
ANN	22.27014	0.930911	0.866595
ANFIS	15.60558	0.967117	0.935316

Conclusion

- a. ANN and ANFIS using Input that are relatively easy to obtain and routinely measured accurately (based on test and simulation) is proven to be effective to approach technical consideration based on scattered data and sufficient sample. Based on Error evaluation, ANFIS provides smaller error (0.967 vs 0.930), thus achieves better prediction for well candidate selection and fracture optimization based on model sensitivity.
- b. There is a limitation of AI approach that may only applicable in case of sufficient data to generate rules in its learning stage. AI network cannot optimize nor predict outside the data range within which it has been trained, hence training data should be selected to cover all minimum and maximum data for all input data.

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