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Estimated rate of penetration using artificial neural networks and optimize drilling parameters in directional wells in Ahvaz field

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ABSTRACT

To further speed up the drilling operations and thus further reducing costs and lower risk operations, we can simulate and predict the conditions to achieve desired results. For this to work with programming and According to data from directional wells drilled in Ahvaz field, can to reached Optimum value for drilling in this field. With The modeling of well conditions and Drilling parameters as for Existing wells in this field, we will find the identical and reliable and functional model. Many factors are effective in rate of penetration. Neural network modeling for the relationship between these variables is very important and many help to optimization the process. In this paper, Using *Bourgoyne and Young's* equation explains the relationship between these variables. The first step in the application of neural networks made model at the starting drilling point of well. Neural network data can be divided into three parts. 70% of data for network training and 15% of the data for the network Validation and 15% of the data for network sensitivity analysis has been assigned. The percentage error in the calculations must reach down. Because the Studies with the optimal values should be to reduce the risk and acceleration of drilling process. Cycle process are includes approximately 2-4 million estimate for each analysis. All of these processes are repeated for Establish a relationship between variables and graphs.

Introduction

Since the process of drilling operations in the upstream petroleum industry is of special attention and it can be named as one of the most expensive activities in upstream. Drilling efficiency and speed is so highly intentioned. Undoubtedly many factors in the performance of the drilling rig same as Technical and economic and political factors can a great impact. In this paper important parameters in the drilling rig shall review. We will be paid to rate of penetration in directional wells have been drilled. Rate of Penetration in drilling industry is usually a relationship Meters of drilling on time (ft/hr) is obtained, that its value is highly influenced by many factors. As for Factors affecting the rate of penetration, therefore, proper selection of these factors in The drilling program is inevitable and Could increase the penetration rate of drilling bit in rock. It should also be noted that Increase the rate of penetration in the rock must be reasonable, because in some cases Increase in non-normative it can break the reservoir rock and finally fluid lost will be occur. Rate of penetration any amount that is more, Represents more drilling speed and Thereby reducing drilling time that will ultimately reduce the total cost of operations. Therefore, we need to optimize the rate of penetration to optimize operations. As regards Average rate of penetration for example in an area if it is about 37 meters per day, with proper optimization and estimation and studies factors influence on rate of penetration, This amount can be increased up to 50 meters per day. Since material and formation properties and Reservoir depth many factors influence the rate of penetration is in rock. As regards with increasing depth, the harder formations and the penetration rate is less, so Knowing that the wells are deep wells of Iran. Optimization and estimates the rate of penetration of drilling wells in Iran is very important.

Regardless of the rigs are used in Iran and as for Data obtained from previous drillings, in this paper Attempt to estimate the optimal penetration rate of drilling these wells come on.

By compare and evaluate Factors, as for mud used and bit type and horsepower and rig hydraulic and Review requirements we can To get the best rate of penetration By soft computing techniques.

Using a factor of 8 below, we will find a model that has the lowest error.

1. Depth
2. Weight on bit
3. Bit diameter
4. Rotation per minutes
5. Mud weight
6. Formation pressure gradient
7. Bit wear
8. Nozzle impact force

Given the problems in the automatic process maintain appropriate drilling parameters with layers lithology and there are well maintained conditions, Drilling industry requires a new method that workers at a desired time to view the desired information and control the drilling parameters. The data analysis will enhance operational efficiency and ultimately reduce costs. To solve problems through modeling with neural networks to optimize the drilling parameters requires the highest rate of penetration in drilling operations will be. The advantages of this method, increased tool life and reduce the time to stop

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drilling operations and is ultimately more productive bit. Neural network modeling allows predicting the future response of a system based on historical data of the phenomenon to be modeled in a fast and reliable manner.

Controllable and incontrollable factors in optimization rate of penetration.

In this method, human errors are eliminated and artificial neural networks are replacing. In this method, operational parameters feature selection based on physical data from wireline logs of the rock formations are considered to have come. This understanding leads to more accurate analysis of the logs. By modeling with artificial neural network changes to increase the rate of penetration and thus increase the life of the bit would lead.

TABLE 1 – Factors proposed to affect ROP

Controllable	Incontrollable
Bit wear state	Formation type
Bit design	Formation properties
Weight on bit	Mud type
Bit rotary speed	Mud density
Flow rate	Other mud properties
Bit hydraulic horsepower	Overbalance / bottomhole mud pressure
Motor / turbine geometry	Bit size
Bit nozzle arrangement	

According to the data that is available, For 6 wells that are located in the Ahwaz field and directional drilled. We optimize the rate of penetration. Since the data are available in groups and various factors. For further enhance the accuracy of network, we will test the network.

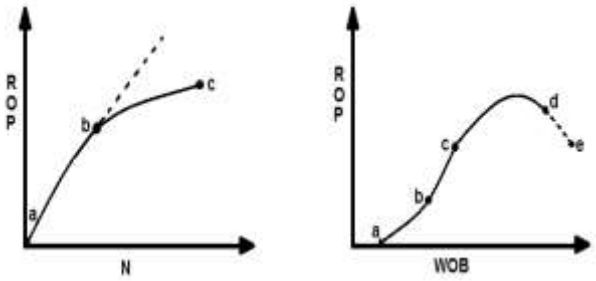
Such that for each review, a parameter will be removed. For optimization of drilling parameters, performance efficiency of drilling operations will ultimately be reviewed. To calculate the efficiency of drilling operations, The final parameter is the rate of penetration.

To investigate this, several factors have been analyzed and the results will be reviewed. To do this with programming according to data from wells drilled in the area came to the optimum value. With modeling of the well conditions and drilling parameters according to the existing wells in the area, we will get to same and reliable and practical model. Modeling requires knowledge of regional geology and accuracy of the information from nearby wells in the field.

To do this, by using programs and mathematical models of neural networks we get efficient and reliable model to future operations. Since the data relating to several wells in a field are examined, in each wells incidence factors is inevitable. For that have continuous and homogeneous model, will need to be homogeneous and continuous data.

For this to perform this calculation wells and the data they need to manage at the same depth. However, the calculation will randomly enter data but this crash should indicate the depth of expression and are compared. Rate of penetration influence is directly in the cost per foot drilled. Much research has been performed on factors affecting the rate of penetration. The following two graphs the relationship between rate of penetration and rotation per minute and weight on bit shows.

Normal graphs at point C drilling ends. Increase in rotation per minute to improve the rate of penetration, hole cleaning problems that will be achieved. In soft formation, ROP increases with increasing RPM. But this relationship is reversed in hard formation.



- The relationship between the penetration rate in the rock, with RPM and WOB Figure 1

Models and mathematical relationships

Many mathematical models to establish relationships between these parameters are variable and ROP. Most of them are a combination of initial controllable variables and formation properties. The most common relationship for modeling such relationships is Bourgoyne and Young's equation. By using MATLAB software will do the calculation of the neural network. Below we mention Bourgoyne and Young's relationship. This model in 1991was introduced to establish the relationship between rate of penetration and initial variable parameters same as sedimentation and fracture pressure, weight on bit, rotation per minute, bit hydraulics and bit wear and … . This model is as follows.

$$ROP = e^{a_1} \cdot e^{a_2(10000-TVD)} \cdot e^{a_3 D^{0.69}(M_W-67.41)} \cdot \left[\frac{W}{d_b}\right]^{a_5} \cdot \left[\frac{N}{60}\right]^{a_6} \cdot e^{-a_7 h} \quad (1)$$

Resulting in by letting each function to calculate the rate of penetration will reach the overall equation.

$$ROP = F_1 \cdot F_2 \cdot F_3 \cdot F_4 \cdot F_5 \cdot F_6 \cdot F_7 \cdot F_8 \quad (2)$$

For the calculations, according to what was discussed in the past that we need to examine the process.

- The first test, we reduce the parameters.
- Then, we reduce the number of data per parameter.

At all stages, the percentage error of the calculations should be low. Review should be to reduce risk and increase drilling speed is optimal. In each modeling method the penetration rate will reach the optimum. Then, using Bourgoyne and Young's equation we will to the optimal GPM and WOB.

In this paper Exactly as optimum rate of penetration is predicted and modeling to determine how inputs are applied to organize. Models created for this process should be more suitable for rock penetration rate in the trained neural network should be established. The increase in the neural network input, process modeling training complex and adding to the final outcome is undetermined. Modeling process, including all factors available, but is more hypothetical variables.

The results predict the rate of penetration

This process includes a cycle of approximately 4-2 million is calculated for each analysis. The process for establishing a relationship between variables and graphs are repeated. In addition, the replication process is to reduce differences and actually create the same output. Table 2, the number of actual data and parameters used in this paper shows.

Neural network data can be divided into three parts. 70% allocated to the data for network training. 15% of the data for the network validation and 15% of the data for sensitivity analysis is dedicated. Finally, all data collected and plotted in the graph are the total. In this paper, the square-error method (R Square) has been used. The difference between the actual data with predicted data is a power of 2. Graphs obtained in the

analysis for each stage The error value (R) is closer to 1, The network result will be better. Sensitivity analysis of the network to prevent network are lazy. If the network training, the network may have been lazy and the cross-sectional results.

Table 2– A sample of data

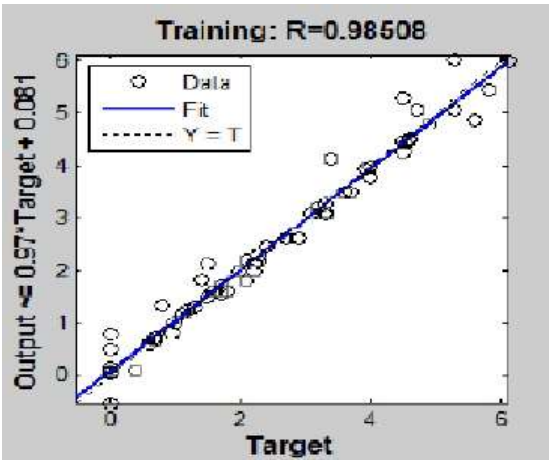
START	NOZZLES	DRILLING	DRILLING	G.P.M	W.O.B	R.P.M	R.O.P	MW	SOLID
DEPTH	SIZE(12/32")	RATE	HRS		X 1000				
2664	3 X 14	0	RIH	RIH	RIH	RIH	o	65	
2664	3 X 14	36	14	400	20-25	M	1.5	68	11.0 %
2700	3 X 14	16	4	400	25	M	4.0	68	11.0 %
2716	3 X 14	59	13	400	25	M	4.5	68	11.0 %
2775	6X16	55	12	400	25	M	4.6	68	11.0 %
2830	6X16	88	24	400	25	M	3.7	68	12.0 %
2918	6X16	93	23	400	10	M	4.0	68	12.0 %
3011	6X16	74	24	400	10	M	3.1	68	12.0 %
3085	6X16	40	12	400	10	M	3.3	68	12.0 %
3125	6X16	27	7	400	10	M	3.9	68	12.0 %
3152	6X16	50	24	400	10/15 000	M+ 35	2.1	68	12.0 %
3202	6X16	48	24	400	10/15 000	M+ 35	2.0	68	12.0 %
3250	6X16	39	18	400	10/15 000	M+ 35	2.2	68	12.0 %
3289	6X16	11	5	400	5/100 00	M+ 35	2.2	68	12.0 %
3300	6X16	55	24	400	5/100 00	M+ 35	2.3	68	12.0 %
3355	6X16	53	24	400	5-10	M+ 35	2.2	68	12.0 %
3408	6X16	10	24	400	5-10	M+ 35	0.4	68	12.0 %

Analysis Graphs

For training the network diagram will reach 70% of the data to the following equation. According to this equation, we reached to the coefficient of error of 0.98508 (Figure 2). Equation will be obtained as follows.

Output = 0.97×Target + 0.081

R = 0.98508

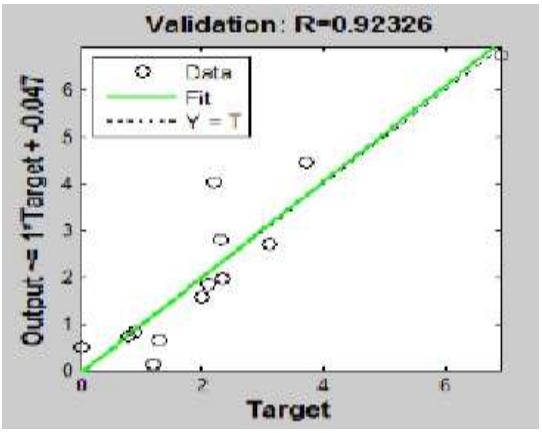


- Graph data for network training Figure 2

For validation the network diagram will reach 15% of the data to the following equation. According to this equation, we reached to the coefficient of error of 0.92326 (Figure 3). Equation will be obtained as follows.

Output = 1×Target + 0.047

R = 0.92326



- Graph data for network validation Figure 3

For sensitivity analysis of network diagram will reach 15% of the data to the following equation. According to this equation, we reached to the coefficient of error of 0.93321 (Figure 4). Equation will be obtained as follows.

Output = 1.1×Traget + 0.31

R = 0.93321

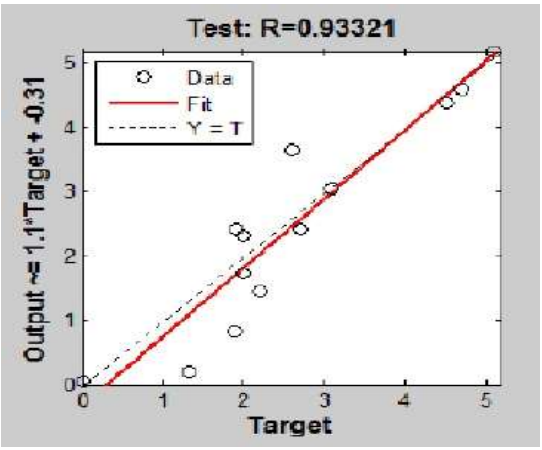


Figure 4 - Graph data for network sensitivity analysis

According to the equations obtained from the total of all available data and graphs can be plotted as follows and *we reached to the coefficient of error of 0.96704 (Figure 5). Equation will be obtained as follows.*

Output = 0.99×Traget + 0.019

R = 0.96704

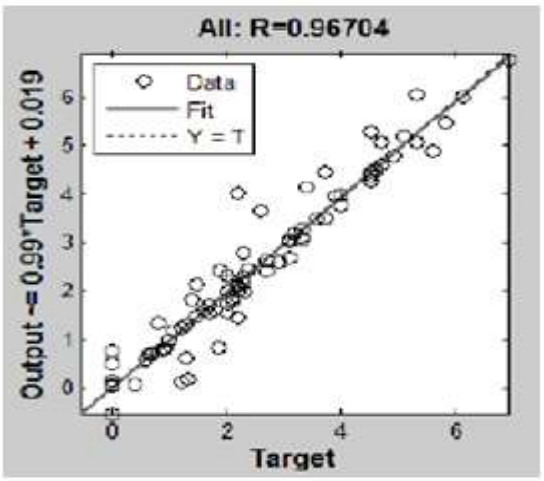
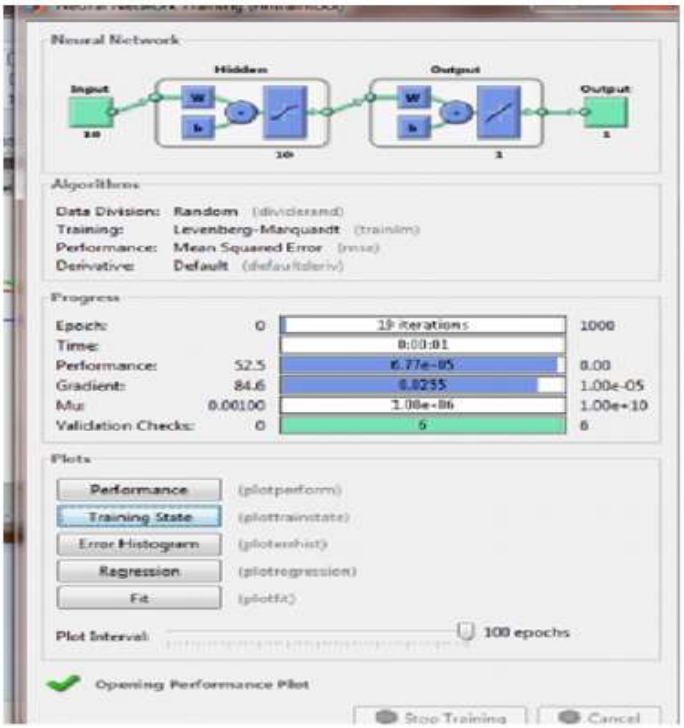


Figure 5- Graph for all data entire network

Repeat the computing (Epoch)

For all process, the following graphs represent the number of repetitions to achieve the desired result is taken. The values obtained in the nineteenth repetition step are shown (Figure 6).

Best Validation Performance = 0.49986
Gradient = 0.025456
Mu = 1 E-006
Validation Checks = 6



After solving equations and models created by the network, the output data will be provided as graphs. These Graphs indicate that the answer we have to repeat step 19 (Figure 7).

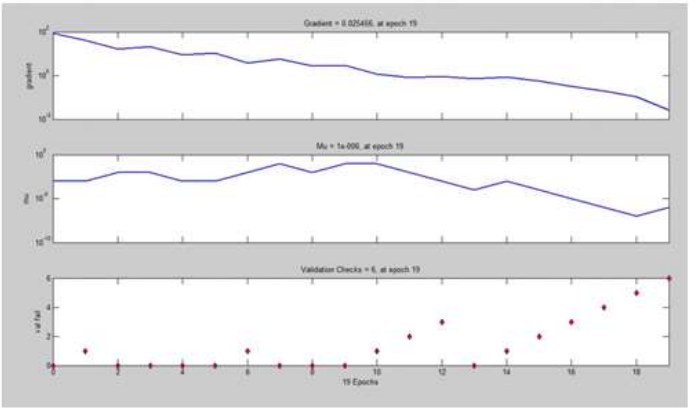


Figure 7 - Repeat the process and solving equations

Network after solving equations and repetitions, offers the best efficiency in the process repeat. Figure 8 shows this issue. At this stage, the mean square error (MSE) is closer to zero have a better answer. The best value will reach 13th repetitions (Figure 8).

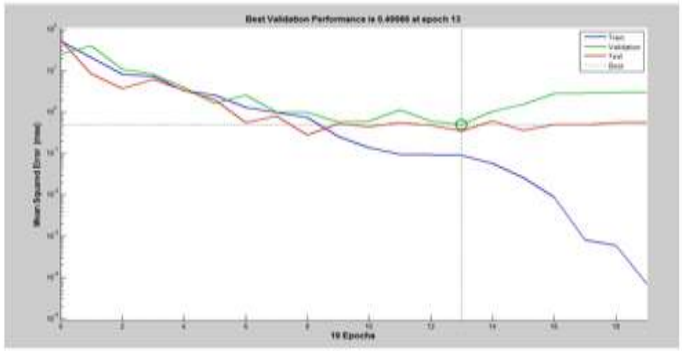


Figure 8 - The best step of repetition

Histogram

Histogram is a graphical representation showing a visual impression of the distribution of data. It is an estimate of the probability distribution of a continuous variable. Histogram consists of tabular frequencies shown as adjacent rectangles, erected over discrete intervals (bins), with an area equal to the frequency of the observations in the interval. The height of a rectangle is also equal to the frequency density of the interval. Histogram data used in this paper is shown in Figure 9.

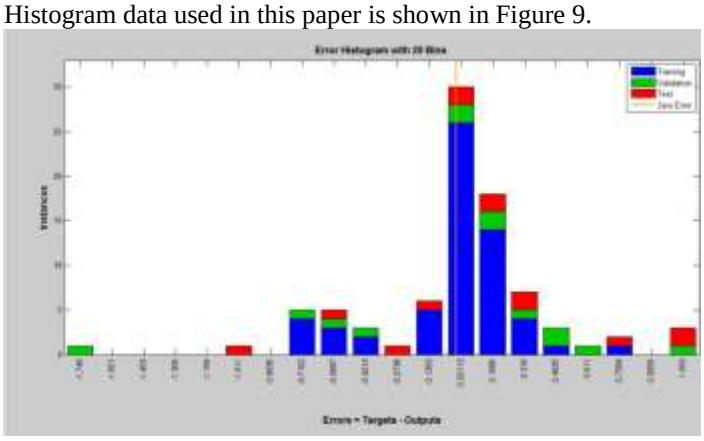


Figure 9 - Histogram

Conclusion

❖Results of this research showed that artificial neural networks are able to predict the parameters affecting the rate of penetration.

❖Percent errors for the data in different sections were obtained using the least squares method, for Network training is equal to 0.98508, and for validating the network is equal to 0.92326 and for sensitivity analysis of the network is equal to 0.92321 and is equal to the total data 0.96704.

❖Since this percentage errors are close to 1, so a reliable network and will be very useful for future drilling in this field.

❖With estimate the penetration rate by the network, we get the best Weight On Bit and Rotation Per Minute.

❖With this method, less human error and the amount of drilling parameters during drilling can be applied.

❖To build the neural network data from six wells in the oilfield in Ahvaz have been biased. Over 300 real data is processed and used.

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