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Extended Abstract

Optimization of drilling rate of penetration considering geomechanical properties and operational drilling parameters in a well from a southern Iranian oil field

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Abstract

Optimization of the drilling rate of penetration (ROP), recognized as one of the key factors influencing the efficiency and productivity of drilling operations, plays a crucial role in the success of the process and directly impacts the reduction of drilling time and associated costs. In this study, conducted in one of the Persian Gulf fields, geomechanical parameters of the studied well were estimated based on petrophysical and rock mechanics data. Additionally, pore pressure variations, stresses, and wellbore stability conditions were simulated through one-dimensional geomechanical modeling using the Geolog software. After evaluating the geomechanical and drilling modeling, the parameters were used for ROP modeling using MATLAB software. ROP modeling and optimization were carried out using two databases (drilling data and drilling–geomechanical data). Initially, a correlation matrix between the geomechanical/petrophysical parameters and drilling ROP was generated, where eight parameters in the drilling–geomechanical database and six parameters in the drilling database yielded the lowest RMSE values between the actual and predicted ROP. These parameters were then applied to ROP modeling using two approaches, Multi-Layer Perceptron (MLP) and Random Forest (RF), with RF selected as the final modeling method. Following the ROP modeling, for the optimization stage, considering the characteristics of different algorithms, the Multi-Objective Particle Swarm Optimization (MOPSO) algorithm was chosen. Accordingly, by optimizing the controllable parameters, the average drilling rate was enhanced to 14.1 m/hr using the drilling database and to 15.5 m/hr using the drilling–geomechanical database. Consequently, the drilling time for the studied depth interval (360 m) was reduced by 2.65 hours using the drilling database and by 4.9 hours using the drilling–geomechanical database, highlighting the significant effect of incorporating geomechanical data on optimizing drilling parameters.

1. Introduction

The drilling process has a special position in the upstream oil industry and is one of the most expensive activities required for the extraction of hydrocarbon resources. Increasing the drilling rate of penetration to decrease drilling costs has always been the focus of researchers in this field. The rate of penetration operations is influenced by several factors, the most important of which are: weight on the bit, rate of penetration, hydraulics, type of drill, mud properties, and formation properties. Therefore, to achieve the optimal rate, a good estimation of the parameters that have a significant effect is necessary [1].

A wide range of drilling variables have been studied to investigate their effect on the drilling penetration rate, and many mathematical models have been created to combine and establish the relationship between drilling parameters. These models optimize the weight on bit and the rate of

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penetration to achieve the minimum cost. Having a model that can determine the optimal rate of penetration based on various parameters can greatly help to improve drilling performance. The introduced mathematical model is more accurate the more parameters it takes into account. It should be noted that to determine a mathematical model, one should pay attention to its applicability, that is, the parameters that cannot be measured and whose field information is not available cannot be considered in a mathematical model [2].

Due to the importance of geomechanical parameters in the drilling process, the effect of environmental parameters on the drilling penetration rate has been investigated. These parameters, which are estimated through well logs, are built in a one-dimensional geomechanical model. After forming an effective database on the penetration rate, it is possible to check the influence of each parameter on the penetration rate.

Its prediction was done according to the characteristics of the neural network and multivariate regression.

2. Methodology

Many variables are effective for modeling the penetration rate of the bit. Some of these variables are parameters obtained from the well and during drilling. However, some of these variables need to be calculated, which are obtained using geomechanical and petrophysical parameters. In this study, first, petrophysical and geomechanical models are made for the studied well. First, the correlation matrix between geomechanical and petrophysical parameters and rate of penetration (ROP) is formed. First, the prediction of the drilling penetration rate and its optimization is done only by using drilling parameters and in the next step by using geomechanical and drilling parameters.

In the part of penetration rate modeling and optimization, firstly, the correlation matrix between geomechanical and petrophysical parameters and drilling penetration rate (ROP) is formed. The degree of effectiveness and the relationship between each of the parameters and penetration rate are studied and 17 parameters are analyzed in a statistical comparison, and in the drilling data part, it is determined that WOB, RPM, FLR, Torque, SPP, HL have the lowest value of RMSE between real and predicted data of ROP and in the part of drilling-geomechanical data, among which RPM, WOB, UCS, FLR, Torque, PHIE, SP, HL, the lowest value of RMSE between the data have actual and predicted ROP. To predict the drilling penetration rate, two methods of multi-layer perceptron neural network and random forest have been used.

The MOPSO algorithm is used to optimize the drilling penetration rate. In the study, the optimization is done with the two goals of increasing the drilling rate and reducing the mechanical-specific energy.

3. Results and Conclusions

In this research, at first, geomechanical modeling was done using petrophysical and core data. After that, the penetration rate was modeled and optimized with two databases (only drilling data and drilling-geomechanical data). At first, the correlation matrix between geomechanical and petrophysical parameters and drilling penetration rate (ROP) was formed, and 17 parameters were investigated, among which 8 parameters were RPM, WOB, UCS, FLR, Torque, PHIE, SPP, HL (in the drilling-geomechanical database) and 6 parameters RPM, WOB, FLR, Torque, SPP, HL (in the drilling database), had the lowest RMSE value between the real and predicted ROP data, and among these parameters in infiltration rate modeling Two methods, MLP and RF, were used, and according to the comparative parameters, the RF method was used as the final modeling method. In the following, optimization was done with the two goals of increasing the drilling rate and reducing the specific mechanical energy. Dupriest's relation was used to calculate the mechanical specific energy. After modeling the penetration rate, for the optimization part, according to the characteristics of different algorithms, the MOPSO algorithm was selected for optimization. Control, the average rate of penetration with the drilling database reached 14.1 m/h the geomechanical drilling database reached 15.5 m/h, and the drilling time for this depth range of the well (360 m) using the drilling database was 2.65 hours, and using It was reduced by 4.9 hours from the drilling-geomechanical database, which shows the effect of using geomechanical data.

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