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Prediction of Cuttings Transport Character in Foam Drilling Using Neural Network

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Foam is widely used in underbalanced drilling practice for oil and natural gas exploration. Foam fluids widely used for underbalanced drilling generally consist of 5~25% of the liquid phase and 75~95% of the gaseous phase. A surfactant accounts about 5% of the liquid phase. The merits of foam fluid drilling compared with conventional mud drilling include high penetration rates, a high cuttings transport capacity, and less formation damage. Determining how to effectively remove cuttings with foam is critical to the drilling process. In foam drilling, insufficient hole cleaning also can result in many serious problems including pipe stuck, lost circulation, premature bit wear, less penetration rate, formation fracturing, high torque and high drag. Cuttings transport is controlled by many variables including the foam velocity, foam quality, the complex non–Newtonian fluid rheology, well deviation angle, hole diameter, drill pipe diameter, drill pipe rotation, drill pipe eccentricity, rate of penetration (ROP), cuttings characteristics (including the size, shape and porosity of bed) and auxiliary condition(temperature and pressure).

This paper describes a new fitting method of cuttings transport with foam, which employs artificial neural networks. The effective parameters in foam drilling were fitted based on two artificial neural networks (ANN): radial basis function network (RBFN) and general regression neural network (GRNN). The results obtained were compared with those from BP network (BPN). It showed that RBFN and GRNN have the advantages of simple architecture, good precision and short computational time. Both models are well fit for the fitting of effective parameters and are easy to be incorporated into the code of cuttings transport in foam drilling.

In this study, the experimental data (70 data) of cuttings transport using foam from the previous literature were used for ANN modeling. The input layer of ANN has 6 neurons including foam velocity(V), foam quality(Γ), concentration of polymer(C), subsurface condition (pressure, p, and temperature, T), and pipe rotation (RPM). The output layer of ANN has 2 neurons including cuttings concentration (CC) and pressure loss ($\Delta p/\Delta L$).

The ANN was trained by different spread constant (SPREAD) for GRNN and RBFN to achieve the optimum SPREAD according to MRE and R between experimental and predicted value in training and testing data. Meanwhile, BPN model was constructed for comparing analysis. The BPN, RBFN, GRNN code were designed in MATLAB software. 60 samples of 70 data samples from the literature were used to train the NN for estimation of cuttings concentration and pressure loss in annulus from input variables (V, C, p, T, RPM, Γ). 10 samples were used for testing NN.

It showed that RBFN and GRNN have the advantages of simple architecture, good precision and short computational time. Through the comparisons on the training results, we show that the RBFN and GRNN are more effective than the BPN. So RBFN and GRNN can be used in many mathematical problems such as this study instead of BPNN and CFD modeling.