Deepwater Oil-Based Drilling Fluid Systembased on Grey Wolf Optimized BP neural network

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Abstract. In this paper,a BP neural network model with 5-9-6 structure is constructed according to various fault gases and different fault types ofWater-based drilling fluid and synthetic-based drilling fluid. While there are few studies relating to oil-based drilling fluid, which is attributed to the potential toxicity of conventional oil-based drilling fluid to the marine environment. However, oil-based drilling fluid is excellent in protecting the borehole stability. To this end, an environmentally friendly deepwater oil-based drilling fluid was developed based on the traditional oil-based drilling fluid. With the advantages such as good borehole stability and good wettability, this drilling fluid will not pollute the marine environment, is resistant to high temperature, and protects hydrocarbon reservoir, which is of great significance for rational exploration and development of deep-sea resources.

Key words: Grey Wolf Optimized, neural network, Deepwater; Oil-Based; Drilling Flui

1. Introduction

The relevant drilling fluid technical measures should be formulated in designing drilling fluid based on the analysis of the impact on the safety, quality and efficiency of drilling operations. The design should be performed on the basis of formation lithology, formation stress, physical and chemical properties of formation shale, formation fluid, formation pressure profile (pore pressure, collapse pressure and fracture pressure), geothermal gradient and other information, reservoir protection requirements, geological purpose and drilling engineering requirements for drilling fluid operations, applicable new technologies and processes of drilling fluid, provisions and requirements of the state and construction area concerning environmental protection.

2. Grey Wolf algorithm

Since grey wolves are at the top of the food chain, they prefer group hunting and group dwarves. Grey wolf optimization algorithm is to imitate the predatory behavior of gray wolf in nature, which is used to solve complex optimization problems. Grey Wolf algorithm is one of the most popular intelligent optimization algorithms, mainly using global random search strategy, with simple structure, easy programming and fast convergence.

In the gray wolf group, mainly divided into α、β、δ、ω. Among them, α on behalf of the wolf, β on behalf of the helper, δ responsible for commanding the wolf without independent decision-making ability and obeying the orders of the α, β two kinds of wolf. In the course of hunting, the α wolves lead the wolves, constantly rounding up their prey and attacking them.

In the mathematical model, each individual in the gray wolf population represents a solution in the population. Among them, the α represents the optimal solution, β the suboptimal solution, the δ represents the third optimal solution, and the δ represents the candidate solution. In each iteration of the gray wolf population, α, β, δ as the first three optimal solutions to determine the location of the prey, and command the wolf to keep close to the prey around, randomly update the location. The gray wolf algorithm flow is shown in Figure 1.

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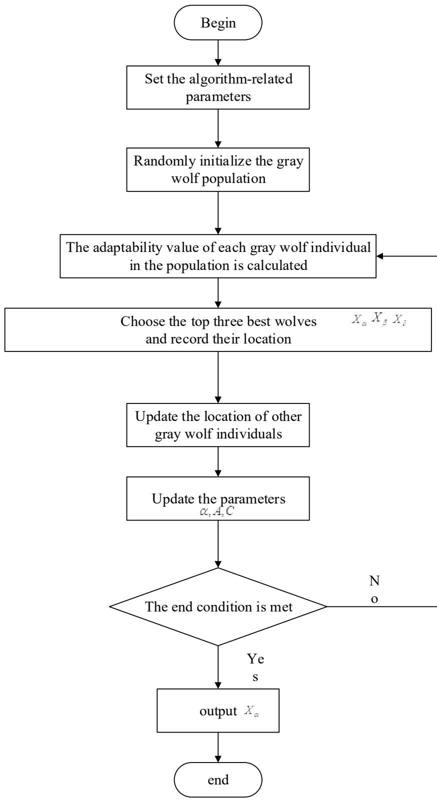

Figure 1 Gray Wolf Algorithm Flowchart

3. The selection of base oil and design of main performance parameters for deepwater oil-based drilling fluid are shown below:

(1) Selection of base oil
Mineral oil with low aromatic hydrocarbon content and appropriate viscosity is the best choice, such as diesel oil and white oil. When diesel oil is chosen as base oil, the flash point and ignition point should be above 82℃ and 93℃ respectively, and the aniline point should be above 60℃.
(2) Selection of oil-water ratio
A reasonable oil-water ratio of oil-based drilling fluid or whole oil-based drilling fluid shall be selected by taking full account of the requirements of drilling engineering and reservoir protection, current situation of process technology and cost factors.
(3) Water phase activity control
It is advisable to use brine as the inner phase for oil-in-water emulsion drilling fluid, and to adjust the water phase activity of drilling fluid to be equivalent to that of formation water. The type and concentration of salts should be selected according to the requirements of water phase activity control of drilling fluid, the ability of various salts to regulate water activity, the supply of required salts and other related factors. The lowest water phase activity can be controlled at 0.75 by saturated sodium chloride brine, while the water phase activity can be controlled below 0.4 by saturated calcium chloride brine.
(4) Emulsion-breaking voltage
The emulsion-breaking voltage of oil-based drilling fluid is a key reference index for the stability of emulsifying system. A higher emulsion-breaking voltage indicates a more stable emulsion. The emulsion-breaking voltage for water-in-oil emulsion drilling fluid should be above 400V.
(5) Density
The density of drilling fluid should be designed based on the highest pore pressure of the formation in the open hole interval, and a safety added value should be added. The added value for oil wells should be 0.05g/cm3~0.1g/cm3 or 1.5MPa~3.5MPa; the added value for gas wells should be 0.07g/cm3~0.15g/cm3 or 3.0MPa~5.0MPa.
The drilling fluid density should be reasonably designed according to the pressure value of overlying strata when drilling in the special complicated stratum, such as gypsum/slat bed, which is prone to plastic deformation. When drilling in collapsible strata, the drilling fluid density should be reasonably determined according to collapse pressure.

4. Determination of pol-based drilling fluid composition:

Oil sample (PND-drilling fluid oil) + organic soil +2.5% primary emulsifier +1.0% auxiliary emulsifier +0.5% wetting agent +5% filtrate reducer type II +2.5% calcium oxide +25% anhydrous calcium chloride solution + barite.

Table 1. Performance Design Items of Oil-Based Drilling Fluid

Items	First Spud-in	Second Spud-in	Third Spud-in	Fourth Spud-in	Fifth Spud-in
Density (g/cm^3)	√	√	√	√	√
Funnel viscosity (s)	√	√	√	√	√
Plastic viscosity (mPa.s)	—	√	√	√	√
Yield value (Pa)	—	√	√	√	√
Gel strength, 10s/10min (Pa)	—	√	√	√	√
HTHP filtrate loss (mL)	—	√	√	√	√
Lime alkalinity (mL)	√	√	√	√	√
Emulsion-breaking voltage (V)	√	√	√	√	√
Aqueous salt concentration (%)	√	√	√	√	√
Solid content % (percent by volume)	—	√	√	√	√
Water % (percent by volume)	√	√	√	√	√
Oil % (percent by volume)	√	√	√	√	√
Sand content % (percent by volume)	—	√	√	√	√

Note: "√" is mandatory, and "-" is optional.

5. The hydrocarbon reservoir protection design is described as follows:

(1) The hydrocarbon reservoir protection design is mainly based on the composition and content of reservoir formation minerals; main reservoir space characteristics (reservoir rock cementation types and pore connectivity features, the size, shape and distribution of pore throat, fracture development degree), analysis data about porosity, permeability, saturation, reservoir pore pressure, fracture pressure, ground stress, formation temperature and formation water; evaluation data of velocity sensitivity, water sensitivity, acid sensitivity, alkali sensitivity and stress sensitivity.

(2) Reasonable technical measures of reservoir protection drilling fluid should be employed depending on the different characteristics of oil and gas reservoirs and well completion methods.

(3) The reservoir protection materials and weighting materials should be acid-soluble, oil-soluble or other plug-removal materials as far as possible.

(4) During reservoir drilling, the solid content of drilling fluid should be reduced as far as possible, the filtrate loss of drilling fluid should be strictly controlled, and the quality of mud cake should be improved. The filtrate loss of the clay-free drilling fluid can be appropriately relaxed.

(5) The alkalinity of drilling fluid, the salinity of filtrate and the type of dissolved ions should be well compatible with the formation to avoid alkali sensitivity, salt sensitivity and salt scale damage of the reservoir.

(6) The reservoir damage evaluation of drilling and completion fluid was conducted in laboratory in accordance with SY/T6540 Lab Testing Method of Drilling and Completion Fluids Damaging Oil Formation, and the core permeability recovery value should reach more than 75%.

The selection of drilling fluid system should meet the geological purpose and drilling engineering needs, and be economical, low-toxicity, low-corrosion, and beneficial to reservoir and environmental protection.

6. Conclusion

This paper makes improvements to BP neural network, because the different characteristic orders vary greatly, so the normalization method is used to normalize the sample data, so that the neural network input layer variables are independent of each other, and the data set is distributed in the data set. In addition, adjusting the number of hidden layer nodes to train and optimize the network, on the basis of dissolved gas analysis, the BP neural network for fault diagnosis 5-9-6 structure is designed, the initial weight and threshold of BP neural network are optimized by genetic algorithm and gray wolf algorithm, and the failure diagnosis accuracy of GWO-BP neural network is improved by 10%, which reaches 80%.

Against some shortcomings of deepwater oil-based drilling fluid, the performance adjustment of various drilling fluid treating agents and the action mechanism of oil-based drilling fluid treating agents were studied, based on which an environmentally friendly, high-performance, deepwater oil-based drilling fluid system was developed in this paper.

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