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Research Status of Deepwater Drilling Fluid on Artificial Intelligence

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Abstract. The potential benefits of creating intelligence are huge, Oil, as the world's main energy material, is an important energy that relates to the national economy and people's livelihood. In recent years, with the rapid development of national economy and society, the demand for energy has also increased. In this context, deepwater energy has become the focus of attention. In this paper, the research results of and the challenges faced by deepwater drilling fluid at home and abroad in recent years are summarized.

Key words: Artificial Intelligence; Deepwater; Drilling Fluid; Challenges

1. Introduction

The academic community is not alone in warning about the potential dangers of AI as well as the potential benefits. According to the survey of the BP Statistical Review of World Energy 2021, the primary energy consumption fell by 4.5% in 2020, the largest decline since 1945, but China was almost alone in increasing oil consumption (220,000 barrels/day) amid a 9.3% drop in global oil demand. At present, the proven reserves of oil and gas in the ocean are considerable. Since 1979, the world's offshore oil exploration has gradually developed towards the deepwater area, and deepwater oil and gas resources have become the focus of oil exploration and development at home and abroad. New electric engines coupled with artificial intelligence and autonomous systems will contribute to a more efficient, integrated transport system that is less polluting and less noisy.

2. Overseas Research Status

2.1 BP neural network

The BP neural network first initializes the network and then sets the output value based on the given input vector and expectations. By calculating the error, if the error is too large, the correction weight and threshold. To determine whether the network still has unlearned samples, if there is, re-enter into the network, if not, update the number of training, determine whether the error meets the requirements, if the requirements are met, the network training ends, if not meet the requirements, the error is re-entered to the network.

2.2 Genetic algorithm

Genetic algorithm is an optimization algorithm with global search, which is suitable for application in the problem of extreme value. The survival of the fittest in nature is the law on which genetic algorithms are based, and in order to obtain the best adaptability value of the individual, the group will evolve in the direction of optimal solution. The main processes of genetic algorithms are replication, cross-cutting and variation. In the evolution of a group, in order to obtain the adaptability value of each generation of individuals, this series of operations needs to be carried out continuously. In each generation, the quality of chromosomes is measured by the degree of adaptability, and after several iterations, the genetic algorithm converges on the chromosomes with the best adaptive values, and the chromosomes of this generation are likely to be the optimal solution to the problem.

(1) R Gandelman et al. (2007) investigated gelation and solidification of synthetic-based drilling fluid in ultra-deepwater environment, aiming to quantify the effect of pressure on solidification temperature and develop an evaluation method for thixotropic fluid properties. Coupled with steady and transient shear and oscillation tests, they finally developed additives and drilling fluid formulation with a pour point below 0°C.

(2)Md. Amanullah et al. (2009) applied nanotechnology to the development of drilling fluid additives for the first time. The high thermal stability of nanoparticles and their ability to adapt to acidic gas environment can significantly reduce the risk of oil and gas exploration and production. They also anticipated that non-toxic biodegradable nanoparticle-based drilling fluid will meet current and

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future requirements for drilling and production in deepwater and sensitive environment.
(3) Based on the previous work, J Abdo et al. (2012) developed nano-enhanced drilling fluid, which has high stability and avoids problems such as plugging, difficulty in borehole cleaning, and improper hydrostatic pressure manipulation. Compared with bentonite, nano-synthetic additives are cheaper.
(4) QS Yue et al. (2013) studied the rheological properties of water-based drilling fluid under deepwater drilling conditions. The experimental results show that without considering the influence of pressure on rheological properties of water-based drilling fluid, the viscosity and dynamic shear force of drilling fluid increased obviously with the decrease of temperature, and their increase was roughly the same; The apparent viscosity ratio from 4℃ to 20℃ was basically 1.50. The analysis shows that the viscosity of water-based drilling fluid depends on the viscosity of dispersion medium, and the viscosity and temperature characteristics of water-based drilling fluid are determined by the properties of water medium.
(5) Maliheh Dargahi-Zaboli et al. (2017) studied the formation of stable oil-water inverse emulsion from trimethoxyoctadecylsilane modified silica nanoparticles for use in drilling fluid model, resulting in the formation of milky white fluid with 60μm droplets. In addition, rheological studies have shown that stable water can be obtained in oil inverse emulsion with ideal properties by using hydrophobic silica nanoparticles, and the drilling fluid can be modified by adjusting the properties and content of nanoparticles. Aging tests at 120°C have shown that they are also stable at high temperatures and apply to challenging drilling operations.
(6) Abdo Jamil et al. (2021) studied two different clay, namely nano sepiolite (SP) and attapulgite (AT), as additives for water-based drilling fluid (WBDF) to improve and stabilize rheological properties. This study focuses on the material's procurement, characterization, development of nano form, and testing process as drilling fluid additive under low temperature and high temperature pressure conditions. The optimum properties of the nano materials developed in the size range of 30~60nm and the concentration of 4wt% were determined by experiments. The results show that the stability of DF is strongly correlated with the form characteristics of the tested clay, implying that the properties of DF can be customized by modifying the form of clay, especially the nano form.

3. Domestic Research Status

(1) Qiu Zhengsong et al. (2013) simulated the dynamic environment of low temperature, high pressure and mechanical disturbance in a water depth of 3000m, and evaluated the ability of oil-based drilling fluid to inhibit hydrate formation with the experimental device for hydrate inhibition evaluation. The experimental results show that the oil-based drilling fluid with high-concentration calcium chloride brine as water phase has a good hydrate inhibition effect, and can meet the needs of deepwater drilling; However, with the decrease of oil-water ratio, the possibility of hydrate formation in oil-based drilling fluid increases.
(2) Han Zixuan et al. (2014) synthesized an association polymer treating agent in the laboratory, which can regulate the rheological properties of drilling fluid at low temperature as a flow pattern regulator, so that it has stable dynamic shear force and gelation at low temperature. A constant rheological synthetic-based drilling fluid was made through the optimization of emulsifier and organic soil addition, the comparative study on rheological properties at low temperature at different oil/water ratios and densities. The results show that compared with the traditional synthetic-based drilling fluid, the constant rheological synthetic-based drilling fluid exhibits stable rheological properties over a wide temperature range, and no gelation occurs at low temperature, which ensures the safety of deepwater drilling.
(3) According to Xiong Yong et al. (2016), the geological situation of western South China Sea is complicated, and there are may potential problems such as poor stability of seabed shale, narrow safety density window, thickening of drilling fluid at low temperature, shallow gas and natural gas hydrate. The comprehensive performance evaluation results show that the deepwater HEM drilling fluid system has stable rheological properties at 4-50℃, strong inhibition performance and hydrate inhibition ability, and a good anti-bit bailing effect; In addition, it has excellent sand carrying capacity, salt resistance, calcium resistance and cuttings pollution resistance, with a temperature resistance of 160℃, which can fully meet the requirements of deepwater drilling above 2000m. The drilling fluid was successfully applied to two kilometer-deep wells LS25-1-1 and LS25-3-1 in Lingshui Block of western South China Sea.
(4) In order to solve the technical problem of narrow safety density window in deepwater drilling process, Luo Jiansheng et al. (2017) developed and optimized key treating agents such as emulsifier, wetting agent and flow pattern regulator for synthetic-based drilling fluid with low-viscosity GTL as base fluid, and constructed the deepwater FLAT-PRO synthetic-based drilling fluid system. The results of laboratory performance evaluation show that the new FLAT-PRO synthetic-based drilling fluid system has the advantages of good rheology, little impact of temperature and pressure on dynamic shear force and φ 6, strong anti-pollution ability and good settlement stability. This system has been successfully applied to ultra-deepwater wells in western South China Sea, and shows a good application value.

4. Challenges for Deepwater Drilling Fluid

Solving the safety problem well enough to move forward in AI seems to be possible but not easy. At present, deepwater wells are faced with many technical challenges, such as low temperature, high pressure, narrow density window, gas hydrate and lost circulation, posing many difficulties to drilling work, besides, oil price has fluctuated greatly in recent years. At the same time, higher requirements are proposed against deepwater well fluid technology, that is, considering drilling cost and environmental benefit while ensuring drilling safety.

(1) Low temperature

The temperature of hundreds or even thousands of meters in deepwater wells decreases with the increase in water depth. Usually, the temperature near the 1000 m deep mud line is about 4℃, and there are places where the temperature is lower than the mud line. As a result, during deepwater well drilling operation, the drilling fluid passes through the aquiclude, and the circulating temperature of drilling fluid is much lower than that of conventional wells through heat exchange. Low temperature will thicken the drilling fluid obviously, easily leading to sticking screen and grout runout. At the same time, the circulating equivalent density increases, and the casing shoe is prone to leak under pressure. In addition, significant gelation will occur at low temperatures, which increases the possibility of forming natural gas hydrate.

(2) Poor stability of seabed shale

In deepwater areas, seabed shales are highly active due to difference in deposition velocity, compaction method and water content. River water and seawater carry fine sediments farther and farther away from the coast. Due to the lack of upper compaction, these sediments have poor cementation and are apt to expand and disperse, resulting in excessive solid phase or fine particles being dispersed in the drilling fluid, thereby affecting the drilling fluid performance.

(3) Shallow gas and gas hydrate

The formation of gas hydrate in deepwater drilling is not only an economic problem, but also a safety problem. Gas hydrates have an ice-like structure, consisting mainly of gas and water molecules. They look like dirty ice, but they are not ice in nature. Gas hydrate can be formed above 0℃ under enough pressure. Hydrates dissolved near the seabed or in wells, when cooled, tend to re-condense on marine risers, kill and choke lines, especially in choke lines, drilling risers, blowout preventers, and subsea wellheads, gas hydrates, once formed, can clog gas pipes, tubing, risers and subsea blowout preventers, causing serious accidents. Similarly, hydrate decomposition during drilling can lead to formation weakening, borehole enlargement, cementing failure, and borehole cleaning problems.

According to domestic and foreign literatures, water-based drilling fluid and synthetic-based drilling fluid are mainly used in deepwater drilling, while there is little research on oil-based drilling fluid. This is due 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 of good borehole stability and good wettability, this drilling fluid will not pollute the marine environment, is resistant to high temperature, and protects hydrocarbon reservoir. This is of great significance for rational exploration and development of deep-sea resources under the current environment of low international oil prices.

5. Brief Summary

In a few decades, artificial intelligence (AI) will surpass many of the abilities that we believe make us special. To sum up, deepwater drilling fluids at home and abroad are faced with numerous technical challenges such as low temperature, high pressure, narrow density window, gas hydrate and lost circulation. These problems should be mainly addressed in the future research and development. The drilling fluid system should be optimized with different treatment methods for different well sections and pipe sections.

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