Discussion on harmless treatment technologies of drilling fluid waste in oil and gas fields

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Abstract. Drilling fluid waste is the multiphase stable suspension composed of clay, drilling cuttings, weighting materials, chemical additives, inorganic salts and oil, containing a variety of substances harmful to the environment, such as oil, chemical additives, heavy metals and macromolecule organic compound. The effects of drilling fluid waste on the environment is mainly reflected in following aspects: pollution of surface water and groundwater resources; hardening of soil is harmful to plant growth or even unable to grow, resulting in the soil can not be replanted; various heavy metals and chemical additives affect the growth of animals and plants, and even are enriched in animals and plants, thus endangering human health. It is unfavourable to the implementation of the strategic objective of sustainable development of the environment and economy, so the drilling fluid should be treated innocuously after drilling.

1. Pollution characteristics of drilling fluid waste
There are many kinds of drilling fluid used during drilling well in domestic oil and gas fields, and the pollution characteristics of drilling fluid waste are closely related to the geological characteristics of oil-gas reservoirs, drilling technologies, drilling fluid system, etc.

Chemical agents need to be added to both water-based drilling fluid and oil-based drilling fluid, with as many as 20-40 types, and the pollution characteristics of drilling mud and drilling cuttings produced in drilling are the same. These drilling wastes are characterized by complex components, high pollutant concentration and great treatment difficulty. These drilling fluid wastes should be treated innocuously or utilized as resources in preference, in order to prevent serious harm to the stratum and surrounding environment.

2. Development status of drilling fluid waste treatment
At present, the harmless treatment of drilling fluid waste is nothing more than from the physical, chemical, biological and other aspects. For example, the chemical treatment is to add inorganic coagulant and organic polymer flocculant to the waste drilling fluid, and remove the toxic and harmful substances in the waste drilling fluid based on the principle of coagulating sedimentation; the biological treatment is to reduce the BOD and COD of the relative content index of organic matter in wastewater through the role of microorganisms; the physical treatment is to separate the suspended matter from the waste liquid by using the Hydrocyclone technology and the centrifugal force.

However, the above treatment methods only solve one kind of problems one sidedly, and the treatment technology of drilling fluid waste in China is still in the exploration stage, and the testing
index after treatment are not stable, so it is urgent to have a mature technical system to meet the national or local requirements. How to remove the harmful substances with complex components from the drilling fluid wastes without omission needs to be combined with multi-disciplinary treatment methods from the aspects of treatment process, chemical agents, biological agents, treatment equipment, which can not only achieve targeted and effective removal, stable treatment indicators, but also achieve reasonable process, simplified equipment, and avoid secondary pollution, so as to be applied and popularized in production.

3. Difficulties in treatment of drilling fluid waste
There are many difficulties in treatment of drilling fluid waste, which can be broadly divided into the following three aspects:

Firstly, the geographical location of each oil field in China is different, correspondingly, the hydrological and geological conditions are also different. Therefore, in the treatment of drilling fluid waste, different treatment technologies need to be adopted for conditioning and comprehensive utilization, and the chemical reagents need to be added vary in material and composition, which makes the physical treatment of drilling fluid waste difficult.

Secondly, in the actual treatment process, the waste produced in each well is also different, so it needs to find specific ways in the treatment process, which virtually increases the complexity of the treatment process, treatment equipment and treatment agent.

Thirdly, the waste after treatment needs to overcome the impact of environmental changes and long-term stability to adapt to the severe application conditions on site.

4. Design of a new-type harmless treatment system for drilling fluid waste

4.1. Design principle
The new harmless treatment process of drilling fluid waste is divided into four systems: drilling fluid separation system, solid-liquid separation system, harmless treatment system and water treatment system. The flow of each system is shown in Figure 1.

![Figure 1. Composition of new-type drilling fluid waste harmless treatment process system.](image)

The process design flow is as follows: firstly, the feeding pump delivers the raw materials to each equipment in the drilling fluid separation system in turn, the drilling fluid separation system delivers the produced drilling cuttings after flushing to the solid-liquid separation system, delivers the mud, sand and flushing water to the harmless treatment system, and delivers the separated sewage to the water treatment system. Secondly, the harmless treatment system delivers the solid-liquid mixture after the treatment to the solid-liquid separation system. Thirdly, the solid-liquid separation system collects the separated solids to the mud tank and adds the curing agent to make bricks, and delivers the separated liquid phase to the water treatment system. Fourthly, the water treatment system recycle the partial liquid for drilling, and the remaining liquid is discharged after harmless treatment.
4.2. Design scheme

• The drilling fluid separation system includes shale shaker, degasser, desander, desilter, centrifuge and flushing device. The shale shaker separates the solid particles in the mud flowing through the screen cloth by high frequency oscillation. The screen cloth of the vibrating screen is from 100 mesh to 200 mesh, mainly used for treating large solid particles.

The drilling mud enters the degasser after rock cuttings removed by the shale shaker, which is to prevent the gas carried in the drilling fluid from the well during the drilling from affecting the mud performance and potential safety hazards.

The drilling cuttings generated by the shale shaker are washed by the washing device and then enter the dryer, the solid phase through drying does not contain harmful substances and can be directly discharged or buried and the liquid phase enters the multiple-effect reactor for harmless treatment.

The centrifuge can remove the free liquid on the surface of solid particles. The larger the rotating speed of the centrifuge is, the smaller the particle size of solid particles can be separated. Generally, the rotating speed is 2800r / min to 3200r / min.

The flushing device flushes the drilling cuttings separated from the shale shaker to remove the residual harmful substances, and the flushing water enters the multiple-effect reactor for harmless treatment, so as to ensure that the separated solid phase meets the requirements of harmless treatment.

• Harmless treatment system includes dosing device and multiple-effect reactor.

The agents used in the harmless treatment system are harmless treatment agents, including NF-10 leaching agent, NF-21 gel breaker, NF-32 flocculant dehydrating agent and NFO oxidizing agent. NF-10 leaching agent has biodegradability and strong metal chelating ability. NF-21 gel breaker is the microbiology flora that can degrade oil and organic pollutants, which directly transforms organic pollutants into organic fertilizer and can be used as resources. NF-32 flocculant dehydrating agent is the chitosan natural polymer flocculant, which has the functions of flocculatin, chelating and bacteriostasis. NFO oxidizing agent has strong oxidizability, can break the gel and oxidize, with obvious effect of removing COD.

After harmless treatment, the mud is transported to the solid-liquid separation system for solid-liquid separation, the separated mud cake can be transported out or added with curing agent to make bricks, and the separated water enters the water treatment system.

• Solid-liquid separation system includes dryer and pressure filter to realize solid-liquid separation.

The separated mud cake can be cured by adding composite curing agent. Due to the complexity of mud composition, single curing agent can not fully meet the curing requirements, composite curing agent is used in practical application, which is is a mixture of various curing agents in a certain proportion. The curing agent used includes lime, cement, water glass and Polymeric Aluminum, after curing for 72 hours, it meets the relevant standards after testing and has the characteristics of low curing cost.

The solidification treatment of waste mud can solidify, seal and transform the harmful substances contained in waste drilling mud, and take reliable treatment of the waste mud, which meets the requirements of the state for pollution-free treatment of solid wastes. Moreover, because the solidification treatment technology of waste drilling mud has the advantages such as convenient construction, short cure cycle, simple process, low cost and strong water absorption, and transforme the harmful substances.

• Water treatment system includes buffer tank and water treatment device.

The water treatment device adopts electro-catalytic oxidation device, air flotation equipment, dosing device and filtration device to realize the harmless treatment of sewage and reach the discharge standard.

Specifically, the pH of the water is adjusted by the dosing device, the organic substances are further decomposed by electro-catalytic oxidation and have sterilizing effect. The air flotation device and filter device can effectively remove the oil and suspended solids in the water, so as to achieve the discharge standard.
5. Conclusion
This paper provides an effective reference for the harmless treatment of drilling fluid waste in various oil and gas fields in China, which has achieved good applying effects in practical application. However, we have to admit that the harmless treatment of drilling fluid waste in oil and gas fields is a systematic project, involving the drilling mud system, the mud circulation system, drilling production process and mud treatment system, in order to comprehensively treat the harmless treatment of drilling waste, it is necessary to start from the source of the production process and strictly control each link, only in this way can the harmful substances in the drilling fluid be controlled in an effective range, the purpose of environmental protection can be realized with the lowest treatment cost, and the development concepts of cost reduction, efficiency increase, safety, health and environmental protection in the industry can be met.

References
[1] Oliver, Bober.(2015)Answers to Questions About Drilling Fluids Disposal[J].National Driller,36(2).
[2] Chemical Dewatering Techniqueof Waste Polymer Drilling Fluid[J].China Oil & Gas,1997(01):30-31.
[3] Preliminary Study on the Effect of Borehole on Seismic Waves in the Deep Borehole Observation System[J].Earthquake Research in China,1994(01):98-107.
[4] Jing Zou,Hong Zhu,Fanghui Wang,Haiyun Sui,Jiantao Fan. Preparation of a new inorganic–organic composite flocculant used in solid–liquid separation for waste drilling fluid[J]. Chemical Engineering Journal,2011,171(1).