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Research and Application of Mud Non-landing System in Geological Drilling

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Abstract:

In order to solve the common problem of mud pollution in the current geological drilling, according to the technology characteristics and market demand, combined with the future development direction, a geological drilling mud non-falling system is designed and studied. The whole system adopts a modular design and is divided into four units: wellhead return slurry collection, natural sedimentation module, automatic mechanical sand removal, storage and slurry mixing. After the project application practice, the utility model has the advantages of convenient installation and disassembly, easy relocation, safety and reliability, can basically meet the use demand, and has strong adaptability.

Keywords:

Geological Drilling, Mud Non-landing System, Solid Control Device, Green Exploration

1. Introduction

Mud is the blood of drilling construction. In geological drilling construction, mud with excellent performance can effectively reduce the occurrence of accidents in the hole, reduce the resistance in the hole, and improve drilling efficiency, especially in complex formation construction. It is an indispensable condition for achieving the goal [1]. Practice has proved that the control of the solid phase content of the mud is the key to maintaining the mud performance. At the same time, with the continuous emphasis on environmental protection in today's society, the conflict caused by direct discharge of mud has become more and more intense, the continuous development of green exploration and drilling technology, and the demand for environmental protection treatment of mud in the process of drilling construction is also increasing.

In the field of oil drilling, the mud solids control devices have been widely used after long-term development, and has achieved serialization and standardization, but it has the characteristics of large volume, heavy weight, expensive equipment, to relocate and so on [2,3], so it is unable to adapt to geological drilling. For this reason, we absorb the mature experience, design and develop a new “Mud Non-landing” system with small volume, light weight, cheap price and easy relocation through

technological innovation, to solves the problems of environmental damage and pollution caused by mud circulation and purification at the drilling site. It can not only realize the "zero contact" and "zero pollution" between the mud and the surface soil during the recycling, but also remove the harmful solid phase through the purification of the system solid control device and improve the recycling rate of the mud.

2. Functional Requirements of the Mud Non-landing System

The geological drilling mud non-landing system should have the following functions:

a. It has the basic function of mud circulation and storage. By adopting modular splicing, it can be flexibly combined into different specifications of volume to meet the requirements of mud volume under different hole depths and construction conditions; the joints of each module are well sealed, which can ensure that the on-site mud does not leak during circulation and storage.

b. It has excellent solid control purification ability and improves the reuse rate of mud. Set up a natural sedimentation module, which can combine chemical treatment agents to strengthen the flocculation sedimentation effect; equipped with a light-weight, small-volume automatic centrifuge, which can remove solid particles of 5 μm or more, effectively control the solid phase content of mud, and maintain mud performance to meet the requirements of different drilling techniques, methods and equipment for mud performance.

c. It has the characteristics of modularization, automation and portability, which has the advantages of convenient disassembly and transportation, low labor intensity, easy operation, and can adapt to different working environments.

3. Structure and Performance Parameters of the Mud Non-landing System

The system mainly includes four parts: wellhead return slurry collection, natural sedimentation module, automatic mechanical sand removal, storage and slurry distribution [4].

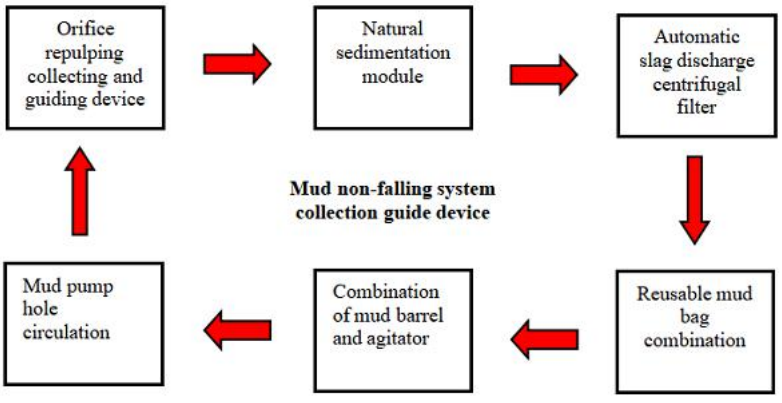

Figure 1. *System flow chart.*

After the mud is returned from the hole to the special orifice device, it is first transported to the mud bag with grid through the connecting pipe, chemical treatment agent can be added to enhance the natural sedimentation effect according to the mud performance, after that, use the low-pressure water pump to extract the sedimented upper slurry to the automatic slag discharge centrifugal filter for automatic

mechanical sand and sludge removal, and then store the treated slurry into the reusable slurry bag assembly, supplement the slurry materials and monitor the slurry performance, and finally pump it into the hole again to start a new cycle (Figure 1). The purification capacity of the whole system is 3m³/h, the power is 2.5kw, and the maximum module size after disassembly is: length × wide × Height = 1400mm × 500mm × 1200mm, with a mass of 180kg, which mainly includes the following components:

3.1. Orifice Device

The Orifice device is made of pipes suitable for the geological drilling rope coring process. The lower part is processed with the same type of thread, which can be directly connected to the orifice. The upper welded outlet pipe is used to export the mud, so as to realize the collection and export of the orifice return slurry under different diameters. (Figure 2)

Figure 2. *Orifice device.*

3.2. Automatic Centrifugal Filtration System

Using CA-2600 automatic slag discharge centrifugal filter, power 2.5kW, rated capacity of 3m³/h, can separate ≥5μm solid phase (Figure 3).

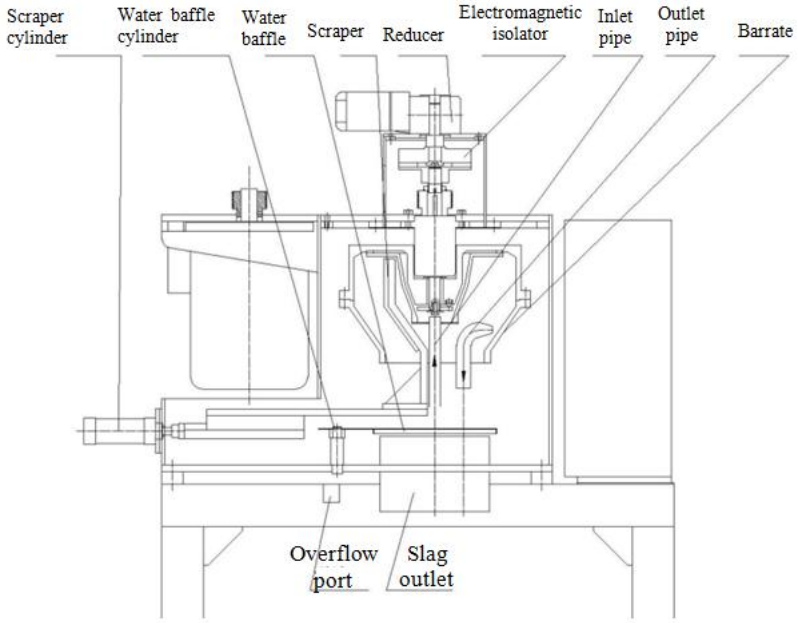

Figure 3. *Centrifuge structure drawing.*

The working process is as follows: when the motor drives the drum to start to rotate, the mud is pumped into the centrifuge drum from the water inlet pipe by the water pump. Under the action of centrifugal force, the solid particles will be deposited on the drum wall, and the clear liquid will flow out of the drum through the water outlet pipe.After working for a period of time, the impurity layer on the drum wall will become thicker and thicker. When the impurity layer reaches a certain thickness (the time interval for slag scraping can be set by the time relay on the electrical box panel according to the on-site working conditions), the drum will Gradually stop the rotation, then the water baffle below the drum is opened, the gear clutch is engaged, the drum is driven by the reducer to rotate at a slow speed, and the scraper is close to the drum wall, scraping off the impurities deposited on the drum wall, from the slag The mouth falls into the trash box.

3.3. Reusable Mud Bags

The mud bag is made of high density polyethylene with a specification of 1m long× 1m wide × 1m high, which has the advantages of good water resistance, strong flexibility, corrosion resistance, good scratch and wear resistance, large volume, easy installation and folding, reusable, environmental protection without pollution. On this basis, two frame support schemes are designed, the first one adopts a lighter frame under the premise of satisfying the strength, which is mainly used as a mud storage container; the other is strengthened in key parts according to the requirements, and the sedimentation grid or mixing equipment can be placed to maintain the mud performance. The inlet and outlet of uniform specifications are arranged on each mud bag, which can be combined and placed according to the requirements of different terrain and hole depth. (Figure 4)

Figure 4. *Mud bag.*

4. Application of Mud Non-landing System

The system has been successfully used in the drilling construction of jinruiyuan mining area in Fanshi, Shanxi, and the effect is good. There are multi-segment crushing zones in the construction formation of the project, which is prone to problems in holes such as falling blocks and collapsing holes. The mining area adopts a new type of advanced and environmentally friendly portable full hydraulic drilling rig Ingel EP600plus, the construction adopts TW series diamond rope coring drilling technology, and uses high performance mud added with cellulose, vegetable gum and other materials.

The project implements the green exploration standard, and according to the requirements, the discharge of mud without environmental protection treatment is strictly prohibited.In the early stage of construction, the mud non-landing system was not popularized, The machine mainly adopts the natural sedimentation method of single long circulation tank and multiple sedimentation tanks to purify the mud, prolong the service life of the mud, and then pump it to the waste mud tank for treatment when the mud performance cannot meet the construction requirements. This method has some problems, such as large area occupied, low treatment efficiency, difficult to guarantee mud performance,weak effect of green environmental protection. After comprehensive consideration, the practical application of mud non-landing system was carried out. The following data are selected from four boreholes with basically the same stratigraphic conditions on two exploration lines in the same mining area, and the comparative analysis is made in terms of construction efficiency, mud performance, related material consumption, and green exploration effect.

4.1. Comparison of Construction Efficiency

The four boreholes adopt the same type of equipment, process and mud formula, among which ZK1101 and ZK1501 do not adopt the mud non-landing system, and zk1102 and zk1502 adopt the mud non-landing system (Table 1). By comparison, the average monthly efficiency of the machine without the mud non-landing system was 695m, and the average monthly efficiency of the machine using the system was 825m, an increase of 18.7%.

Table 1. *Comparison of drilling construction efficiency.*

Serial number	Hole number	Construction equipment	Final hole depth/m	Final hole diameter/mm	Construction Period/d	Efficiency unit per month/m	Average efficiency unit per month/m	Note
1	ZK1101	EP600pluss	460.88	NTW	19	727	695	Circulating mud, without mud non-landing system
2	ZK1501	EP600pluss	529.58	NTW	24	662		
3	ZK1102	EP600pluss	479.58	NTW	16	899	825	Circulating mud, with mud non-landing system
4	ZK1502	EP600pluss	550.58	NTW	22	750		

According to the on-site feedback and simple shift report records and statistics, there are three main reasons for mud to affect the monthly efficiency of drilling platform, First, a large number of solid particles in the circulating mud are not cleaned in time, which aggravates the damage of seals in water pumps, faucets and other parts, and increases the equipment failure and maintenance time; Second, the mud with high solid content is easy to produce mud skin on the inner wall of the drill pipe, which seriously affects the fishing and bottom speed of the inner pipe of rope coring; Third,

in the process of mud performance maintenance, frequent slag fishing, slurry replacement and harmless treatment of waste slurry have increased the labor intensity and time consumption of on-site construction personnel.

4.2. Mud Performance

During the two drilling constructions of ZK1102 and ZK1502 with mud non-landing system, the density, sand content, viscosity and other basic properties of the mud returned from the wellhead (before purification) and the treated mud (after purification) were tested and compared. The test data are shown in Table 2.

By comparison, it is found that the average sand content of the mud before purification is more than 4%, and the average sand content of the mud after purification is less than 0.8%, the sand removal effect is remarkable, and the sand content of the geological core drilling mud is basically less than 1%, and the design purpose of the device is achieved. In addition, the removal of harmful solid phase effectively reduces mud viscosity, water loss, and improves mud performance.

Table 2. *Performance comparison before and after mud purification.*

Project	Sample number	Density (g/cm^3)	Sand content%	Funnel viscosity (s)	Water loss (30min)
Before purification	1	1.060	4.5	39	7.1
	2	1.070	5.0	42	7.4
	3	1.060	4.5	40	6.9
	4	1.080	5.0	44	7.8
	average	1.0675	4.75	41.25	7.3
After mud purification	1	1.040	0.5	26	6.3
	2	1.035	0.5	25	6.0
	3	1.030	< 0.5	23	5.8
	4	1.035	0.5	24	6.1
	average	1.035	0.5	22	6.05

4.3. Related Material Consumption

Using the mud non-landing system to maintain the mud performance can reduce the generation of waste mud, save mud materials, delay the loss of seals and reduce the drilling cost.Through the statistical comparison of the loss of mud materials and equipment of the four drilling holes. It is found that the mud cost of ZK1101Z and ZK1501 is high, especially the seal loss at ZK1501 pump, faucet, etc. is serious, which seriously affects the efficiency unit per month and the mud cost is the highest at the same time. On the contrary, zk1102 and zk1502 have effectively maintained the mud performance by using the mud non-landing system, so there is no need to change a lot of mud, which reduces the mud consumption and seal loss. Compared with the mud without using the mud non-landing system, the average cost is reduced by more than half. (Table 3)

Table 3. *Drilling related material consumption statistics.*

status	Hole number	Related materials cost/RMB			Total/ RMB	workload/ m	Cost (RMB/m)	average cost (RMB/m)
		bentonite	mud materials	Water pump, faucet				

				and other seals				
without mud non-landing system	ZK1101	3000	3200	1200	7400	460.88	16.06	17.77
	ZK1501	4200	3600	2400	10200	529.58	19.26	
with mud non-landing system	ZK1102	1200	1800	600	3600	479.58	7.5	8.06
	ZK1502	1800	2000	900	4700	550.58	8.5	

4.4. On-site Green Exploration Evaluation

The field application shows that the use of the mud non-landing system is more in line with the requirements of green exploration and geological drilling. During the construction, the mud pool and the large waste liquid pool are not excavated, which reduces the destruction of vegetation and the excavation of soil and stone, and causes less damage to the ecological environment of the mining area. The mud is all in the pipeline, the machine site is clean and tidy, there is no mud leakage accident, and the amount of waste pulp is less, basically achieving “zero emission” and “zero pollution”.

5. Conclusions

Combined with the construction characteristics of geological drilling, the designed geological drilling mud non-landing system can effectively control the solid content of mud, improve the mud skin on the inner wall of drill pipe, reduce the damage of equipment seals, ensure the stability of mud performance, reduce mud cost, improve construction efficiency, obtain certain economic benefits, and achieve the purpose of research and application.

Through multi-unit modular combination, the whole system includes the existing drilling site mud circulation system, which is convenient for installation and disassembly, convenient for relocation and transportation, and can meet the construction needs of drilling holes of different depths in different areas. There is no need to dig mud ponds and large waste liquid tanks, so it does little damage to the ecological environment of the work area, can basically achieve "zero" discharge, which can effectively support the development of green exploration and drilling technology. Also has a certain reference value for the optimization and improvement of the mud non-falling system in the geological drilling site in the future.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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