# Design and establishment of ground command experiment platform in drilling

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**Keywords:** intelligent drilling, the down link command, experimental platform

**Abstract:** It is necessary to intervene the downhole drill drilling direction in an intelligent drilling system, this paper studies the method of computer instructions transmitted intervention from the ground to the underground, designs and builds a set of simulated intelligent drilling system indoor experiment platform on which a command can be transferred, and test verification. The results show that will be a very good indoor experiment platform, it can transmit a control signal to the underground. The research results provide a reference for attitude intervention methods of downhole drilling tools in the intelligent drilling system as well as an experimental verification platform for instruction coding method research, downhole complex environment construction and weak signal detection.

## 1. Introduction

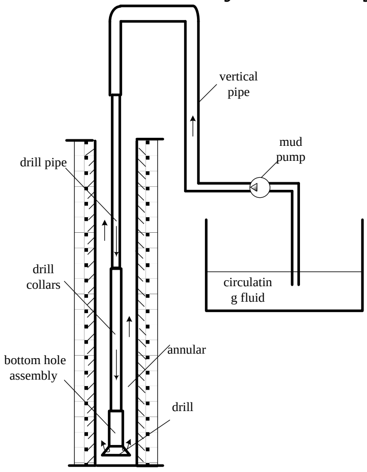
Rotation-guided closed-loop drilling technology is an advanced intelligent drilling technology [1], and the intervention of underground tool working attitude is essential [2]. In the aspect of information transmission from the surface to the underground, some foreign researches use electromagnetic wave and mud as the medium for signal transmission [4], and some mature products transmit information through mud pulse [5]. The domestic research direction mainly focuses on mud pulse, drill pipe drilling speed and other aspects [3]. These technologies have their own advantages and disadvantages, so they are all in the principle scheme stage. in order to reduce cost and as far as possible use of mature technology, in recent years, domestic studies have focused on mud transmission scheme [6], at present this technology has not been a breakthrough, downward drilling to achieve control instruction still need interrupt drilling, Obviously, this will greatly reduce drilling efficiency, so it is imperative to study a method of downlink instruction without stopping the drilling.

## 2. Working principle

The composition of the actual drilling equipment is shown in FIG. 1. It is better not to change the drilling technology of the existing well site, and try to use more mature technology. Therefore, a method is proposed to increase the “diverging” device to realize the information transmission from the ground to the underground, that is, to add a branch pipeline from the mud pump outlet to the wellhead, and install a switch circuit on the branch to achieve the purpose of “diverging”. Under normal circumstances, the mud flow in the drilling platform is provided by the mud pump in the surface mud pit. The mud enters the drill pipe along the direction of the arrow in the riser, reaches the drill string, passes through the bit nozzle, and finally returns to the surface mud pit from the annulus cavity of the borehole to form the circulation system. At this point, the pressure sensor in the drill bit senses the pressure of the slurry. The branch pipe is introduced out from the riser, and the branch pipe is connected to the switch valve. When the switch valve is opened, the mud flows instantaneously, causing the pressure in the riser and the drill bit to plummet. When the switch valve is closed, the pressure of the circulation system gradually returns to normal. A series of negative mud pulses are generated between the opening and closing of the switch valve. When the switch valve is opened, the

  DOI: 10.25236/ciais.2019.044

instantaneous acceleration of mud flow in the branch pipeline is large, which may lead to pressure rebound. In order to avoid such a situation, it is necessary to connect the switch valve with the mud pool with a pipe with a larger diameter, and increase the accumulator to stabilize the liquid flow. In addition, in order to control the liquid flow pressure, a set of throttle valves can be added on this basis. In order to protect the switch valve and prevent mud from flowing back from the pipe, a one-way valve must also be installed on the pipe. Manual valves can also be installed on the tubing as necessary to ensure the reliability and safety of the drilling system.



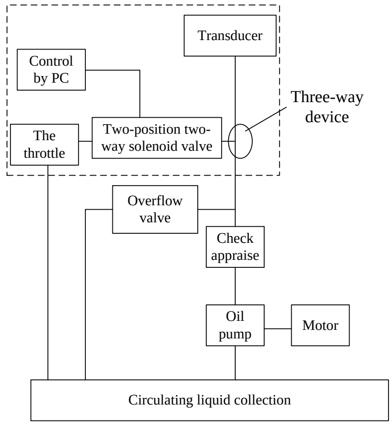



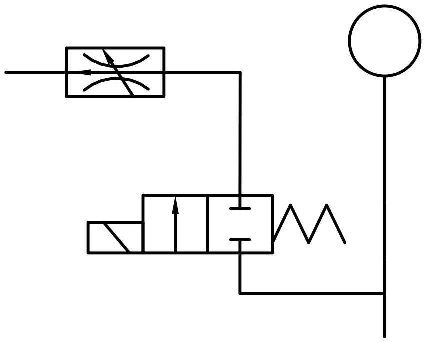

Figure 1 Actual drilling equipment composition Figure 2 Schematic diagram of a simulated drilling equipment

A set of hydraulic circulation system is designed to simulate the actual drilling cycle, as shown in FIG. 2. The bypass valve branch and sensor sensitive device are added in the main circulation loop to meet the requirements of the real device. The three-way pipe with matching diameter integrates the bypass branch, downhole sensitive mechanism and main circulation path, as shown in the dotted line in FIG. 2. The control circuit is designed to open or close the two-position two-way solenoid valve. The solenoid valve is installed in the front end of the sensor equipment. The specific working process of the system is as follows: Start the motor to provide power for the circulation system, the oil pump starts to work, adjust the overflow valve to ensure the highest pressure of the system, when the system pressure is greater than the limit pressure, the high-pressure oil flows back to the collection pool through the overflow valve. Normally the solenoid valve closed, PC control valve body opened to complete the bypass principle. The throttle valve is used to adjust the flow of liquid into the well. In the actual drilling, the distance from the wellhead to the bottom of the well is relatively long, and there will be time delay in the change of system pressure. Therefore, this phenomenon can be simulated by lengthening the tubing line in the experiment.

## 3. The construction of the experimental platform for information transmission

### 3.1 Solenoid valve selection

The displacement of the hydraulic pump cannot be founded. The reference figure for calculation is shown in FIG. 3, where the motor power is used as the premise to calculate:



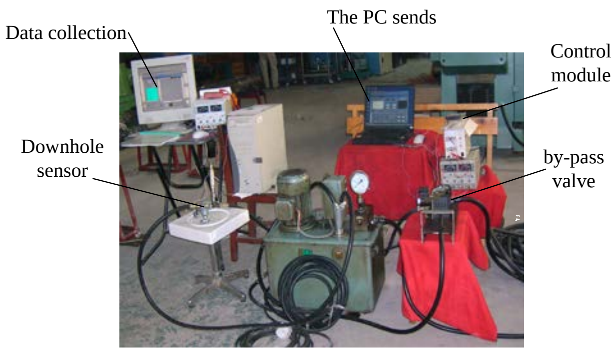



Figure 3 Schematic diagram of bypass calculation      Figure 4 Experimental platform

$$p_0 = \frac{pQ}{60}[7] \tag{1}$$

($p_0$-- motor power (KW);p--- the working pressure of the system (4MPa);Q - --flow (l/min)

After calculation, Q=16.5 l/min, At present, the common sizes of solenoid valves on the market are 6mm and 10mm, and the minimum sizes of throttle valves are 10mm. Therefore, three kinds of data are used to calculate the pressure difference of the system. Switch solenoid valves are selected respectively with a diameter of 10mm and a flow rate of 40 l/min; 6mm, flow rate 10 l/min;

The throttle valve size is 10mm, and the throttle range is 1.6 l/min ~ 40 l/min for flow differential pressure estimation. According to the formula

$$q=C_d A_0\sqrt{\frac{2\Delta P}{\sigma}}[7], \tag{2}$$

$$\Delta P=\frac{1}{2}\left(\frac{q}{C_d A_0}\right)^2\sigma \tag{3}$$

(q-- flow coefficient; $C_d$-- the cross;$A_0$-sectional area of the flow orifice; Δp-- pressure difference before and after closure; σ--liquid density)

According to the above analysis and calculation, the following conclusions can be drawn: (1) the solenoid valve has a diameter of 10mm with a flow rate of 40 l/min and the throttle valve is all open with a flow rate of 40 l/min. However, the pump flow rate is 16.5 l/min. Therefore, after the solenoid valve is opened, the flow rate at the throttle valve is 16.5 l/min, and the pressure difference at both ends of the throttle valve is

Δp = 0.008 MPa, (2) the size of the solenoid valve 6 mm, the flow of 10 liters/minute, throttle valve is all open state flow every minute 40 liters, so when the solenoid valve open, the system will be at the bottom of the solenoid valve circuit there is high pressure (because the solenoid valve flow is less than the system flow), throttle valve open position without adjustment effect, calculate the pressure difference at both ends of the solenoid valve Δp = 0.024 MPa, (3) when the flow at the throttle is 1.6 l/min, estimate the pressure difference between the two ends of the valve

Δp =31.3MPa

But at this time, the pressure of the overflow valve control system is maintained at 4MPa.

### 3.2 Selection of pressure sensor

Select pressure sensor the model produced by Beijing avic electromechanical research institute is cyb-20s thin film pressure transmitter, with a range of 0 ~ 40MP and a power supply requirement of +5VDC.

### 3.3 Establishment of experimental platform

According to the above theoretical calculation and the selection of solenoid valve and pressure sensor, the established experimental platform is shown in FIG. 4

### 3.4 Pressure sensor calibration

With 1MPa as the unit, change the pressure output of the standard manometer (0 ~ 25MPa), increase and decrease the pressure successively, repeat three times, use the data acquisition circuit to collect the sensitive signal output of the sensor, and obtain the output characteristic curve of the pressure sensor through the measured data as shown in FIG. 5.It is not difficult to see that the output of the sensor is a standard voltage signal with good linearity, which is connected to the signal acquisition circuit board for acquisition.

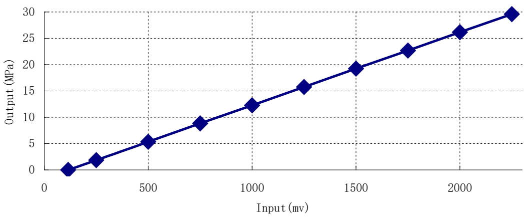



Figure 5 sensor output characteristic curve

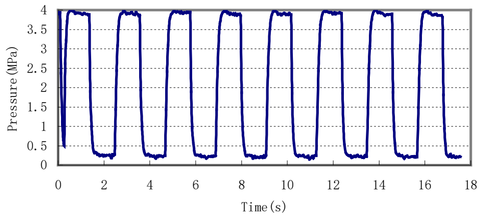



Figure 6 Electromagnetic valve working process system pressure change curve

### 3.5 Control design and valve opening test

Whether the solenoid valve can be opened as scheduled is the key to send down command by computer control The DC-DC controllable power supply produced by xi 'an spectrum power supply co., ltd. is selected to convert the DC voltage of +12V into the DC voltage of +24V. When the control signal comes, the output voltage of 24V will be available. This design is conducive to reducing the power consumption of the whole system. Choose to conform to the requirements of the equipment 22EH - H6B bidirectional solenoid valve, power consumption of 40W or less, through the computer serial port to send command, SCM according to the state, output level by 74LS04 drive circuit power module, main chip P5.0 C8051F060 port output high/low level, according to certain rules, transform the +12V power supply solenoid valve core and the voltage of +24V, The electromagnetic valve opens, the bypass oil circuit is conducted, and the pressure in the main circulation system is reduced and monitored by the pressure sensor. The experiment shows that the solenoid valve can work normally, and a group of valve opening data is selected as shown in FIG. 6.

### 4. Conclusion

Based on the theory of intelligent drilling system, and builds a set of indoor simulation experiment platform for attitude intervention of downhole drilling tools, selects the key components in the experiment platform, and explains the principle and function of the main components in detail. The experimental data show that the experimental platform can realize the downhole instruction transmission under the computer control during drilling, which provides the reference for the research on the information engineering under the computer control. At the same time, it can also provide experimental verification platform for coding method research, downhole complex environment construction and weak signal detection.

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