Test principle and measuring method of friction coefficient of drilling fluid lubrication tester

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Abstract. This paper introduces the test principle of the friction coefficient, and then introduces its measurement method, which provides a theoretical basis for the overall design of the tester. We propose the following scheme: design a set of DC pulse width modulation (PWM) servo control system with microprocessor as the control core. The whole system needs to detect four physical quantities: motor speed, motor armature current, excitation current and pressure. The current transformer is used to detect the armature current and excitation current of the motor, and the friction coefficient and film strength are converted by microprocessor to keep the excitation current constant. The speed sensor is used to detect the speed of the motor, the pressure sensor is used to detect the applied pressure, and the microprocessor is used to realize the automatic control of the speed.

Keywords: Drilling; Friction coefficient; Drilling lubricant

1. Test principle of friction coefficient

When two objects (such as A, B) are in contact with each other and produce relative displacement, not only a pressure orthogonal to the contact surface but also a frictional force parallel to the contact surface is generated. If A is to maintain a certain speed (B is the reference), it must be constantly given a certain external force, at this time A also receives a certain amount of friction, this value of friction is called sliding friction [1]. The direction of the sliding friction is opposite to the direction of the relative speed. Experiments have shown that the sliding friction force F is proportional to the pressure P and has an expression:

$$F = \mu P \tag{1}$$

Where: F represents friction, the unit is N;

P Represents the vertical force on the friction surface, the unit is N;

μ Represents the friction coefficient.

It can be seen from the formula (1) that the friction coefficient μ can be measured as long as the vertical force P and the friction force F on the friction surface are measured.

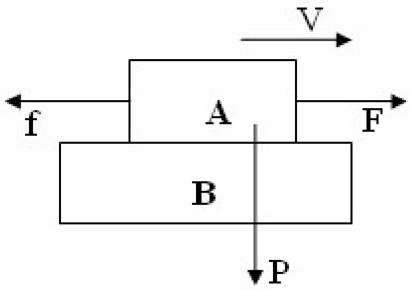

Fig 1. Schematic diagram of the relative displacement of two objects

The friction coefficient μ is related not only to the material and surface condition of the contact object, but also to the relative motion speed. In order to reduce the "friction coefficient", a liquid film, that is, a "lubricating film" may be applied between the two contact faces. The reduction in the "friction coefficient" is determined by the quality of the liquid film, which is the chemical agent that improves the quality of the liquid film. The smaller the friction coefficient, the stronger the ability of the lubricant to improve the friction between the two contact faces.

2. Determination method of friction coefficient

Replace the two objects that slide in parallel with the slider and the slip ring, and add a positive pressure perpendicular to the slip ring on the outside of the slip ring. The friction coefficient should be determined under the following standard conditions:

1. Slip ring movement speed 60 rev / min.
2. The force on the slider 444.8 cattle.

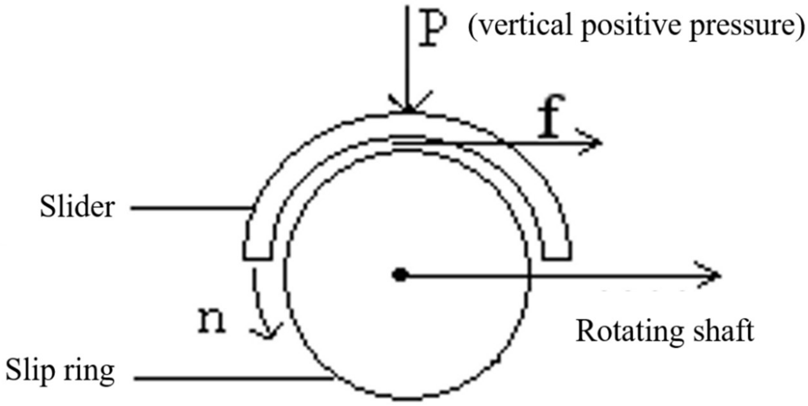

Fig 2. Parameter simulation test device

In order to obtain the correct fit of the slip ring and the slider when measuring the friction coefficient, the slip ring and the slider must be worn in. The surface of the slider should be smooth and scratch-free after running-in. If all the blocks and rings have the same metal structure, the friction coefficient for distilled water should be 0.34 under the above standard conditions. However, since this ideal situation does not exist, the correction factor CF must be determined [2].

The determination of CF is as shown in (2):

$$CF = \frac{0.34}{\mu} \tag{2}$$

Where CF represents the correction factor;

μ represents the friction coefficient.

In the actual test process, if the medium to be tested is distilled water, the measured friction coefficient should be in the range of 0.32 to 0.36. Exceeding this range, it can be considered that the slider and the slip ring are not worn-in and should be re-run.

After the correction factor is measured, the friction coefficient can be measured according to the calculation formula of the friction coefficient of the sample. The formula for calculating the friction coefficient of the sample is shown in (3):

$$\mu = \frac{F(CF)}{P} \tag{3}$$

Where: F represents friction, the unit is N;

μ Represents the friction coefficient;

CF represents a correction factor;

P represents vertical positive pressure in units of N.

3. Measurement and control implementation

According to the test principle, in order to complete the test of the friction coefficient, there must be two objects that slide in parallel. The slider and the slip ring are now used instead of the two objects that slide in parallel; in addition, it can be known from the measurement method that the moving speed of the parallel sliding object is the peripheral speed. Therefore, the motor is selected as the driving power, that is, the slip ring is mounted on the rotating shaft of the motor, and the slider is fixed. The vertical force can be added to the slider to simulate the parallel sliding object by controlling the rotation of the motor shaft. The plane diagram is shown in Figure 3.

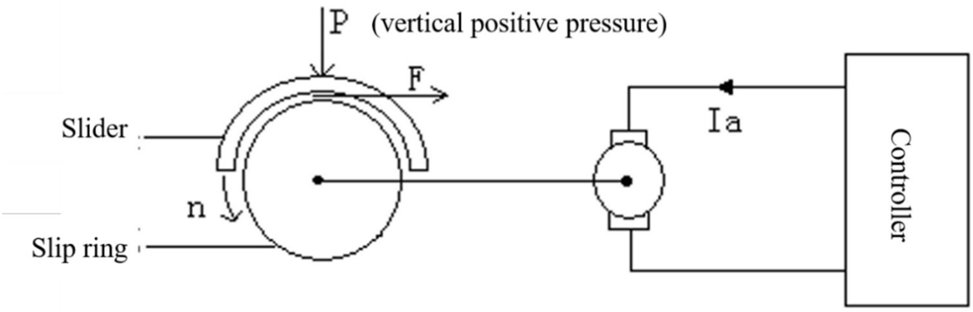

Fig 3. Schematic diagram of the parallel sliding of the slider and the slip ring

Through investigations, it is found that because the drilling fluid lubrication tester produced abroad is relatively expensive, most domestic oilfields generally use domestically produced lubrication testers, but the drilling fluid lubrication tester produced in China has two shortcomings. It is only possible to measure the friction coefficient and not visually display the values. These instruments use a tachometer to indicate the relative motion speed, the pressure gauge indicates the vertical positive pressure and the torque meter directly indicates the friction due to the relative motion, and then pass the chart. Or formula conversion, which brings great inconvenience to the user; Second, the motor speed cannot be automatically controlled, only by manually adjusting the potentiometer to achieve the required speed.

In view of the current status of the drilling fluid lubrication tester, we propose the following design idea: According to the motor drag theory, when the DC-excited motor runs at a constant speed and a vertical force is applied to the slider, it acts on the motor shaft. The electromagnetic torque $T = C_M \phi I_a$ and the friction torque T_f are balanced [3-4], and the friction generated on the contact surface between the slider and the slip ring is proportional to the amount of change ΔI_a of the armature current of the motor. Among them:

$$\Delta I_a = I_a - I_0 \tag{4}$$

Where: I_a represents the armature current with load;

I_0 represents the armature current at no load.

The formula F=μP can be converted into:

$$\Delta I_a = \mu_1 P \tag{5}$$

Therefore, as long as the force P acting perpendicularly on the slider is fixed, the friction coefficient μ_1 can be calculated by detecting the armature current of the motor and sending it to the microprocessor for calculation under the condition that the motor speed is constant. The positive pressure P acts vertically on the slider through the torque wrench. Since the torque wrench measures the moment, its unit is N·m. If the arm is fixed, the automatic pressurization of the pressure is achieved by a stepping motor.

Since the DC motor has good starting and braking performance, it is suitable for smooth speed regulation over a wide range. The traditional thyristor-motor system (V-M system) occupies an important position in the DC speed control system due to its economic and reliability advantages. But the thyristor-motor system (V-M system) also has its weaknesses. First, due to the unidirectional conductivity of the thyristor, it does not allow for reversal, which creates difficulties for the reversible operation of the system. Second, the components are sensitive to overvoltage's, overcurrent's, and excessive du/dt and di/dt. Any one of the indicators above the allowable value can damage the component in a short amount of time. Finally, when the system is running at a lower speed, the conduction angle of the thyristor is small, so that the power factor of the system is very low, and a large harmonic current is generated to cause distortion of the grid voltage waveform, damaging nearby electrical equipment [5], also affects the control accuracy.

With the development of power electronics technology, various power electronic devices have emerged. Among them, the emergence and application of self-shutdown devices have injected great vitality into the development of power electronics technology, which greatly promoted the development of various new power electronic circuits and control methods [6-7]. DC pulse width modulation (PWM) type speed control system composed of gate-level turn-off thyristor GTO, full-control power transistor GTR, insulated gate bipolar transistor IGBT, P-MOSFET and other fully controlled power electronic devices It has matured and used more and more widely. Compared with the traditional thyristor-motor system (VM system), it has great advantages in many aspects: 1. The main circuit is simple and requires less power components; 2. Switch The frequency is high, the current is easy to be continuous, the harmonics are less, the motor loss and heat are small; 3. The low speed performance is good, the steady speed precision is high, and the speed regulation range is wide; 4. The system frequency bandwidth, fast response performance, dynamic anti-interference Strong ability; 5. The main circuit component works in the switching state, the conduction loss is small, and the device efficiency is high. [43] Therefore, DC pulse width modulation (PWM) technology can be used to achieve automatic control of motor speed, and it also has higher measurement accuracy than V-M system.

4. Conclusion

Based on the above design ideas, we propose the following scheme: design a DC pulse width modulation (PWM) servo control system with microprocessor as the control core. The whole system needs to detect four physical quantities, motor speed and motor power. Pivot current, field current and pressure. The current transformer is used to detect the armature current and the excitation current of the motor, and the value of the friction coefficient and the film strength is converted by the microprocessor and the excitation current is kept constant; the rotation speed sensor is used to detect the rotation speed of the motor, and the pressure is detected by the pressure sensor. Size, automatic control of the speed through the microprocessor.

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