

Study of Remote Hydraulic System Based on AMESim Rotary Blowout Prevention Type Hydraulic Rotary Table

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Abstract: Turntable is one of the important supporting equipment in oil drilling and repairing operation, which is mainly used as the power to drive the square drill pipe, drive the drill pipe to drill or deal with the well accident when used to rotate the drill column. In this paper, we study the rotary blowout-proof hydraulic turntable, which can meet the general rotary power requirements and also realize the control of wellbore annulus blowout-proof seal during rotary operation. Study the hydraulic working principle of the drilling rotary blowout prevention hydraulic rotary table and draw the hydraulic schematic diagram, combined with the hydraulic schematic diagram to complete the AMESim hydraulic system modeling. Briefly describe the construction idea of the hydraulic system model of the drilling rotary blowout prevention hydraulic rotary table and analyze and verify the simulation results.

Keywords: Rotary Anti-Blowout Hydraulic Turntable; Hydraulic system; AMESim; Simulation and Emulation.

1. Introduction

Turntable is one of the indispensable supporting equipments in oil drilling and repairing operation, which plays a vital role in the whole operation process. The main function of the rotary table is to rotate the square drill pipe through its driving force, and then drive the drill pipe to carry out the drilling operation, or to rotate the drill column when dealing with the accident in the well, in order to complete the corresponding operation tasks. Hydraulic turntables mounted on the drilling platform do not require additional sealing as their working environment is relatively closed and stable. On the other hand, the hydraulic rotary table mounted on the wellhead is directly exposed to the wellhead and has to withstand the dual action of high pressure in the well and the rotation of the drill column, so it must be equipped with rotary blowout-proof sealing function to ensure the safety and smooth operation of the work. The rotary anti-blowout hydraulic rotary table is a kind of advanced equipment integrating rotary power and anti-blowout sealing. It can not only meet the requirements of general rotary power to drive the drilling column to carry out normal drilling operations, but also be able to rotate the operation at the same time, the wellbore annulus blowout sealing control, effectively preventing blowout accidents. This type of rotary table can not only meet the needs of conventional workover operations, but also meet the challenges of conventional pressurized workover operations, and can be the ideal choice for rotary blowout prevention and pressurized workover operations.

The performance of the hydraulic system has a decisive influence on the realization of the hydraulic rotary table's function and operational safety. Therefore, when using a hydraulic rotary table for oil drilling and workover operations, we must carry out rigorous testing and evaluation of its hydraulic system. As a professional modeling and simulation tool, AMESim software can help us understand the performance characteristics of the hydraulic system more accurately and predict its performance in the actual operation, so as to ensure the reliability and safety of the hydraulic rotary

table in the oil drilling and repairing operation. Therefore, it is of great significance to use AMESim software to model and simulate the hydraulic rotary table.

2. Hydraulic System Principles and Mathematical Modeling

2.1. Hydraulic System Working Principle

The main hydraulic components of the hydraulic circuit of the rotary anti-spray hydraulic turntable are hydraulic cylinder, variable pump, hydraulic motor, throttle valve, flushing valve and other components. The secondary pressure regulator ensures the stability of the pressure of the whole main circuit, which has a certain protective effect on the whole system. At the same time, the three-position five-way valve is controlled by the pilot-hydraulic handle above, which controls the 1 and 2 ports of the hydraulic cylinder, thus changing the output flow of the variable pump and thus the output pressure.

2.2. Control Loop

The displacement of variable hydraulic pump is controlled by the speed potentiometer handle. The main controller reads the speed potentiometer handle signal and processes it, outputs two PWM signals to control the pilot proportional solenoid valve of the electronically controlled variable hydraulic pump, and controls the pilot proportional solenoid valve's control pressure through the output of linear voltage or current signals to change the swashplate swing angle of the electronically controlled variable hydraulic pump to realize the change of displacement and change the rotational speed of the hydraulic motor. Move the potentiometer handle to different positions to control the hydraulic rotary support turntable forward, reverse, stop and stepless speed change. By adding a start/stop ramp, a smooth and shockless movement is realized. In this way, the speed of the hydraulic rotary support wheel is controlled to change proportionally in the forward and reverse directions and can be locked in a certain position, and the wheel is stopped and braked in the center

position.

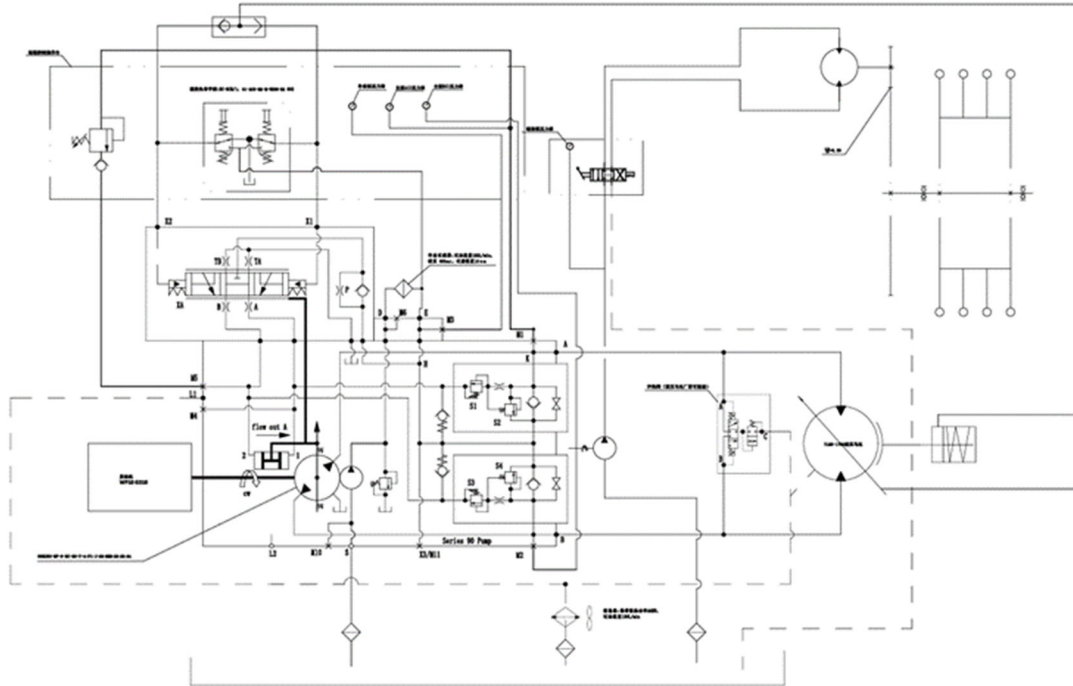


Figure 1. Rotary anti-blowout hydraulic turntable hydraulic system schematic diagram

Operate the torque potentiometer to control the handwheel to control the torque of the hydraulic rotary support turntable. The main controller reads the torque potentiometer control handwheel signal and processes it, and outputs a PWM signal to control the proportional solenoid relief valve of the bridge-type regulator assembly to change the adjusting pressure of the proportional solenoid relief valve, thus realizing the adjustment of the torque range of the hydraulic rotary support turntable. Rotary support turntable is usually for high-speed low torque and low-speed high torque operating conditions. In order to reduce the power of the main hydraulic pump motor, the main hydraulic pump is set up with constant power output characteristics, so that when the external load is large so that the pressure is $>9\text{MPa}$, with the increase of pressure, the displacement of the main hydraulic pump becomes smaller, and the speed of the hydraulic motor decreases, i.e., the speed of the hydraulic rotary support rotary table decreases and the torque increases.

2.3. Cooling and Charging Circuit

Radial piston motors often generate a lot of heat when driving conventional turntables. High temperatures will reduce the viscosity of the fluid, which will lead to a reduction in the service life of the hydraulic system components; at the same time, the low viscosity will also reduce the maximum power of the motor. Therefore, the system is equipped with an external flushing pump to cool the motor casing, and the external cooling oil returns to the tank through the motor casing and cooler. The hot oil generated by the hydraulic system is displaced by the internal flushing valve, cooled down by the cooler and returned to the tank. In order to replenish the hydraulic oil lost due to heat dissipation and leakage in the basic Bohle circuit, the system adopts a gear pump as the replenishment pump. The replenishment pump replenishes the cooling fluid to the low-pressure line of the basic hydraulic circuit through the check valve in the high-pressure relief valve block. The low pressure relief valve is

used to control the replenishment pressure.

2.4. Overload Protection and Braking Circuit

In the process of shutdown, in order to protect the main hydraulic pump from impact, the pump is equipped with two high-pressure relief valve block at the high-pressure outlet; the same in order to protect the hydraulic motor, the hydraulic motor in the import and export of a two-way relief valve. According to the characteristics of the closed loop, operating speed potentiometer handle back to the center, so that the hydraulic pump swashplate tilt angle of zero, closed in and out of the pathway, so that the import and export of the hydraulic pump flow rate is zero, the hydraulic motor speed is zero, hydraulic rotary support turntable to stop running. At the same time, due to the hydraulic motor in the import and export of a regulating pressure is much higher than the system pressure of the two-way relief valve, the hydraulic motor can not rotate, but also to achieve the hydraulic rotary support turntable braking. This belongs to the system brake, also called internal brake.

2.5. Torque Adjustment and Anti-torque Release Circuit

When the hydraulic rotating support turntable needs to set the torque, operate the torque potentiometer to control the handwheel to adjust the proportional solenoid relief valve of the bridge-type regulating assembly, and then change the adjusting pressure of the proportional solenoid relief valve. As the hydraulic rotating support turntable drives the drill pipe, the elastic torsion of the drill pipe accumulates a large amount of torsional potential energy. Thus, when the hydraulic rotary support rotary table stops running, the thousands of meters long drill pipe has a very huge torsional potential energy forcing the hydraulic rotary support rotary table to invert; the need to release the drill pipe counter-torque, it is necessary to slowly lower the bridge regulator assembly of the proportional solenoid relief valve pressure slowly

overflow. In this way, the hydraulic motor slowly releases the counter-torque generated by the drill pipe, so that the elastic torsional potential energy of the drill pipe is converted into heat, preventing the occurrence of the accident of drill pipe disconnection.

3. Hydraulic System AMESim Modeling Simulation

3.1. Main circuit

First of all, according to the hydraulic schematic diagram to build the hydraulic system closed main circuit, consisting of bidirectional variable pumps, bidirectional motors, flushing valves, high-pressure relief valves, etc., this part of the model is shown below.

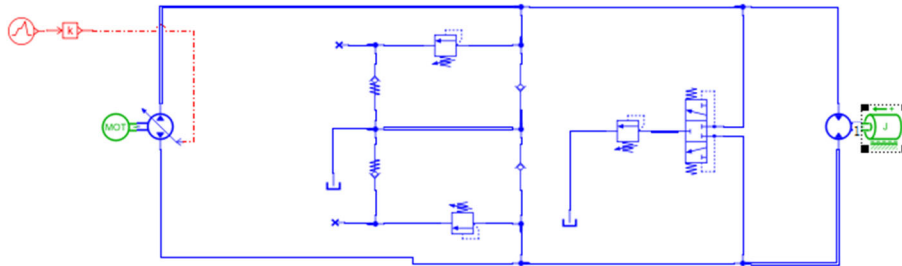








Figure 2. Hydraulic system closed main circuit model

Table 1. Main Loop Model and Structure Physical Unit Comparison Table

Submodel Labeling	Structural Physical Unit (Physics)	Modeling Element
Pump04[PU003]	Displacement per Radian Pumps	
Pmover01[PM000]	Electrical Machinery	
Presscontrol01_2[RV010]	Relief Valve	
flushvalve [FLV00]	Flushing Valve	
motor02[MO001]	Bidirectional Motor	
rload01[RL00]	Moment of Inertia	

3.2. Control and Replenishment Circuits

In order to facilitate the simulation model construction, the hydraulic pilot handle is replaced by a signal and directional

valve equivalent. A quantitative pump provides charge and control oil, and other hydraulic components include directional valves, hydraulic cylinders.

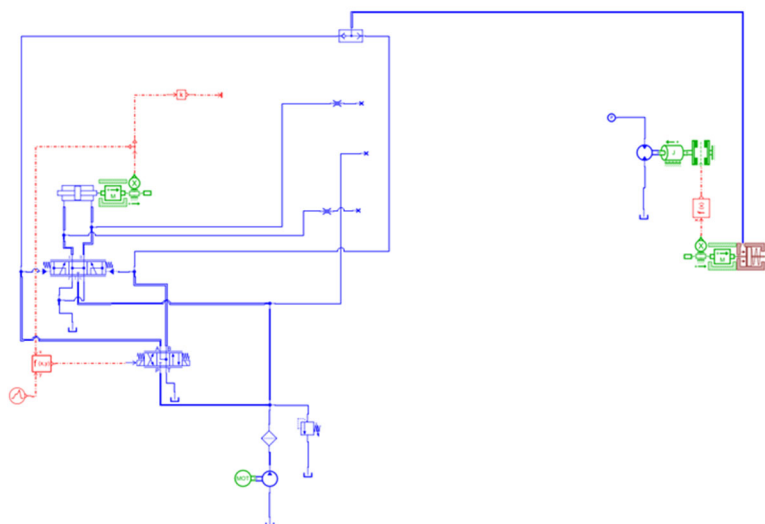
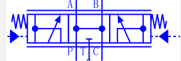






Figure 3. Control and Charge Circuit Model

Table 2. Control and Charge Circuit Model and Structure Physical Unit Comparison Table

Submodel Labeling	Structural Physical Unit (Physics)	Modeling Element
Dirvalve_1[sc_1-1]	Pilot Operated Proportional Directional Valve	
Actuator002[HJ021]	Variable Cylinder	
Pump01[PU001]	Displacement Pump	
Presscontrol01_1[RV010]	Relief Valve	
Fofxy_1[FX0]	Control Function	

3.3. Simulation Model of Turntable Hydraulic System

According to the hydraulic schematic diagram and the

calculation of the selection parameters to build the simulation model, drilling rotary blowout prevention hydraulic rotary table hydraulic system simulation model is shown in the figure below.

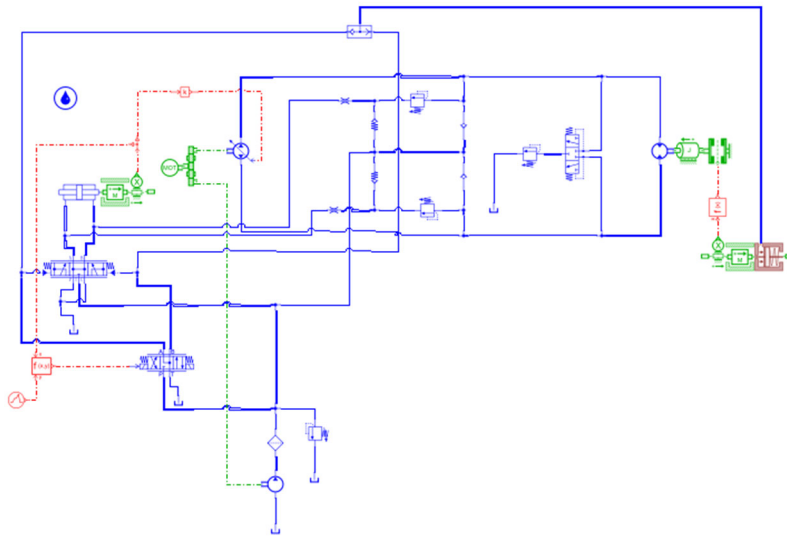


Figure 4. Simulation Model of Turntable Hydraulic System

4. System Modeling and Simulation Analysis

4.1. Start-up and Positive Work Process

Set the input signal in the signal model in the control loop to simulate handle control, the signal range is -10 to 10, indicating the maximum speed from the reverse direction to

the maximum speed in the forward direction. To simulate forward start, the input signal is set to go from 0 to 10 in 1s, followed by a continuous 4s signal of 10, and the control signal curve is shown in Figure 5. The simulation result curves are shown in Figure 6, which are the main pump flow, the main system pressure curve, the control oil circuit pressure, the brake hydraulic cylinder displacement curve, the rotating motor speed, and the motor output torque.

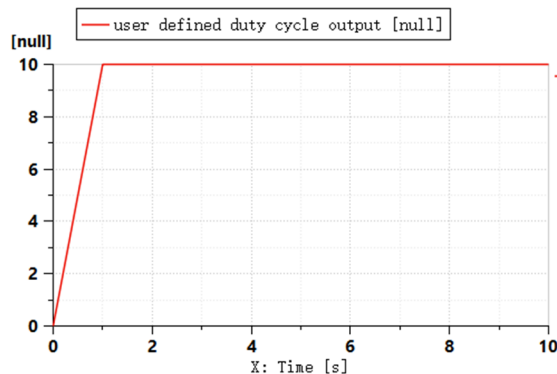


Figure 5. Control Signal Curve for Startup and Forward Control Process

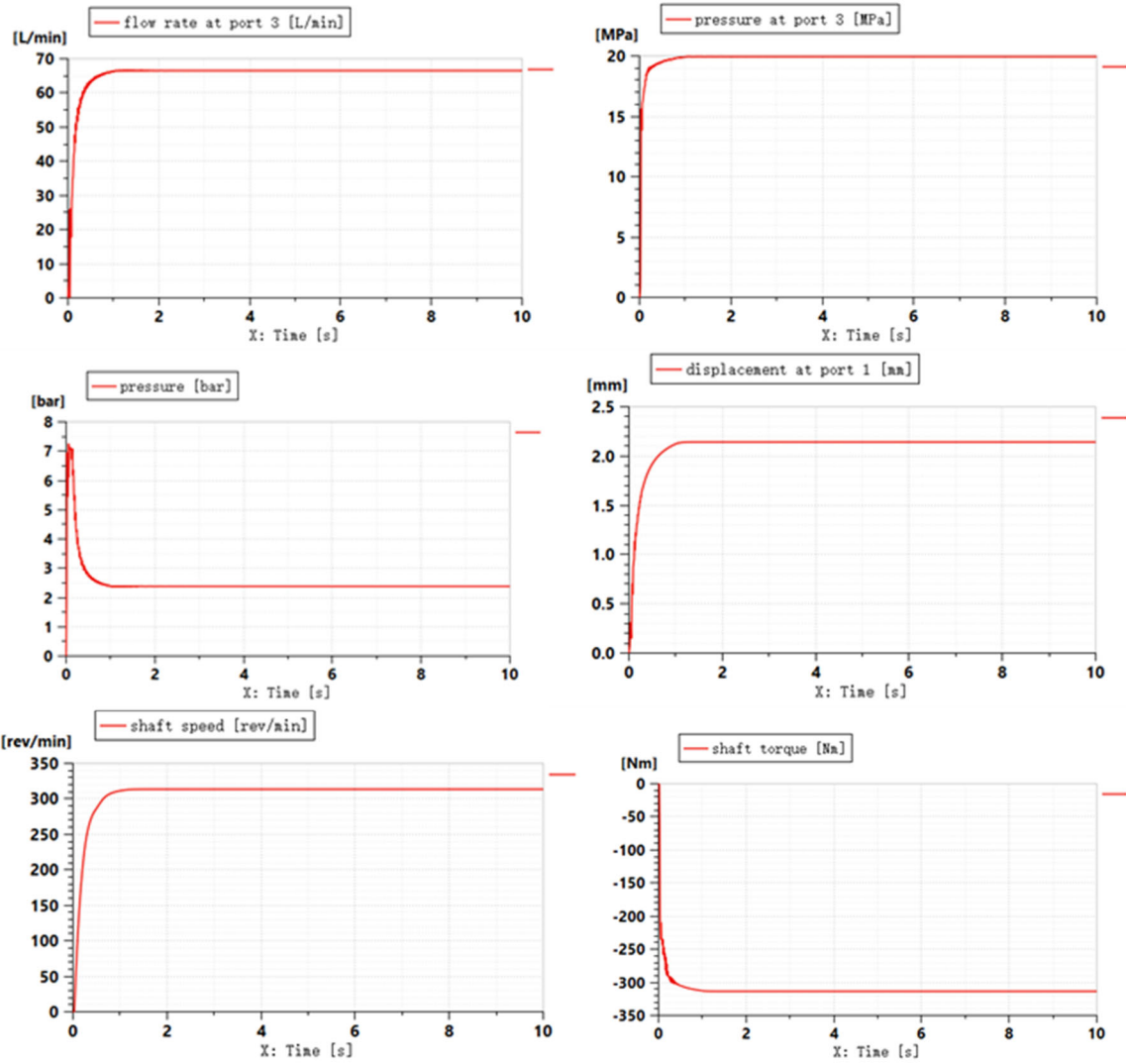


Figure 6. Simulation Result Curve of Startup and Forward Control Process

4.2. Output Flow Conditioning Process

The control signal curve is shown in Figure 7. The simulation result curves are shown in Figure 8, which are the

main pump flow, the main system pressure curve, the control oil circuit pressure, the brake hydraulic cylinder displacement curve, the rotating motor speed, and the motor output torque.

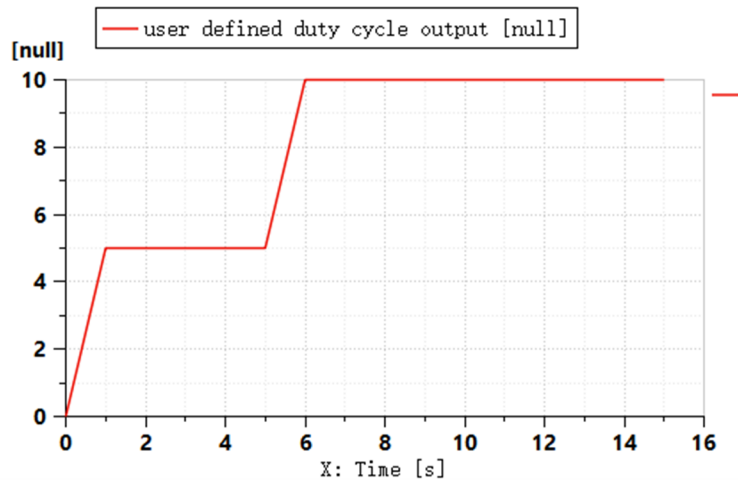


Figure 7. Output Flow Regulation Process Control Signal Curve

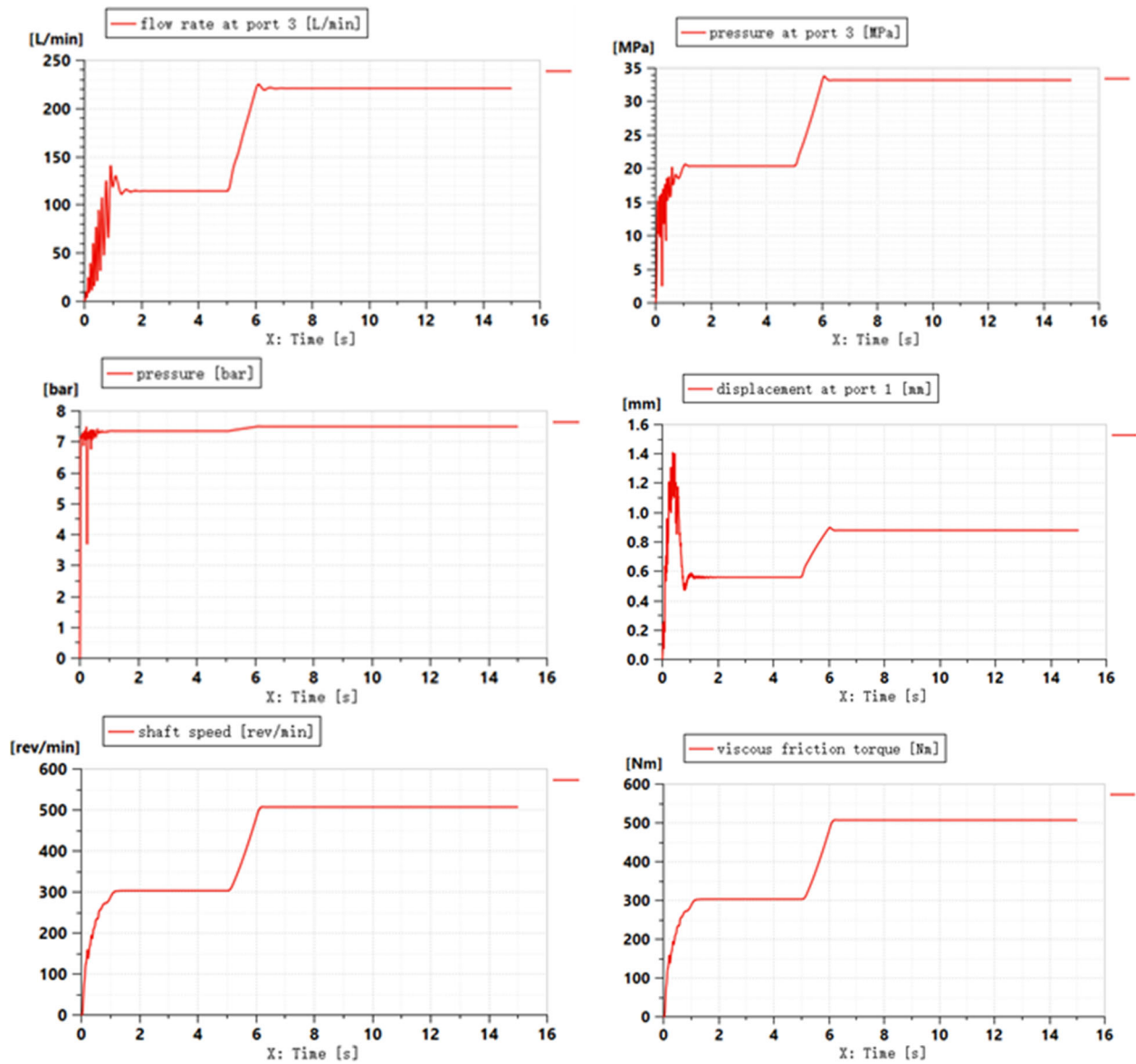


Figure 8. Output Flow Regulation Process Simulation Result Curve

4.3. Automatic Output Pressure Adjustment Process

The control signal curve is shown in Figure 9. The

simulation result curves are shown in Figure 10, which are the main pump flow, the main system pressure curve, the control oil circuit pressure, the rotating motor speed, and the motor output torque.

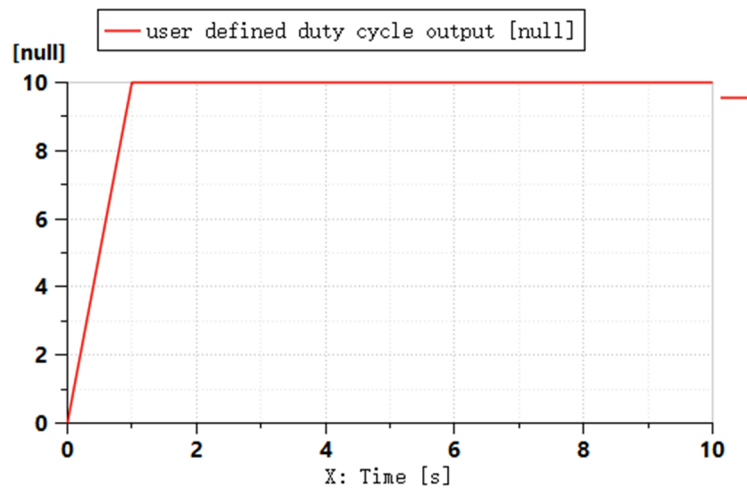


Figure 9. Output Pressure Automatic Adjustment Process Control Signal Curve

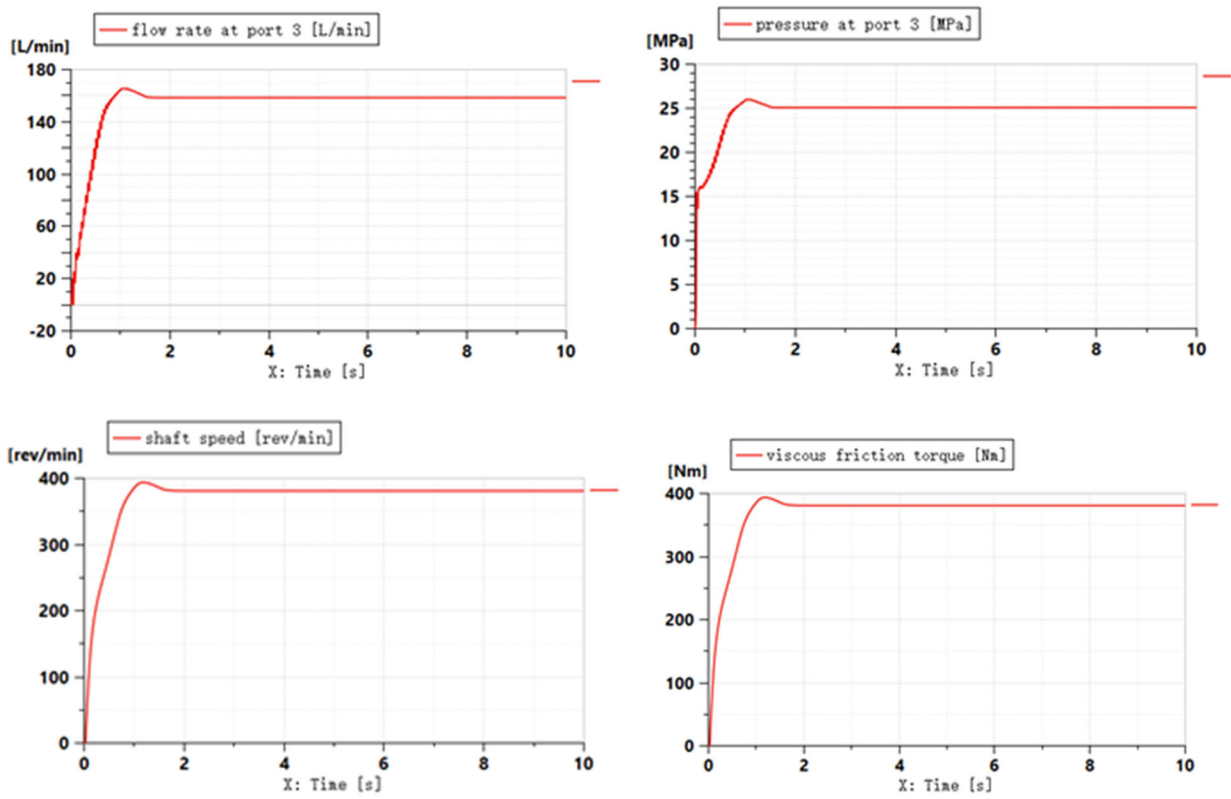


Figure 10. Output Pressure Automatic Adjustment Process Simulation Result Curve

4.4. Automatic Output Pressure Adjustment Process

The control signal curve is shown in Figure 11. The

simulation result curves are shown in Figure 12, which are the main pump flow, main system pressure curve, rotating motor speed, motor output torque, brake cylinder displacement, and friction torque.

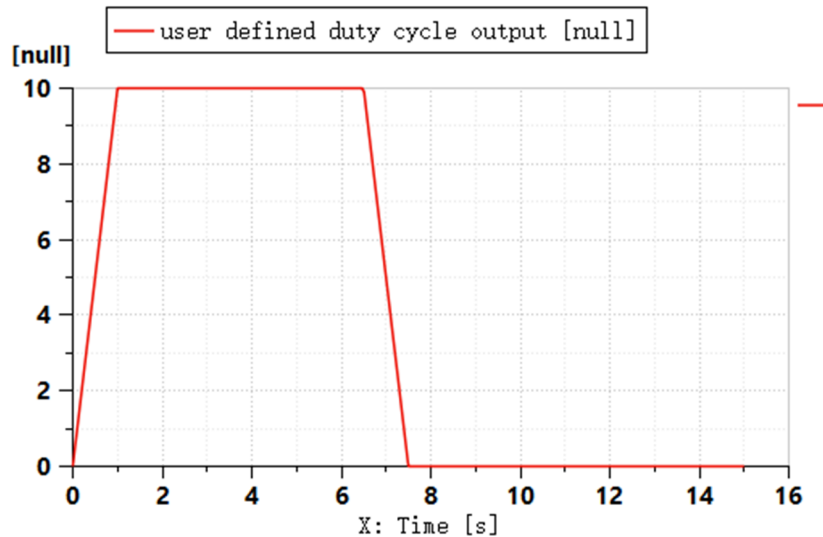


Figure 11. Control Signal Curve for Stopping and Braking Process

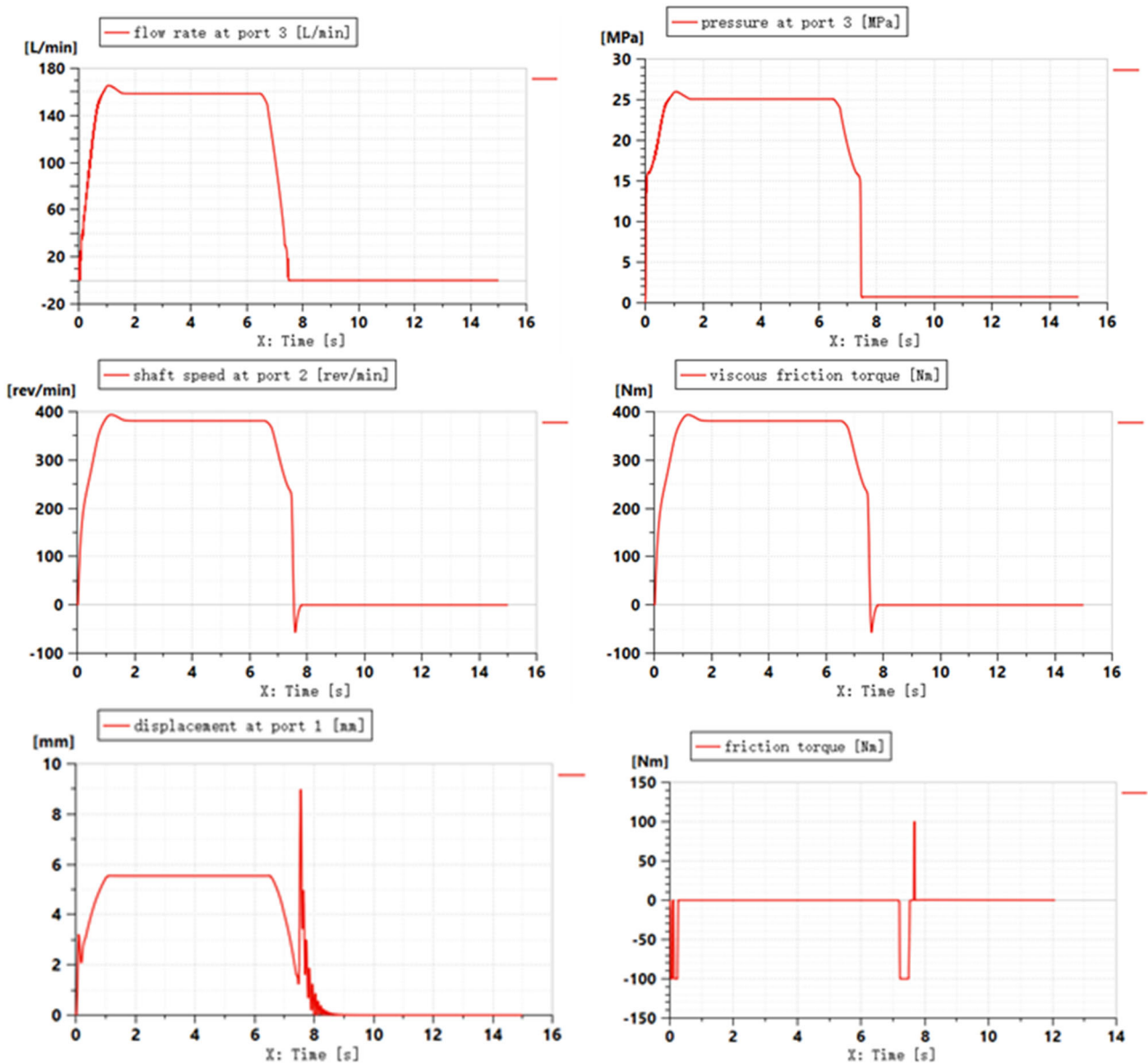


Figure 12. Simulation Result Curve of Stopping and Braking Process

4.5. Simulation Results Analysis

We simulate and analyze the pressure of the hydraulic system. By working the turntable in different functions, we can observe the pressure change of each hydraulic component in the system. By comparing the simulation results with the design requirements, we can evaluate the pressure stability and load adaptability of the hydraulic system. If the pressure of the hydraulic system fluctuates too much, it may lead to unstable operation or even damage of the system. Therefore, when analyzing the results, we need to pay special attention to the pressure fluctuation in the system and adjust and optimize accordingly as needed.

In the simulation results, we can also evaluate the speed and flow characteristics of the hydraulic system. By rotating the speed and flow rate changes of the hydraulic system under different operating conditions, we can observe the working status of each hydraulic component in the system. If the speed and flow rate of the system cannot meet the actual demand, it may lead to low efficiency or failure to accomplish the task. Therefore, when analyzing the results, we need to pay attention to the speed and flow rate changes in the system and make corresponding adjustments and optimizations as needed.

By analyzing the simulation results of the turntable hydraulic system, we can evaluate the performance of the system under various working conditions and find the direction of improvement. This is an important guidance for design optimization and practical application. Through continuous analysis and optimization, we can further improve the performance and reliability of the hydraulic system and realize the efficient work of the rotary disc hydraulic system in the oilfield.

5. Conclusion

This paper analyzes the hydraulic system principle of drilling rotary blowout prevention type hydraulic rotary table, and then uses AMESim software to model the hydraulic system, adjust the parameters and simulate the system, and then analyzes the simulation results. According to the study can be obtained the following conclusions:

- 1) The hydraulic principle of the rotary hydraulic system is correct, and the simulation modeling method and type are accurate;
- 2) The turntable is equipped with various functions such as starting and forward work, automatic adjustment of output

pressure, stopping and braking.

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