Design of Controllable Power System for Underwater Transmission Mechanism

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Abstract. This paper designs a controllable power system for underwater transmission mechanism, which uses a permanent magnet synchronous motor to control a bidirectional hydraulic pump to drive the hydraulic cylinder to move in both directions. The electromechanical static pressure scheme is designed to greatly reduce the volume and weight of the hydraulic pump; Control, it can control the forward, reverse and speed regulation of the motor, and can also cancel the control valve parts such as hydraulic reversing valve and pressure reducing valve. There are only power supply and signal transmission interfaces externally, and both hydraulic actuation system and electric actuation. The advantages of the system, the system composition is greatly simplified, and the equipment volume is greatly reduced.

Keyword: Underwater transmission mechanism · Controllable power system · Electromechanical static pressure

1 Introduction

With the continuous exploration and in-depth research of human exploration in the marine field, the research needs of various marine vehicles are becoming more and more urgent [1]. The energy and power research of various marine exploration devices is the core of technology research and development, which is efficient, stable and reliable power [2]. The system is the guarantee for the successful operation of all marine installations.

Compared with electric transmission technology, hydraulic technology has the unique advantage of being used in underwater operation equipment. The power-to-weight ratio is large [3]. Under the same power, the volume and weight of underwater operation equipment can be reduced, and larger torque can be obtained. The system structure is simple and fast. It has good performance and stable transmission, which meets the control requirements of some underwater operation tools such as underwater manipulators. It can achieve stepless speed regulation in a large range, which is convenient for large-scale speed regulation of the propeller, easy to prevent overload, and makes underwater remote control operation more It is safe and easy to realize power adjustment, which is convenient to improve the efficiency of underwater operation equipment

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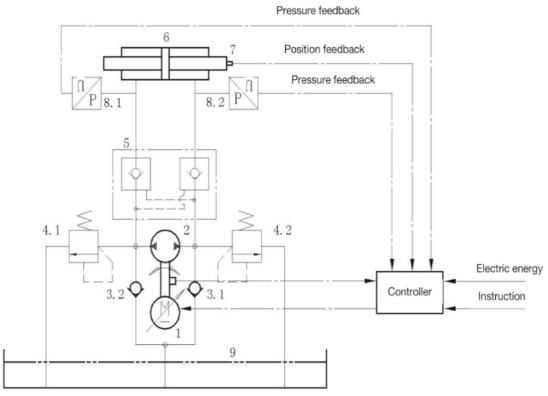
and reduce power consumption. The many advantages of hydraulic technology make it widely used in underwater operation equipment [4].

This paper designs a controllable power system for underwater mechanisms, which can meet the requirements of high pressure resistance in underwater environments. It is resistant to seawater corrosion, has a reliable sealing structure and electrical insulation. It has broad application prospects in various aspects such as the start and stop control of the cabin door, the real-time control of the robot arm grasping the target, the control of the rudder control system, and the control of the water jet propulsion system.

2 Scheme Principle

The controllable power system for underwater mechanisms is composed of a controller, motor driver, rectifier, underwater motor, two-way hydraulic pump, hydraulic cylinder, hydraulic lock, overflow valve, fuel tank, position sensor, pressure sensor system to ensure underwater transmission. The controllable power system for the mechanism works reliably and stably (Fig. 1).

The system drives the two-way gear pump for the motor and pushes the piston in the hydraulic cylinder to move in a certain direction. Taking one direction operation as an example, the explanation is as follows: After the control driver is powered on, if an instruction is obtained (assuming that the piston moves to the right), the motor is driven by the driver to rotate counterclockwise. At this time, the right side of the two-way gear pump is the inlet, from the oil tank The oil is sucked in through the one-way valve and pumped out through the left-side outlet. The oil enters the left cavity of the hydraulic cylinder through the left hydraulic-controlled one-way valve and pushes the piston to



1.Motor; 2.Bidirectional hydraulic pump; 3.Tubular check valve; 4.Threaded cartridge direct-acting relief valve; 5.Threaded cartridge hydraulic lock; 6.Hydraulic cylinder; 7.Motion detector; 8.Pressure Sensor; 9.tank

Fig. 1. Schematic diagram of the controllable power system for underwater transmission mechanism

move to the right. At this time, the oil in the right cavity of the hydraulic cylinder The liquid will flow back to the inlet of the two-way gear pump through the hydraulic control check valve on the right (this valve has been opened by the high pressure hydraulic control on the left) for the oil circulation of the static pressure system. During this process, the safety relief valve will open when there is a high-pressure failure in the system, allowing the oil to flow back to the tank to ensure the safety of the system. The controller collects and monitors the pressure of the two chambers of the hydraulic cylinder through the pressure sensor, and at the same time monitors the piston stroke position through the micro switch. This position information is also a signal for judging that the piston is running in place and automatically stopping the motor. The principle of reverse operation of the whole system is the same.

3 Hardware System Design

3.1 Design of Control Drive System

The control circuit is composed of the minimum system, power supply module, decoding circuit, PWM circuit and sampling circuit. The driving circuit is composed of IPM and driving circuit. AC/DC conversion circuit is added according to the overall demand. The software and hardware schematic diagrams are shown in Fig. 2.

The control driver adopts a space vector control strategy, with current and speed double closed-loop control, which can realize information interaction with the host computer, display and alarm multiple faults in real time, and monitor the pressure and position in the process of system operation in real time.

The control drive has a multi-channel protection mechanism while the drive fault signal and overcurrent protection signal are protected by software, hardware protection is added to enhance the speed and reliability of the protection. The rectifier adds an

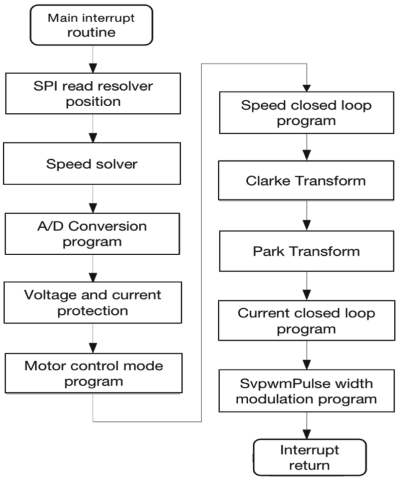


Fig. 2. The logic principle diagram of the control drive software of the controllable power system

AC/DC module on the basis of retaining the DC power supply meet the ability of AC and DC power supply to work normally.

3.2 Design of Underwater Motor

The underwater motor is composed of rotor, stator, end cover assembly, watertight connector socket, resolver, etc. The names and functions of each component are shown in Table 1.

Table 1. Composition and function of underwater permanent magnet synchronous servo motor

Serial number	Name		Function	Remarks
1	Rotor	Rotor shaft	Support magnet, yoke	Transmit torque
		Yoke	Provide a loop for the magnetic flux	
		magnetic steel	Provide main flux	
2	stator	Stator winding	Current is applied to form an armature magnetic field, which interacts with the main magnetic field to drive the rotor to rotate	1. The external mechanical seal interface of the motor is connected to the gear pump through the mechanical interface; the sealing of the wiring port and the electrical connector is designed 2. It adopts 8-pole, 9-slot, fractional-slot electromagnetic structure, and the stator adopts concentrated winding. This structure can eliminate tooth harmonics and high-order harmonics.
		Stator core	Provide a path for magnetic flux	
		Housing components	Protect the inside of the motor, fix the stator core, install the bearing, and fix the junction box	
3	End cap assembly		① Protect the inside of the motor	Design end cover to shell, end cover to back cover sealing structure
			② Install the bearing	
			③ Fixed resolver	
			④ Fixed junction box	
4	socket		① The resolver socket feeds the resolver signal back to the driver	The motor has an external electrical interface and a sealed structure is designed
			② The motor socket receives the signal from the driver to drive the motor	
6	Resolver		Recognize the position of the rotor and send a signal	/

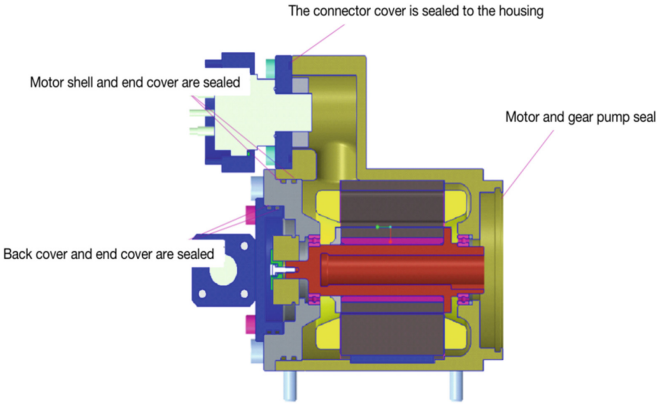


Fig. 3. Seal structure diagram

The motor and the constant hydraulic pump set are connected with the coupling through the spline, and the valve island stop position is positioned and sealed, which makes the motor pump interface simple, eliminates the rotary sealing link, and improves the reliability of the seal; to make the motor adapt to the marine working environment. Multi-layer sealing structure, using multiple reliable axial and radial seals instead of dynamic seals to ensure the isolation of the underwater environment between the inside of the motor and the outside of the shell, the connector and the shell sealing structure, and the motor shell and the end cover are double-sealed The structure, the double-sealing structure of the rear cover and the end cover, the sealing structure of the motor and the gear pump, etc. improve the reliability of the motor, and improve the cooling performance and long-term working ability of the motor (Fig. 3).

Since the supporting equipment needs to be placed in sea water for a long time, the sea water corrodes common metal materials seriously, which affects the reliability and safety of the product. Therefore, after comparison, a titanium alloy TC4 with good corrosion resistance and mechanical properties is selected as the motor housing.

3.3 Design of Hydraulic Actuation System

The hydraulic cylinder adopts a double rod symmetrical structure. The hydraulic lock and the overflow valve are used to interact with each other to ensure the safe pressure of the system, and to ensure the stable and reliable operation of the two-way hydraulic cylinder; the design of the redundant position sensor is adopted to ensure that the controllable power system is in place. Support a variety of given forms of commands to adapt to different overall usage requirements. With manual control function, manual operation can be performed in the case of motor failure or control drive failure.

The movement of the hydraulic cylinder is controlled by the two-way hydraulic pump, thereby greatly reducing the volume and weight of the hydraulic pump; through the servo control, the forward, reverse and speed regulation of the motor can be controlled, and the hydraulic reversing valve, pressure reducing valve and other controls can be eliminated For valves, there are only power supply and signal transmission interfaces

on the outside, and both have the advantages of a hydraulic actuation system and an electric actuation system. The system composition is greatly simplified and the equipment volume is greatly reduced. A subsubsection. The paragraph text follows on from the subsubsection heading but should not be in italic.

4 Conclusion

Compared with electric transmission technology, hydraulic technology has the unique advantages of being used in underwater operation equipment. The power-to-weight ratio is large. Under the same power, the volume and weight of underwater operation equipment can be reduced, and larger torque can be obtained. The system structure is simple and fast. It has good performance and stable transmission, which meets the control requirements of some underwater operation tools such as underwater manipulators. It can achieve stepless speed regulation in a large range, which is convenient for large-scale speed regulation of the propeller, easy to prevent overload, and makes underwater remote control operation more It is safe and easy to realize power adjustment, which is convenient to improve the efficiency of underwater operation equipment and reduce power consumption.

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