ISSN: 2688-9323

The Structure Design of the Electronically Controlled Variable Pump with a Dynamic Plunger Adjustment

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Abstract

This paper optimizes the structure design of the variable pump, and dynamically adjusts the effective stroke of the plunger to achieve the control of the pump oil volume of the variable pump, realize the dynamic adjustment of the plunger pump, and improve the system efficiency.

Keywords

electronically controlled variable pump; plunger effective stroke; electronically controlled dynamic adjustment; optimized structural design.

1. Introduction

The hydraulic system has stepless speed regulation, large power-to-volume ratio, flexible component layout, easy implementation of overload protection, stable work, easy automation, components can be self-lubricated, long service life, and hydraulic components are easy to achieve serialization, standardization and generalization, etc. Advantages, widely used in various industrial fields. In the hydraulic system, the hydraulic pump is used as the power source, and its working state determines the stability and efficiency of the system. With the demand of technological development, variable pumps with high-precision control, simple structure, high efficiency and energy saving have become the forward direction of people's research and design. At present, the common variable pump on the market uses an axial plunger to change the inclination of the swash plate to achieve flow control. This method requires the addition of a swash plate control mechanism, which not only increases the weight of the system, but also complicates the structure. The author of this paper has designed a kind of electronically controlled variable control structure of plunger dynamic adjustment. The effective stroke of the plunger is controlled by a stepper motor to realize dynamic input adjustment of flow. The variable mechanism of the swash plate is removed, and the development of digital and miniaturization of variable pump is realized.

2. Stepper Motor Pulse Width Control Principle

2.1. Stepper Motor Control Principle

In high-precision mechatronics systems, stepper motors have replaced traditional servo motors. Pulse width control technology (PWM) is commonly used in the control of stepper motors, which discretizes the motor drive control signal into several pulse frequency conversion signals. In the stepper motor, the drive signal of each winding changes with the change of the control signal. The current obtained by the motor windings is in a stable state from small to large, and the synthesized magnetic field of the motor is also working in a stable state. The rotor rotates in microsteps according to the stable law of the synthesized magnetic field to realize the precise control of the stepper motor.

ISSN: 2688-9323

2.2. Principle of Pulse Width Control (PWM)

Pulse width control, also known as pulse width modulation (PWM), usually uses the high-frequency non-sparking switching characteristics of high-power electronic switches (thyristors, transistors, field effect transistors or IGBTs, etc.) to control the DC voltage. By triggering and controlling the electronic switch, the power switch is in the "off" or "on" state, and the length of the "off" and "on" time in a cycle is changed according to the control requirements, so as to achieve the control of the average effective power Purpose, changing the on-off time in this way is also called "duty cycle", that is, changing the pulse width of voltage or current, called pulse width modulation. When the pulse width changes, the average voltage obtained by the motor windings also changes to achieve the purpose of speed regulation.

In pulse width modulation, the electronic switch must perform repeated "off" and "on" actions in accordance with the time control law. When the electronic switch is "on", the power supply forms a closed loop, and the stepper motor windings are energized. When the electronic switch is "off", the power supply circuit is disconnected and the stepper motor winding loses power. In the single time of "disconnect" and "conduct", the voltage at the winding end of the stepper motor is equal to the average of the two voltages. As long as the "off" or "on" time is changed in one cycle, the voltage at the winding terminal of the motor can be changed to realize the pulse width speed regulation of the motor.

3. The Structure Design of the Plunger Dynamic Adjustment Type Electronically Controlled Variable Pump

In the plunger dynamic adjustment type electronically controlled variable pump system, flow control is the key to the performance of the variable pump, and it is related to the success or failure of the system efficiency. In the variable pump control system loop, the delivery flow of the pump is controlled by changing the feedback pressure, and the delivery flow is adjusted as the feedback pressure changes. When the control system detects that the feedback pressure matches the workload flow rate, the variable pump system outputs the flow rate required by the load, reducing unnecessary power loss. When the control system detects that the feedback pressure does not match the work load flow, the variable pump control system changes the feedback pressure, adjusts the output flow of the variable pump, matches the work load, and ensures sufficient output power. In order to obtain sensitive variable pump flow control accuracy, stepper motors have unique control accuracy, which can meet the flow control requirements of variable pumps.

3.1. Overall Design

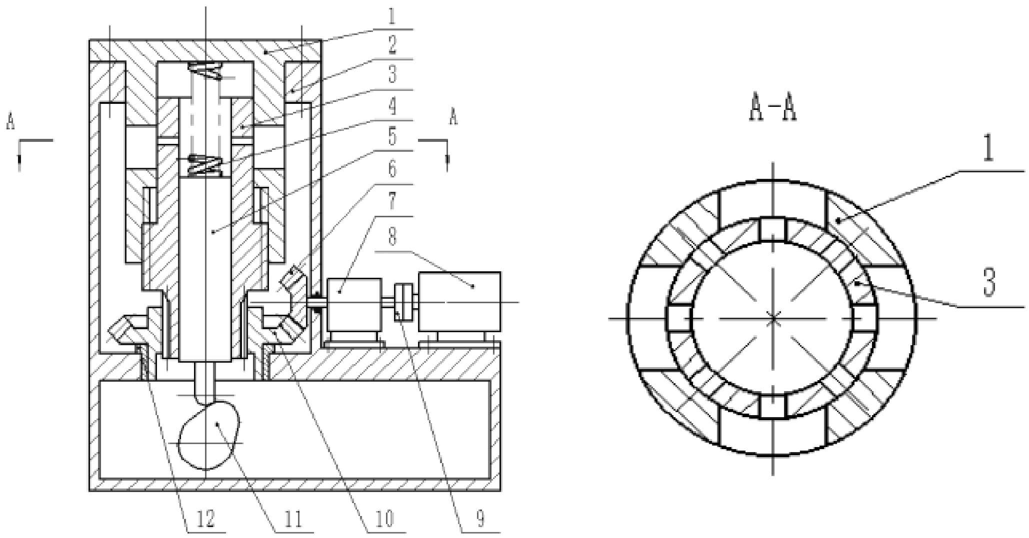
With the rapid development of production technology today, various automation equipment has gradually replaced manual operations, especially in heavy manual labor. The unique characteristics of hydraulic systems have been widely used in various mechanical equipment, and hydraulic pumps are among them. One of the core components. In the application process, people also put forward more stringent requirements on the use of hydraulic pumps. The quantitative pumps in the past can no longer meet people's needs now, and the variable pumps dominate. The common variable pumps in the single market have the characteristics of large volume and low control accuracy. In today's technological development, shortcomings are gradually revealed and need improvement.

Through market research, people hope to obtain a product with small size, high power, and high control accuracy to meet the needs of multifunctional equipment. According to the characteristics of market demand, on the basis of the original variable pump, the electronically controlled stepper motor flow control system replaces the swash plate flow control system to achieve the purpose of small volume and precise control.

ISSN: 2688-9323

3.2. Structural Design

According to the overall design requirements, the plunger dynamic adjustment type electronically controlled variable pump is composed of a control motor and a pump body. Stepper motors have the advantages of strong reliability, easy maintenance, computer control, no cumulative error, and little interference to the electronics side. Its structure is shown in Figure 1.



1—Cylinder liner 2—Body 3—Slide sleeve 4—Compression spring 5—Piston 6—Gear shaft 7—Support body 8—Stepper motor 9—Coupling 10—Big gear 11—Cam mechanism 12—Support bearing

Figure 1. Structure diagram of the plunger dynamic adjustment type electronically controlled variable pump

3.3. Working Principle

As shown in Figure 1, this electronically controlled variable plunger pump is mainly composed of a stepping motor control system, a body system and a drive system. Cylinder liner, cam mechanism, support body and stepping motor are all installed on the machine body. The large gear is installed on the machine body through the support bearing and meshes with the gear of the gear shaft. The large gear and the lower end of the sliding sleeve are connected by sliding splines. In the cylinder liner, the lower part of the sliding sleeve and the lower part of the cylinder liner are connected by a threaded pair. The upper middle part of the sliding sleeve and the upper middle part of the cylinder liner are in clearance fit. At the same height of the middle part of the sliding sleeve, there are many small holes evenly distributed in the circumferential direction. At the same height position, there are a number of large holes evenly distributed in the circumferential direction. No matter what the relative position of the sliding sleeve and the cylinder liner, at least one small hole on the sliding sleeve communicates with the large hole on the cylinder liner. Installed in the sliding sleeve, the plunger and the sliding sleeve are in clearance fit, the top of the plunger is equipped with a compression spring, the lower end of the plunger is in contact with the cam of the cam mechanism, the gear shaft is rotatably supported on the support body, and the stepping motor passes through the coupling The device is connected with the gear shaft.

The stepping motor 8, the coupling 9, the supporting body 7, the gear shaft 6, the large gear 10, the supporting bearing 12 and the sliding sleeve 3 and accessories constitute the stepping motor control system. The stepping motor obtains the control signal and outputs torque. The coupling, support body and gear shaft are reversed by 90 degrees by the gear shaft and the large

ISSN: 2688-9323

bevel gear, driving the sliding sleeve 3 to move up and down (the sliding sleeve and the cylinder liner are threadedly connected) to realize the on-off and adjustment of the small hole and the large hole The amount of traffic. The control signal of the stepping motor is provided by the requirement of the output flow of the machine's work, and the corresponding pulse control signal is sent out by the single-chip microcomputer. After the stepping motor receives the control signal, it rotates the corresponding angle and the sliding sleeve moves to the corresponding position.

Cylinder liner 1, body 2 and related accessories constitute the body system. Body 2 installs and supports the components of the electronically controlled variable pump. Cylinder liner 1 connects and positions the sliding sleeve by threading, and encapsulates the components in the pump to form a hydraulic chamber. , To ensure the correct installation and normal operation of the internal components of the variable pump.

The cam mechanism 11, the plunger 5, the compression spring 4 and accessories constitute the driving system. Under the action of the driving force, the cam mechanism starts to operate. The rotation of the cam drives the plunger to overcome the elastic force of the compression spring to move upward and start pumping oil. The oil pump ends when it reaches the top end. Under the action of the cam return stroke and the compression spring, the plunger quickly descends to carry out the oil suction process to prepare for the next pump oil cycle. This reciprocating movement forms the effect of pumping oil. With the electronic control system, the oil volume can be reached. Dynamic control purpose.

3.4. Flow Control

The pulse width modulation technology (PWM) control waveform is easy to implement and can be divided into hardware control type, software control type, hardware and software combination control type and single-chip control type. The hardware control type is composed of circuit components such as KA3525A and other chips and its peripheral components, which is low cost and easy to realize. The software control type is composed of a software chip and its auxiliary circuits. The software is solidified in a dedicated chip and realized through chip program adjustment. The combination of software and hardware takes into account the characteristics of software and hardware and realizes pulse width modulation. The single-chip microcomputer control type is composed of a single-chip microcomputer and its auxiliary components, and is realized by methods such as timing counting. The software of the single-chip microcomputer can be written and changed according to the needs of the equipment, which has a better and higher degree of freedom and can give full play to the advantages of pulse width modulation.

In order to realize the dynamic adjustment of the plunger and control the flow of the variable pump, the electronic control unit needs to input a pulse width modulation waveform control signal (PWM) to the stepper motor, and the frequency and duty ratio of the control signal need to be input by the electronic control unit. PWM control realization method: change the frequency and duty cycle of the PWM control waveform by changing the assignment of the internal timer of the electronic control unit. The value of the internal timer of the electronic control unit needs to be input by the upper computer, and the oil suction and oil discharge of the variable pump are determined according to the demand detected by the upper computer to realize dynamic control.

4. Conclusion

The structure of the plunger dynamic adjustment type electronically controlled variable pump is designed, and the effective stroke of the plunger is changed by the electronically controlled stepper motor to realize the dynamic adjustment of the pump oil volume. The structure is relatively simple. The volume and mass of the pump are greatly reduced, which reflects the development direction of digital variable pumps.

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