Shuwen Zhang *et al.* NEM:FOMI(2024)03
DOI: 10.62022/FOMI.issn3005-5466.2024.01.009

ISSN: 3005-5466
EISSN: 3005-5474

ARTICLE Open Access

Research and Application of "Soft" Devices for Realizing Servo Amplification

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Abstract: This article analyzes and discusses the working principle and problems encountered by various servo amplification devices used in the on-site continuous adjustment system, analyzes and discusses the application of the servo mechanism, and analyzes the mechanism of the servo device's implementation of the "positioning" function on the control device. Intended to guide the continuous adjustment process in controlling the function/accuracy of actuator equipment and application debugging, ensuring the safe and stable operation of production equipment and facilities.

Keywords: servo amplification; working mechanism; application

1 Introduction to servo amplification mechanism

Under normal circumstances, the automatic detection and control function of parameters such as pressure, flow rate, temperature, liquid level, and composition in the continuous energy fluid production process often adopts a PID loop control system. According to the requirements of the production process equipment characteristics, the designed continuous control regulating valves must have a "positioning" function, which requires a specific "servo device" to achieve [1].

Based on the size of the deviation and the positive and negative deviation, it is converted into a high-power power signal that can drive the servo motor or control the "three-phase motor" of the AC/DC contactor to reverse. The motor drives and regulates the three action processes of valve opening, closing, and stopping through the deceleration mechanism [2].

2 Basic principle of servo amplification

2.1 Definition of servo system

It refers to an automatic control system (device) that utilizes the action of a certain component (such as a control rod) to reach or approach a predetermined state of the system, and can compare the desired state (predetermined value) with the actual state value, and adjust the control components according to their differences.

2.2 Characteristics of the working state of servo systems

For a valve driven by continuous adjustment of a certain process parameter, the "deviation" size of the servo amplifier determines the valve opening size, rather than the PID output signal size determining the valve opening [3]. Before the "deviation" disappears, the actuator runs in one direction of opening or closing the valve. When the "deviation" disappears, the actuator stops running, The valve position is relatively stable at the workstation corresponding to the adjusted parameters, achieving "positioning". However, according to the working mechanism of PID regulation, the output state signal of the servo amplifier will fluctuate up and down on the original output value. This state causes the "deviation" signal of the servo amplifier to constantly change back and forth at zero point, that is, repeatedly appearing "positive deviation" and "negative deviation", and the actuator will repeatedly "forward" and "reverse" on/off at the original "positioning" state position, Thus, the valve position is in a dynamically stable "positioning" state.

2.3 The basic process of PID adjustment positioning function

One of the main functions of servo is "positioning", which involves changing the opening of the actuator and positioning it to seek stability of the controlled parameters under the

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output PID control signal of the regulator. After the actuator is positioned at a certain opening, the control signal output by the regulator changes because the "deviation" trend of the regulating parameter is zero [4]. This change is the fluctuation of the original output signal of PID. Then the actuator opening after that is also in the "positioning" state of the new opening of dynamic balance with the control signal output by the regulator, The opening and closing states of the actuator constantly change their position at the "positioned" opening point to seek balance, in order to strive for "positioning" in this way, because the controlled parameters fluctuate up and down in a small (micro) amplitude above the set value. The PID adjusts the output signal to put the actuator in a "waiting" state. But when there is interference caused by correlated parameter changes in the controlled parameters, the stability of the controlled parameters is greatly affected. The PID control signal output by the PID controller will undergo significant changes, and the executing mechanism will follow the output of the controller to "position" in a new position, causing the controlled parameters to return to the original set value and fluctuate up and down with small (micro) amplitude [5].

3 Analysis of the Application of Servo "Hard" Devices

The servo device of the PID continuous regulation system is equipped with an electric servo amplifier in the electric control valve, and an electro-hydraulic servo proportional valve in the electro-hydraulic actuator, that is, an electric servo amplifier+electro-hydraulic proportional valve. Both of them enable the actuator to perform power drive conversion and control the valve's "positioning" function under the action of continuous process control input signals [6].

In the process of PID continuous adjustment, controlling the valve is actually a continuous alternating process of "opening" and "closing". In the process of adjusting the adjusted parameters, it is a process that relies on servo devices to constantly seek balance, which is a dynamic balance process. When there is a new disturbance in the adjusted parameters, there will be a process of seeking new equilibrium, relying on the role of the servo mechanism.

The function of servo is to change the "on" and "off" actions of the actuator, accompanied by the "stop" state, by the "deviation" generated after comparing the input signal of the PID output actuator control with the position feedback signal. The control signal output by PID is compared with the position signal to generate positive or negative "deviation", thereby outputting the positive and negative switch signals of "on" and "off" and the "stop" signal when the deviation is zero, which is the positioning of the execution device after the "on" or "off" operation action is in place.

The servo amplifier used in the execution device of the continuous adjustment system often uses its specific servo hardware device, which has low functional accuracy, a large dead zone for action switching, poor maintainability, and insufficient flexibility in parameter correction during servo operation and maintenance, affecting the quality of adjustment [7].

4 The basic theory of servo "soft" devices follows

According to the functional principle of the "servo" amplifier, a "soft" device that uses PLC (or DCS) to continuously adjust the servo amplification of the system is achieved. The PID control input signal and the actuator position feedback signal are respectively connected to the AI module of the PLC, and the DO signal is generated through the comparison module program design configuration of the PLC (note: there is a positive and negative difference in comparison deviation). Then, it is configured to the DO module of the PLC to output "on" and "off" two different channels. The "1" and "0" switch signals generated in the two output channels (the outputs of the two channels should be "interlocked" and cannot be "1" at the same time) are sent to the driving equipment device (such as a forward and reverse servo motor or a relay controlled three-phase motor with forward and reverse rotation). By using electro-hydraulic servo proportional valves, etc., the forward and backward operation control of the actuator can be achieved, as well as the "stop" operation control of the actuator when the "deviation" is zero (i. e., when the DO output of both open and close channels is "0", the actuator stops running). Thus achieving the power amplification drive and control positioning function of the regulating valve actuator by PID control signals. To achieve the above servo functions, two " ⩾ " signal comparison modules, two "NOT gate" modules, and two "AND gate" modules are required in the PLC program configuration, and two channels each of the AI/DO hardware modules are used [8].

5 The application value of "soft" servo devices

(1) This configuration of a "soft" servo device can replace specific servo hardware devices configured by some actuators. (2) It is possible to "transplant" such "soft" servo devices to existing adjustment execution devices as needed. (3) In the design, manufacturing, and production of servo devices, such configuration design can be carried out to fully utilize mature and reliable automation equipment (PLC, DCS) to transform traditional servo hard devices, improve device sensitivity, and promote the improvement of regulation system quality.

6 Application prospect

This "soft" servo device is suitable for servo amplification devices configured in the execution units of all PID continuous control systems in the production process, such as the electric actuator and electro-hydraulic actuator of the control valve. It can be widely used in the production, design, manufacturing, and development of servo amplifier technology products, and promote the adoption of servo amplifier

"soft" technology devices in equipment design, selection, and configuration of PID continuous regulation systems. It can also analyze and research "specific" servo hard devices in special application scenarios and transplant and match the use of "soft" servo devices, solving the problems of strong "specificity", high failure rate, poor universality, and difficult interchangeability of certain hard servo device applications.

Received: January 20, 2024 Accepted: January 28, 2024 Published: March 20, 2024

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