Research on Optimization and Improvement of Electric Actuators

Yi Kang¹, Wenxin Xu¹*, Hongyan Jin²
¹Harbin Engineering University, Heilongjiang, China
²state Grid Qiqihaer Electric Power Company, Heilongjiang, China

*Corresponding author email: xuwenxin@hrbeu.edu.cn

Abstract. Taking REXA electrohydraulic actuator as the research object, the necessity of applying REXA electrohydraulic actuator in electric actuator requiring frequent adjustment is elaborated. First, the principle of electrohydraulic actuator is introduced and its advanced nature is also expounded. Then, based on the advanced nature of REXA electrohydraulic actuator, REXA electrohydraulic actuator is analysed.

Keywords: Electro-Hydraulic Actuator, Continuous Regulation, Dead Zone, Energy Conservation.

1. Introduction
The quality problems often occur during the later operation of frequently regulated electric actuator, which ultimately affects the normal production of enterprises [1-3]. From the development of current related technologies, REXA electrohydraulic actuator, as the representative of high and new technology, can meet the operation requirements of a variety of frequent operating equipment with strong applicability [4]. Because of the cancel of huge hydraulic station system, the equipment has a stronger running capacity [5]. Therefore, technicians need to transform electric actuator relying on the REXA electrohydraulic actuator in light of this situation [6].

2. Operational Principle of REXA Electrohydraulic Actuator
From the operational principle, it is necessary to apply REXA electrohydraulic actuator in electric actuator requiring frequent adjustment as REXA electrohydraulic actuator takes a complete set of hydraulic control system as the core and has the advantages of integration, miniaturization and intelligence (as shown in Figure 1) [7]. It can meet the requirements of frequent regulation of conventional machinery, realize quick close down and open on performing structure design [8]. Therefore, the system has the advantage of advancement.
The controller can receive the signals transmitted from the outside and transmit them to the servo motor, and receive position feedback from the displacement sensor on the oil cylinder. Therefore, from the function point of view, electrohydraulic actuator is more powerful in operation. REXA electrohydraulic actuator (as shown in Figure 2) has stronger running ability and can meet the operation requirements of electric actuator with frequent adjustment.

3. The Advancement of REXA Electrohydraulic Actuator

Traditional electric actuator generally adopts original electrohydraulic actuator. On the current situation, this kind of electrohydraulic actuator has been difficult to meet the requirements of electric actuators that need to be regulated frequently. Compared to straight line, REXA electrohydraulic Actuator has obvious advantages, which can satisfy the usage specification of electric actuator requiring frequent adjustment. Its advantages are mainly focused on the following aspects:

3.1. Composition

From the view of structure composition, the REXA electrohydraulic actuator is advanced. Compared with traditional electrohydraulic actuator, the structure of REXA electrohydraulic actuator is simpler. Therefore, the maintenance of equipment and management process is simple, and no special person is required to manage it. The details are shown in Table 1.

3.2. Energy Consumption

REXA electrohydraulic actuator is also superior in terms of energy consumption. Compared with traditional electrohydraulic actuator, the energy consumption of REXA electrohydraulic actuator is
better as the device is equipped with closed cycle mode. Therefore, the oil in the equipment does not come into contact with the outside and the probability of energy waste or equipment failure is relatively low. Meanwhile, from power consumption, because REXA electrohydraulic actuator has only one motor, its power consumption is obviously lower than that of the original actuator. Thus it can be seen that REXA electrohydraulic actuator is also advanced in energy consumption. The details are shown in Table 2.

**Table 1. Comparison Table of Device Structure**

| Performance Index | REXA Electrohydraulic Actuator | Original Electrohydraulic Actuator |
|-------------------|-------------------------------|-----------------------------------|
| Composition       | It is composed of servo motor, fine, flow matching valve, bi-directional gear pump and so on | Two AC motors, fuel tank, two accumulator plugs, electric heater, oil filter box, non-return valve, pressure gauge, servo hydraulic cylinder and air cleaner |
| Electric Machinery| A servo motor with 2W power. Adopt intelligent control method. | Two motors with 20W power. Continuous rotation |
| Control Valve     | A servo motor. Accept the steering control of hydraulic pump only | A PARK control valve, easy to block nozzles |

**Table 2. Energy Consumption Comparison Table**

| Performance Index | REXA Electrohydraulic Actuator | Original Electrohydraulic Actuator |
|-------------------|-------------------------------|-----------------------------------|
| hydraulic pressure system | Adopt closed cycle mode. Oil flows only when it is adjusted, so there is no need to do too much maintenance | Open cycle mode. Oil is easy to oxidize, so it needs to be replaced regularly. |
| maintenance content | less maintenance content | Need to replace filter cartridge, hydraulic oil regularly |
| power consumption | 2.4KW/a | 183880KW/a |
| oil consumption | - | 1400-1500L/a |

3.3. **Working Performance**

Compared with traditional electrohydraulic actuator, the performance of REXA electro-hydraulic actuator is stronger, because it adopts intelligent technology to meet the requirements of frequent adjustment of electric actuator under various conditions. Therefore, from the working performance, the potential energy of electrohydraulic actuator is stronger, and it has a number of advantages such as ideal stability, good safety, energy saving and environmental protection, etc. The details are shown in Table 3.

According to the analysis above, REXA electrohydraulic actuator is advanced. Compared with traditional electrohydraulic actuator, REXA electrohydraulic actuator has more advantages in functional performance, energy consumption and equipment structure, which makes the performance of REXA electrohydraulic actuator stable and easy to maintain. And it can meet the requirements of frequently regulated electric actuators. So it is necessary to use it.

3.4. **Actuators are the weak link in process control**

In industrial process control, the three basic elements of measurement, control and execution are interconnected to form a closed-loop system. The accuracy, stability and responsiveness of the three elements determine the quality of the final product. No matter how well any one or two of them are, the control process is always limited by the weakest link.
In the past four decades, thanks to the revolution in electronics, the measurement and control aspects of process control have been greatly improved. However, most improvements in control are limited by the poor positioning performance, stability and responsiveness of traditional actuators.

Table 3. Functional Performance Comparison Table

| Performance Index     | REXA Electrohydraulic Actuator                                                                 | Original Electrohydraulic Actuator                                                                 |
|-----------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| working performance   | Stable operation of equipment. Adopt intelligent work mode, and perform uninterrupted operation. The influence of oil quality on the operation effect of the equipment is not obvious. No solenoid valve is set inside the equipment. Because of few key devices, the structure is simple, and it is helpful to the safety management of the unit. | The operation of the equipment is affected by the fluctuation of oil pressure, so the equipment demands the oil quality. In general, the operation effect is not ideal. More parts of the equipment, and large leakage probability of hydraulic pipe cause the risk of fire |
| safety                | Less hydraulic oil used, so it is environmentally friendly and will not produce serious pollution. | Large oil consumption of hydraulic oil makes leakage problem easy to occur                             |
| environmental protection |                                                                                            |                                                                                                     |

On the other hand, while the role of implementing agencies in terms of crew efficiency, safety and reliability is crucial, their performance is often overlooked. In many cases, actuator problems are often not mentioned until after a serious or complete failure (closing down, blowing out). For the rest of the time, their poor performance was either undetected or simply tolerated, and more obvious problems were taken seriously.

3.5. Current situation of pneumatic and electric actuators

For control valve actuators, users usually only think of pneumatic actuators or electric actuators. Data show that only the executing agency with high regulation times (SPH 2000 or more than 2000) can be compatible with microprocessor based control system and advanced strategy accurately, so as to achieve the requirements of current industrial process for high-performance loop.

Pneumatic actuators have inherent weaknesses. The compressibility and friction of air or gas are unavoidable weaknesses of the pneumatic positioning system. Implementing agencies need to overcome friction to exercise. However, there is a large difference between the friction coefficient at the beginning of the exercise and the friction coefficient at the time of the exercise, resulting in a step change in the valve position. The degree of this step determines the positioning resolution of the actuator. When the control instrumentation system requires accuracy of 0.5%, this "run-out effect" causes the positioner to be subjected to large unbalance forces, easily causing oscillations, and the production process and regulator need constant position correction.

For applications where regulation is infrequent, electric actuators are able to meet the stringent accuracy requirements of the control system. In order to achieve this accuracy requirement, the electric actuator needs to be constantly repositioned to reach the expected end position transmitted by the system meter. The problem is that when the motor starts to start, it will flow over a large current so that it produces heat. If it is frequently started, it will be enough to make the motor hot. The number of times per hour in the technical specifications of the electric actuator (SPH) is the most allowed position to prevent the motor from overheating. The precision of the electric actuator determined by SPH does not change obviously with the change of the process conditions. It is an inherent characteristic of the actuator (Table 4 shows the minimum dead zone and accuracy of the electric actuator at different process rates Rc in units of percentages per second). As the electric actuator for the mechanical transmission, after running for a period of time, various components / components due to differences in operating frequency and load conditions, each wearing parts have exceeded the
standard, the fault features of this phase are: The aging of motor coil leads to lower insulation and unstable operation; the stability of the motor is decreased when the lubrication of the motor is not good; the comparison coil aging of positioner or the aging of position current converter decrease the positioning accuracy; the wear of the transmission parts of the reducer causes the electric mechanism to be unadjustable and so on, which results in a marked decrease in the efficiency of the electric actuator and a gradual increase in the failure rate.

Table 4. Minimum dead zone and accuracy of the electric actuator

| SPH  | 4000 | 2000 | 1200 | 600  | 300  |
|------|------|------|------|------|------|
| Travel time (seconds) | 30   | 30   | 30   | 30   | 30   |
| Rc=0.05 |     |      |      |      |      |
| Minimum dead | 0.044 | 0.068 | 0.14 | 0.296 | 0.591 |
| Accuracy | 0.25% | 0.86% | 1.44% | 2.87% | 5.74% |
| Rc=0.01 |     |      |      |      |      |
| Minimum dead | 0.009 | 0.017 | 0.030 | 0.059 | 0.120 |
| Accuracy | 0.25% | 0.87% | 1.45% | 2.90% | 5.81% |
| Rc=0.001 |     |      |      |      |      |
| Minimum dead | 0.001 | 0.002 | 0.003 | 0.006 | 0.012 |
| Accuracy | 0.25% | 0.87% | 1.46% | 2.91% | 5.81% |

4. Conclusion
REXA electro-hydraulic actuator can meet the operation requirements of electric actuator with frequent adjustment, and it is advanced in terms of technology, structure, energy consumption and safety, which determine that it is necessary to use REXA electrohydraulic actuator when transforming electric actuator. Therefore, relevant personnel must further understand the advanced technology of REXA electro-hydraulic actuator and adopt a variety of effective means to improve the application strategy of REXA electro-hydraulic actuator so as to better meet the operation requirements of electric actuator.

References
[1] Loukianov A G, Fridman L, Cañedo J M, et al. Higher Order SM Block-Control of Nonlinear Systems with Unmodeled Actuators: Application to Electric Power Systems and Electrohydraulic Servo-Drives[J]. Lecture Notes in Control & Information Sciences, 2008, 375:401-425.
[2] Li P Y, Krishnaswamy K. Passive Bilateral Teleoperation of a Hydraulic Actuator using an Electrohydraulic Passive Valve[J]. International Journal of Fluid Power, 2004, 5(2):43-55.
[3] Tri N M, Nam D N C, Park H G, et al. Trajectory control of an electro hydraulic actuator using an iterative backstepping control scheme[J]. Mechatronics, 2015, 29:96-102.
[4] Karpenko M, Sepehri N. On quantitative feedback design for robust position control of hydraulic actuators[J]. Control Engineering Practice, 2010, 18(3):289-299.
[5] Qinghui Yuan, Perry Y Li. Self-Calibration of Push-Pull Solenoid Actuators in Electrohydraulic Valves[J]. Asme International Mechanical Engineering Congress & Exposition, 2015:269-275.
[6] Tri N M, Nam D N C, Park H G, et al. Trajectory control of an electro hydraulic actuator using an iterative backstepping control scheme[J]. Mechatronics, 2015, 29:96-102.
[7] BinYao, FanpingBu, Chiu G C. Non-linear adaptive robust control of electro-hydraulic systems driven by double-rod actuators[J]. International Journal of Control, 2012, 74(8):761-775.
[8] Meng J X, Wang Y, Wang X B. Simulate Research on High Precise Electro-hydraulic System Adjusted by Hybrid Fuzzy Controller[J]. IEEE, 2009, 1(1):153-157.