증기터빈 Bypass Valve 통합전자제어 유압구동시스템에 관한 연구

A study of the integrated electronic control hydraulic driving system of steam turbine bypass valve

#안경관 [1], *딩광쨩 [1], 윤종일 [2], 김무림 [3], 최진태 [3]
#K. K. Ahn(kkahn@ulsan.ac.kr)[1] , D. Q. Truong[1], J. I. Yoon[2], M. R. Kim[3], C. T. Choi[3]
[1] 울산대학교 기계자동차공학부, [2] 울산대학교 기계자동차공학과 대학원, [3] 포항산업과학연구원

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1. Introduction

Hydraulic systems have been considered as the potential choices for modern industries ranging from heavy-duty manipulators to precision machine tools because of their advantages. Previous servo hydraulic actuators mostly contain hydraulic control valves, thus lots of energy was transferred into heat due to throttle losses at the valves. In order to overcome these weak points in the conventional hydraulic systems and satisfy new demands, hybrid actuator – electro-hydraulic actuator, known as the compact energy-saving and low-noise hydraulic device which shifts from high-speed electric system to high-force hydraulic system [1-4]. Due to its efficiency, EHAs have a wide range of applications for which high accuracy and fast response of force/pressure or position control are exceedingly necessary, especially in heavy industry, etc.

In power generation of steam turbine, bypass valve plays an important role. In order to improve the bypass valve performance as well as to save power, electro-hydraulic bypass system is necessary. This research is a proposition to use the EHA with automatic feedback control as an advanced solution for steam turbine bypass valve control in POSCO Corp. The EHA hardware structure is based on the used SHA parameters and working conditions to satisfy all the desired bypass valve requirements. A test rig is setup in order to evaluate the EHA with position control performance.

2. EHA design and verification

2.1 Specifications of EHA

Based on the previous research [2], an EHA type, intelligent hydraulic (IH) servo driver pack, made by YUKEN Company is chosen as a feasible solution. The suitable IH pack specifications are then selected and shown in Table 1.

Consequently, the schematic diagram of the test rig is shown in Fig. 1. The system hardware consists of the EHA, which is named motion generator, a load and a linear sensor to feedback position signal. In addition, a computer included PCI-bus multifunction cards are used built the overall control system to perform position control performance of the EHA.

Table 1. Specifications of EHA

Parameters	Values
Pump displacement [cc/rev]	16
Max. shaft speed [rpm]	2000
AC servo motor power [kW]	4.4
Rated Torque [Nm]	28.4

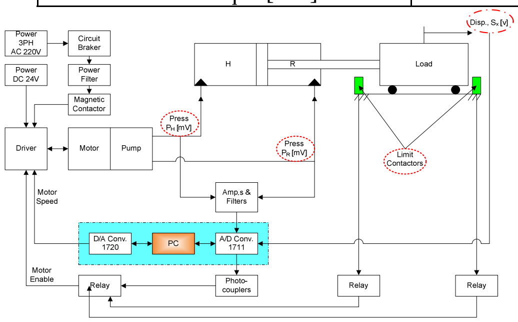

Fig. 1 Schematic diagram of the EAH test rig

2.2 Position control using quantitative feedback theory (QFT)

Quantitative Feedback Theory (QFT) is a unified theory that designs and implements robust control for a system with structure parametric uncertainty to satisfy the desired performance specifications, even when faced with the presence of disturbance, noise amplification or resonance [2]. The QFT method proposes as a general control strategy the two of freedom structure presented in Fig. 2.

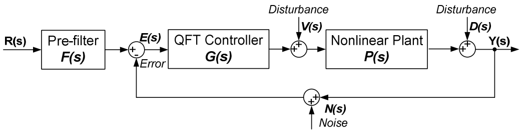

Fig. 2 Structure of the QFT control system

The first step in designing a robust QFT controller is thus to derive a family of uncertainties of the plant transfer function. By using the identification process, the EHA can be presented by a family of second-order transfer functions as follows:

$$P(s)=\frac{k}{(1+p_1 s)(1+p_2 s)},\ [mm/V] \quad (1)$$

where $k\in[64.58,81.31][N/mV]$; $p_1\in[0.11,1.79]$; $p_2\in[0.11,1.71]$

In QFT, for tracking performance requirement, the strictly proper controller, G(s), and a strictly proper pre-filter, F(s), (Fig. 2) are to be designed based upon the stability and system performance's specifications in the time domain. In this case, the system should fulfill the following control criterions:

Settling time less than 1.5 [s].

Maximum percentage of overshoot $\leq 2[\%]$

Based on the design requirements, the robust QFT controller is determined:

$$G(s)=\frac{6.13\times10^5 s-6.851\times10^5}{s^2+3399s+1.035\times10^6} \quad (2)$$

$$F(s)=\frac{14.04}{s+14.45} \quad (3)$$

2.3 Experimental results

The QFT control algorithm used to control the EHA are built by the combination of Simulink and Real-time Windows Target Toolbox of Matlab and connected to Advantech cards. In order to check the working performance of EHA for position control, a sinusoidal excitation signal is given as the reference. As the result, the position response of the system using the designed QFT controller is depicted in Fig. 3. From this figure, it is clearly that the EHA using the proposed controller is able to apply to the CPC of the SRM.

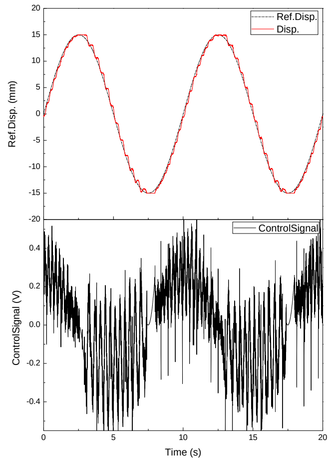

Fig. 3 Position response of the EHA using QFT Controller

3. Conclusions

In this research, an advanced solution for the steam turbine bypass valve is proposed as a closed-loop feedback control using EHA. The EHA specifications are selected based on the setting parameters of the traditional actuator controlling the bypass valve and the control requirements. In addition, the QFT controller is also suggested to use for the closed-loop feedback bypass valve with high stability.

Acknowledgement

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Reference

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