INTEGRATED TUNING OF BI-AXIAL SERVOMECHANISMS FOR PRECISE MOTION CONTROL

Chul-Mo Sung¹, Kyung-Don Kim² and Sung-Chong Chung¹*
¹Hybrid System Design & Control LABoratory
Department of Mechanical Design
Hanyang University, SungdongGu, Seoul 133-791, KOREA
²Small Business Corporation, Gyeonggi Regional Headquarter, Suwon, KOREA

ABSTRACT
In order to ensure high-speed and high-precision specifications in servomechanisms, tracking and contour errors should be minimized through optimal selection of servo parameters. In this paper, integrated tuning procedure based on the integrated design concept is performed to derive the optimal tuning method. Control parameters are optimally selected through a nonlinear constrained optimization problem of the integrated design process, while parameters of the mechanical subsystem are specified according to the identified mechanical subsystem model. Experimental results show that both tracking and contouring errors are significantly reduced by applying the proposed integrated tuning method.

INTRODUCTION
Precision servomechanisms are used widely in the manufacturing, IT, machine tool, FPD (flat panel display) and aerospace industries. It is important to improve contouring and tracking accuracy in high-speed manufacturing systems. To improve contouring accuracy in the multi-axis control, cross-coupled control (CCC) systems have been applied so far [1]. However, it is difficult to select the controller parameters optimally because the cross-coupled control system is a multivariable, nonlinear, and time-varying control system. To improve tracking performance of servos with servo lag, friction and external load, etc., ZPETC [2] and optimal ZPETC [3] have been applied in motion control systems. However, tuning of these inverse model-based feedforward controllers is difficult in practical environments due to many tuning parameters. Modelling error and nonlinearity of the servomechanisms have hindered perfect tracking as well.

In this paper, an optimal tuning method of cross-coupled controller linked with the feedforward controller is studied to reduce both the contouring and tracking errors of a biaxial servomechanism through the previously developed integrated design [4,5] and tuning [6] methods. The integrated tuning is an optimal tuning method based on the integrated design concept [4,5]. Its control parameters are optimally selected through a nonlinear constrained optimization procedure of the integrated design process, while parameters of the mechanical subsystem are specified according to the identified mechanical subsystem model. Linear and circular motion experiments are performed on a bi-axial servo to verify the effectiveness of the developed optimal tuning procedure.

CONTOUR ERROR
A cross-coupled controller is a effective control structure to reduce contour errors directly by coupling multiple axes. In order to design the cross-coupled controller, it is required that contour error, difference of normal direction between the required and active positions, should be calculated correctly. In case of linear motion, contour error is given by

\[ e_y = -e_x \sin \theta + e_x \cos \theta \]  

(1)

\[ e_y \]

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{Contour error in a linear motion.}
\end{figure}