The Vibration Suppressible Method with Estimated Torsion Torque Feedback in Fuzzy Controller

Yeon-Gyu Choo, Kwang-Seok Lee, Hyun-Deok Kim and Bong-Gi Kim, *Member, KIMICS*

***Abstract*—** In torque transmission system, we must suppressed vibration for Accuracy characteristic response of motor, Therefore, vibration suppression factor is very important motor control. To suppress vibration, a various control method has been proposed. Specially, one method of vibration suppression used disturbance observer filter. This method is torsion torque passing disturbance observer filter. By the estimated torsion torque feedback, vibration can be suppressed. The CDM(coefficient diagram method) is used to design the filter and Proportional controller. But using coefficient diagram method, not adapted controller parameter in disturbance. For this solution, we used fuzzy controller for auto tuning controller parameter. We proved this approach is confirmed by simulation.

***Index Terms*—** Motor Vibration Suppression, Adaptive Fuzzy Controller, Coefficient Diagram Method, Disturbance Observer Filter

I. INTRODUCTION

A torque transmission system, which is composed of several gears and couplings, is flexible. Therefore, the torsion vibration occurs when the motor velocity abruptly changes. Consequently, for Accuracy characteristic response of motor, we must suppress vibration. Therefore, vibration suppression is very important motor control.[1] To suppress vibration, various control method have been proposed. Specially, one method of vibration suppression in 2-inertia system used CDM method. The CDM method has suggested by Shunjji Manabe.[2-3] He gets desired controller's value using a stability exponent and a time constant. But there is not any mathematical proof on account of getting a stability exponent and a time constant. Besides, these parameters are set up owing to permission of disturbance. For this solution, we used fuzzy inference system for auto tuning controller parameter. We proved of this approach is confirmed by simulation.

Manuscript received August 11, 2008; revised October 8, 2008.

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An industrial servo system is generally composed of a multi-inertia system having several inertia moments and springs, but most of the system can be analyzed by approximating them with a 2-inertia system, which is the simplest vibration model. Therefore, we use a 2-inertia system in the simulation. 2-inertia system model is shown in fig. 1. A Block diagram of a velocity control system is shown in fig. 2. The parameters in fig. 2 are as Table 1.

Table 1 Parameter in System Model

Parameter			
J_M	motor inertia	D_M	motor viscous damping
J_L	road inertia	D_L	load viscous damping
ω_{ref}	reference velocity	T_C	torque constant
ω_M	motor velocity	S_C	spring coefficient
ω_L	load velocity	M_T	motor torque
I_{ref}	current reference	D_T	disturbance torque
K_p	controller gain	T_T	torsion torque

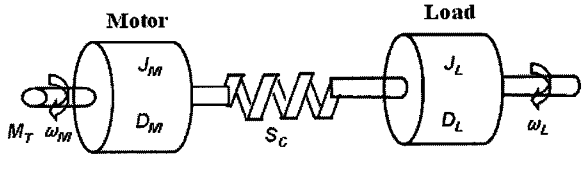

Fig. 1 System model of 2-inertia system

II. CONTROLLER DESIGN

In this paper, a rule-based scheme for auto tuning of parameter K_P is proposed for process control. The new scheme utilizes fuzzy rules and reasoning to determine the controller parameter and the P controller generates the control signal. It is demonstrated in this paper that human expertise on gain P scheduling can be represented in fuzzy rules. The approach taken here is to exploit fuzzy rules and reasoning to generate controller parameters. It is assumed K_P that are in prescribed ranges $[K_{P,min}, K_{P,max}]$, respectively.

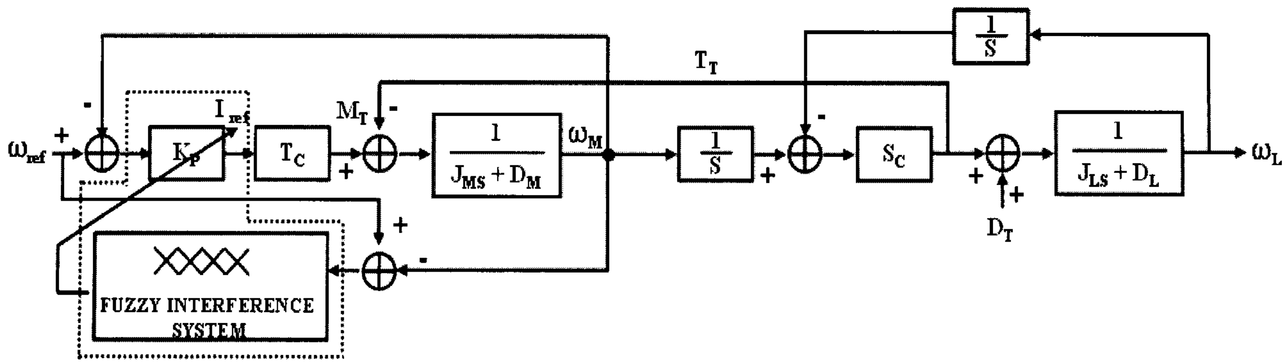

Fig. 2 Block diagram of vibration suppression with proposed controller

The appropriate ranges are determined experimentally and will be given in equation (1). For convenience, K_P is is normalized into the range between zero and one by the following linear transformation;

$$K_P' = (K_P - K_{P,\min})/(K_{p,\max} - K_{p,\min}) \tag{1}$$

In the proposed scheme, parameter K_P are determined based on the current error $e(k)$ and its first difference $\Delta e(k)$. The parameter K_P' is determined by a set of fuzzy rules of the form; If $e(k)$ is A_i and $\Delta e(k)$ is B_i then K_P' is C, $i=1,2,\ldots,m$. Here, A_i, B_i, C, are fuzzy sets. Defuzzification is

$$K_P' = \sum_{i=1}^{m} \mu_i K'_{P,i} \tag{2}$$

here, $\mu_i = \mu_{A_i}[e(k)] \cdot \mu_{B_i}[\Delta e(k)]$ is membership function. Once K_P' is obtained, the parameter K_P' is calculated from the following equations that is due to (1),

$$K_P = (K_{P,\max} - K_{P,\min})K_p' + K_{p,\min} \tag{3}$$

based on an extensive simulation study on various processes, a rule of thumb for determining the range of K_P is given as;

$$K_{P,\min} = 0.32K_u, K_{p,\max} = 0.6K_u \tag{4}$$

where are K_u, T_u are respectively, the gain and period of oscillation. Using the Ziegler-Nichols method, $K_u = 0.8$, $T_u = 0.5$.

III. SIMULATION

In this paper, we simulated for vibration suppression using three type controller. An each controller is PI controller,[5-8] CDM and auto tuning controller for K_P using fuzzy inference system. Parameters used in the simulation are shown in Table 2.

Table 2 Value of Parameter

Parameter		
J_M	motor inertia	4.02×10-3
D_M	motor viscous damping	2.92×10-3
J_L	load inertia	2.00×10-3
D_L	load viscous damping	2.00×10-3
T_C	torque constant	1
S_C	spring coefficient	39.2

Fig. 3 and 4 shows step response of motor and load velocity. From fig. 3 and 4, we know that large overshoot and steady state error occurred using PI controller, but using CDM controller and proposed controller superior to PI controller. But method using proposed controller better than CDM controller for more or less overshoot term. Fig. 5 shows current waveform in step response.

Finally, the parameter K_P is obtained by using equation 10 that waveform shows fig. 6., 7 and 8 shows step response in disturbance. We know as output waveform, proposed controller better than CDM method and PI controller. Fig. 9 shows current waveform in disturbance for step response. Fig. 10 shows the parameter K_P is changing waveform in step response.

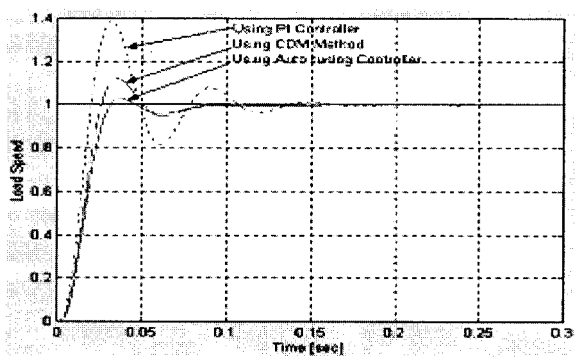

Fig. 3 Velocity of load

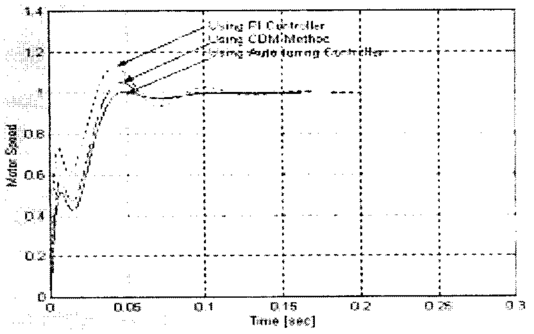

Fig. 4 Velocity of motor

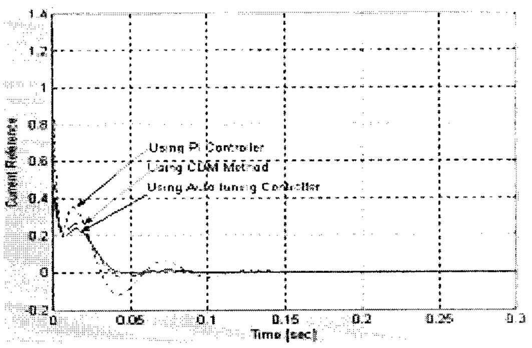

Fig. 5 Reference current

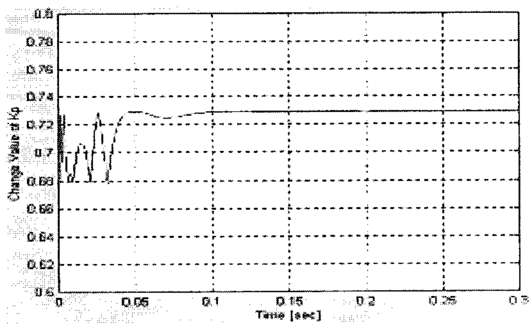

Fig. 6 Waveform of parameter *Kp*

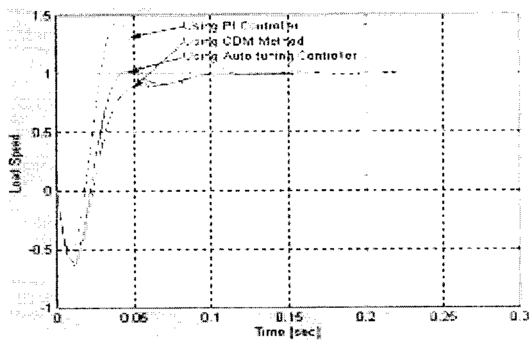

Fig. 7 Velocity of load(in disturbance)

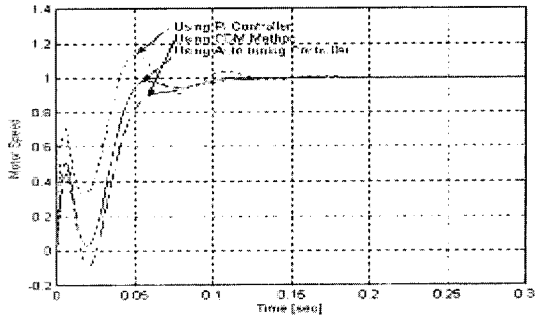

Fig. 8 Velocity of motor(in disturbance)

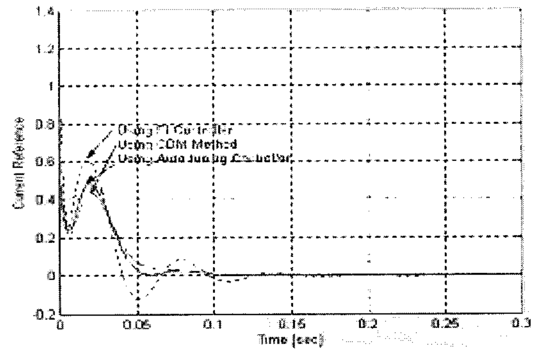

Fig. 9 Reference current (in disturbance)

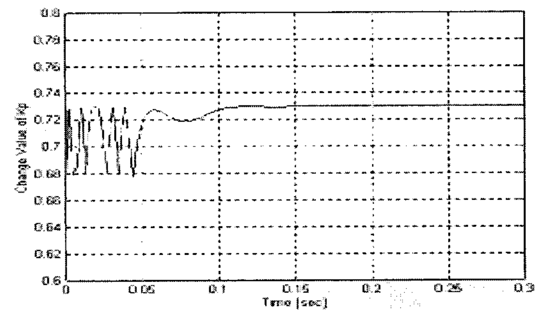

Fig. 10 Waveform of parameter *Kp*

V. CONCLUSIONS

In this paper, we used auto tuning parameter K_P using fuzzy inference system for vibration suppression. We compare a CDM method, PI controller and proposed controller. It is found that the proposed controller is very useful than other controller(PI controller and CDM Method) for vibration suppression. Also, proposed controller excellent that vibration suppression in disturbance or not.

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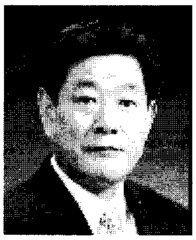

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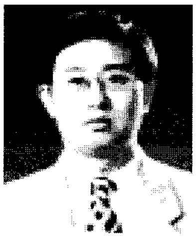

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