Comparison of Conventional and Fuzzy P/PI/PD/PID Controller for Higher Order Non Linear Plant with High Dead Time

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***Abstract*:** Several industrial processes have the "dead-time effect " produced due to measurement delay or due to the approximation of higher order dynamics of the process by a simple transfer function model. This delay causes the unstabilty of the whole system. In this paper the designing of Fuzzy controller is done for the system having higher order and high dead time. Performance table shows the affects of the proposed Fuzzy Logic Controllers as compared to the ZN tuned Conventional Controllers.

***Keywords*:** PID controller, Zeigler-Nichols tuning, Fuzzy logic controller, High Dead time, tuning, simulation**,**

I. INTRODUCTION

Conventional PID controllers have been a wide range of use in industry because of its simple structure and acceptable performance. This controller deals with both time response and frequency response improvements if they are properly tuned. But as the demands increases to control the different systems in industries, performance of conventional controllers are tend to degrade. Now systems are getting complicated day by day introducing higher order plants which increases the dead time so resulting the unstabilty in the systems.There is drastic change in the performance of controllers with the introduction of Fuzzy systems and so the Fuzzy controllers (P, PI, PD, and PID) has been designed and tuned for third order system with such a high dead time which is difficult to control by the use of conventional controllers. FLC has been widely used for nonlinear, high order & high dead time plants. This paper has two main considerations. Firstly, a PID controller has been designed for nonlinear unstable third order with high delay system using Zeigler Nichols tuning method (De Paor & O'Malley, 1989; Venkatashankar & Chidambaram, 1994; Ho & Xu, 1998), & its performance is analysed. Secondly, for the same system a FLC is designed with five membership functions, then its performance is analysed and compared with the conventional one. The parameters which are to b compared, taken here are peak overshoot(M_P), Rise time(T_R) & Settling time(T_S)..

II. GENERALISED FORM OF CONVENTIONAL CONTROLLER

A PID controller is designated by:

G(s) = P+I+D

= $K_P + K_I/s + K_D s$ -------------- (1)

= $K_P (1+ 1/ T_I/s + T_D s)$ ---------- (2)

Where K_P = proportional gain, K_I = integration coefficient, K_D = derivative coefficient.

T_I = integral action, T_D = derivative action.

For the best performance of the system, there is need of adjusting these three parameters which is more difficult & time consuming.

III. DESIGNING OF CONVENTIONAL PID CONTROLLER

For the higher order and high delay time system with transfer function

$$G(s) = \frac{1}{s(s+2)^2} * e^{-9s}$$

PID controller family is being designed. Fig1 shows the simulink model of the conventional controller and plant with the unity feedback.

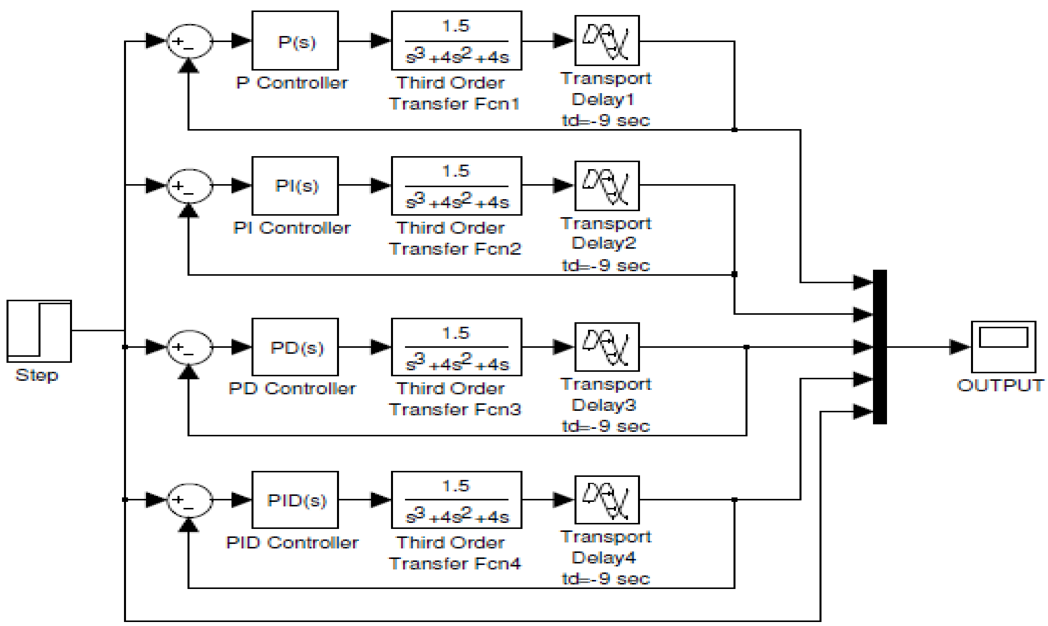

Figure 1: Conventional P, PI, PD and PID Controllers

Tuning of conventional controller has been done by the Ziegler–Nichols Method, which is used in mostly all the Industrial PID Tuning.

Table I: Ziegler–Nichols Method

Controller	Kp	Ki	Kd
P	0.5*Ku	--	--
PI	0.455*Ku	0.545*Ku/Pu	--
PD	0.71*Ku	--	0.15*Pu
PID	0.588*Ku	1.17*Ku/Pu	Ku*Pu/13.6

Ku and Pu are Ziegler-Nichols parameters, can be calculated for plant by inserting the plant in setup with a step input and gain K and tuning the gain K up to which the plant output is sustained oscillations. At that time Gain K will be equal to Ku and Pu will be time difference between two consecutive peaks.

IV. DESIGNING OF FUZZY LOGIC CONTROLLER (FLC)

For the same plant, simulink model of only PID fuzzy controller with unity feedback is shown in fig2. In this paper for the 2-input FLC, 5 membership functions for each input (error & change in error) & outputs are used. Fuzzy PI+PD Controller have been designed with Fuzzy PI and Fuzzy PD by adding the outputs of the PI and PD controller. It has two inputs Error (E) and change in Error (CE) with Gains GE, GE1 and GCE, GCE1 and an output U with Gain GCU, GU. The controller has been used as feedback controller. To design the fuzzy PID controller first rule base has been created in FIS Editor and the controller has been used as feedback controller. The controller has been tuned by 'Hit and Trial Method' by tuning gains GE, GE1, GCE, GCE1, GCU, GCU1.

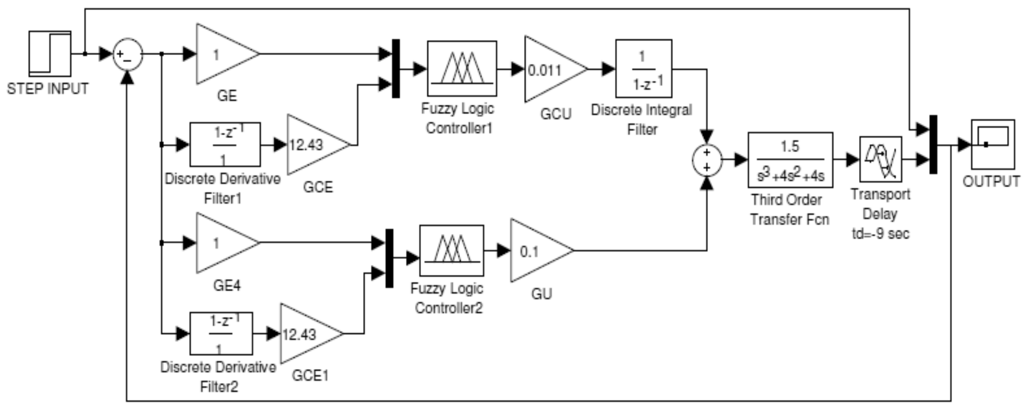

Figure 2: Simulink model of PID fuzzy controller

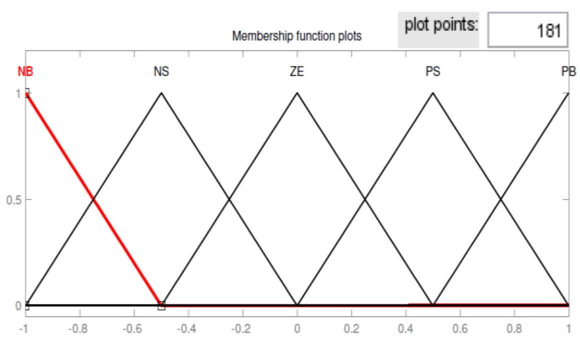

Figure 3: Membership functions for the output parameter

Membership functions for the output parameter are shown in Fig3, here NB means Negative Big, NS means Negative Small, ZE means Zero and PB means Positive Big & PS means Positive Small.

V. RESULT

Table 1: Performance table of Conventional PID controller's family

Controller Type	t_r (sec)	M_p (%)	t_s (sec) 2%	t_s (sec) 5%
P	24	28.7	77	--
PI	22.5	73.2	132	--
PD	19.5	59.8	129	--
PID	19.5	HIGH	HIGH	HIGH

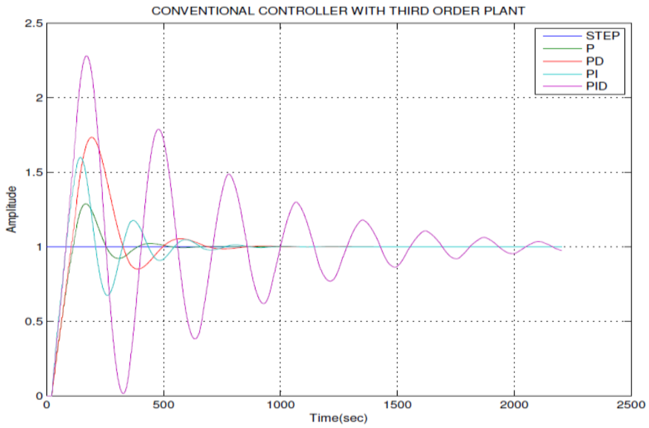

Figure 4: Response of Conventional controller

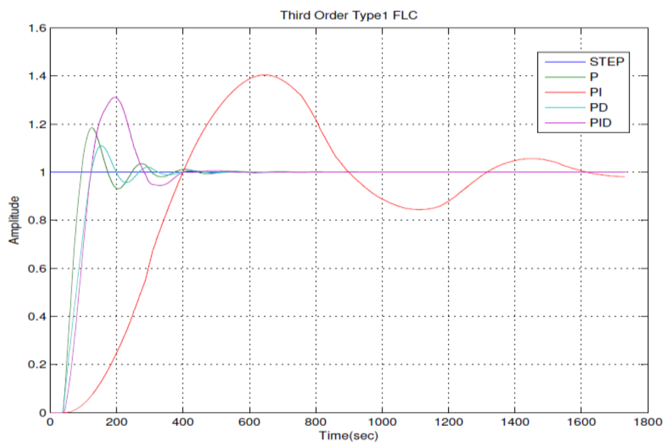

Figure 5: Response of Fuzzy controller

Table 2: Performance table of Fuzzy PID Controller's Family

Controller Type	t_r(sec)	M_p(%)	t_s(sec) 2%	t_s(sec) 5%
FP	28	18.5	97	87
FPI	135	40.37	--	466
FPD	38	10.96	84	--
FPID	38	31	129	--

VI. Conclusion

This paper shows the designing & performance of conventional & Fuzzy logic P,PI,PD,PID controller for higher order with high delay time nonlinear plant. Simulation results using MATLAB/SIMULINK are discussed for ZN tuned PID controller & the Fuzzy logic controller. The PD Fuzzy logic controller gives low value of overshoot & smaller settling time than ZN technique which gives the high overshoot & settling time. The simulation results confirms that the PD Fuzzy Logic controller with simple design for the higher order & high delay time gives the better performance in case of stability comparing with the ZN tuned P,PI,PD PID controllers.

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