Optimization of PD, PID and Fuzzy Logic Controller for Industrial Application

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Abstract: Measuring the flow of liquid is a critical need in many industrial plants. The aim of this paper is to do the comparative study of Proportional Derivative controller, conventional PID controller and fuzzy logic controller for flowing fluids. In this paper, performance analysis of proportional derivative, conventional PID controller and fuzzy logic controller has been done by the use of MATLAB and simulink and in the end comparison of various time domain parameter is done to prove that the fuzzy logic controller has small overshoot and fast response as compared to PID controller and PD controller. PID controller is the most widely used control strategy in industry. The popularity of PID controller can be attributed partly to their robust performance and partly to their functional simplicity. In this paper, the response of the PID and PD controller is oscillatory which damage the system. But the response of the fuzzy logic controller is free from these dangerous oscillation in transient period. Hence the Fuzzy logic controller is better than the conventionally used PID controller.

Keywords: Fuzzy Logic Controller, PID and PD Controller, Matlab/ Simulink.

I. INTRODUCTION

Flow control is critical need in many industrial processes. The control action of chemical industries maintaining the controlled variables. In this paper, we control the flow via three method: PD, PID and FLC. PD and PID control is one of the earlier control strategies [1]. PID controller has a simple control structure which is easy to understand but the response of PID, PD controller is not fast. To overcome these problems we use fuzzy logic controller. Performance analysis of PD, PID and FLC has been done by the use of MATLAB and simulink. Comparison of various time domain parameters is done to prove that the FLC has small overshoot and fast response as compared to PD and PID controller.

2. CONTROL SYSTEM OF FLOW PROCESS STATION

The flow process station consist of a reservoir from which the liquid is transferred to the overhead tank by means of a motor [9]. Flow is the process variable of this process. The desired flow is set by the user. An orifice meter measure the flow rate of the liquid. Differntial pressure transmitter senses the pressure difference and it is calibrated to provide the correct flow rate.[9]. DPT now sends the measured value to the process computer where controller is employed. After execution of the fuzzy simulation in MATLAB, the control variable is given to the final control element. The objective of this paper is to maintain the desired flow rate.

3. DESIGN CONSIDERATION

A. Design of PD Controller

Figure.1 shows the simulink model of the PD Controller with unity feedback.

Derivative controller (Kd) reduces both the overshoot and the settling time. The closed-loop transfer function of the given system with a PD controller is:

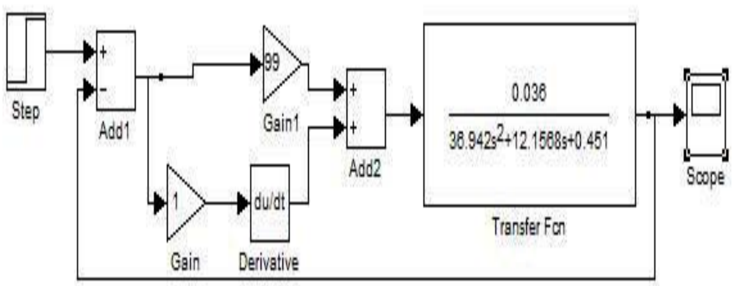

Fig.1. simulink diagram of PD Controller

B. Design of PID Controller

A simple strategy widely used in industrial control is PID controller [4]. A PID Controller is being designed for a higher order system. Fig.2 shows the simulink diagram of the PID Controller with unity feedback.

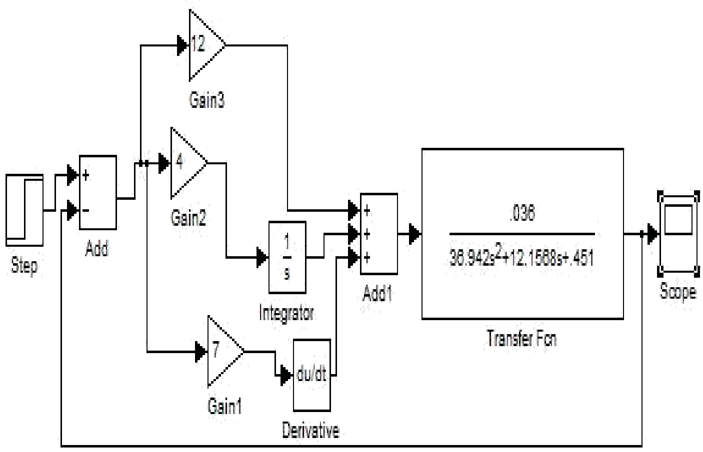

Fig.2. simulink diagram of PID Controller

The response of this technique is not fast and reliable. To overcome these problem we proposed the Fuzzy Controller sothat the closed loop system exhibit small overshoot and settling time with zero steady state error.

U(t) = KP e(t) + KP/ TI e(t)t0dt + Kp TD de(t)/dt

Where,

U(t) = Control signal applied to plant, K_P = Proportional gain, K_I = Integral gain, K_D =

Derivative gain

The selection of these K_P, K_I and K_D values selects according to the desired response.in general the dependency shows in the following table.

Table 1. Effect of increasing parameter values independently on the response

Paramete r	***Rise Time(T_r)***	***Overshoo t (Mp)***	***Settling Time(Ts)***	***Error (Ess)***
KP	Decrease	Increase	Small Change	Decrease
KI	Decrease	Increase	Increase	Decrease Significantl y
KD	Minor Decrease	Decrease	Decrease	No effect

C. Design of Fuzzy Logic Controller

Figure 3. shows the simulink model of the Fuzzy Controller with unity feedback

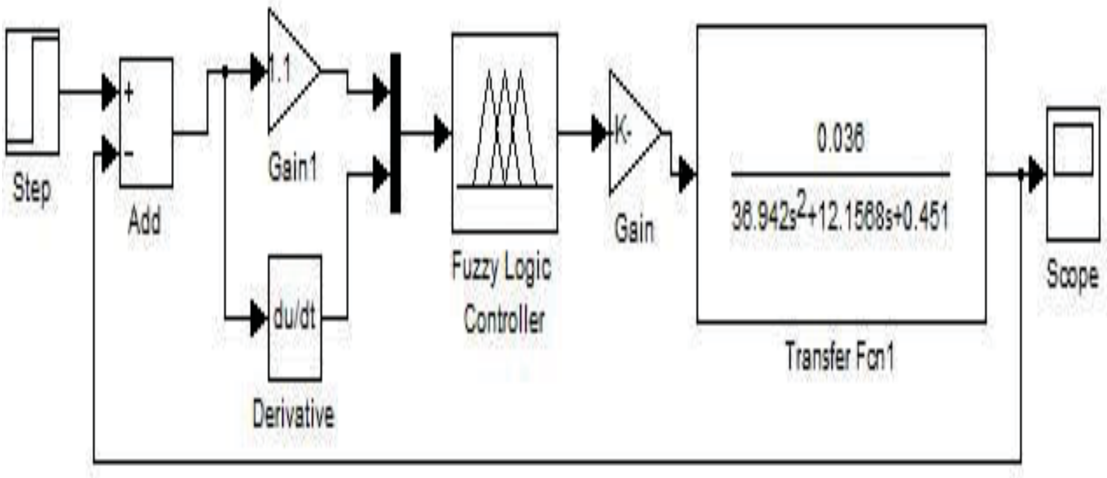

Fig.3. simulink diagram of Fuzzy Controller

[1]. *Fuzzy Membership Function*

There are two fuzzification methods namely, Mamdani and Sugeno. Generally used Defuzzification methods are center of area, center of gravity, fuzzy clustering, first of maxima, last of maxima, mean of maxima, semi-linear Defuzzification, quality method, middle of maxima [4]. Centroid defuzzification method is used in this paper.

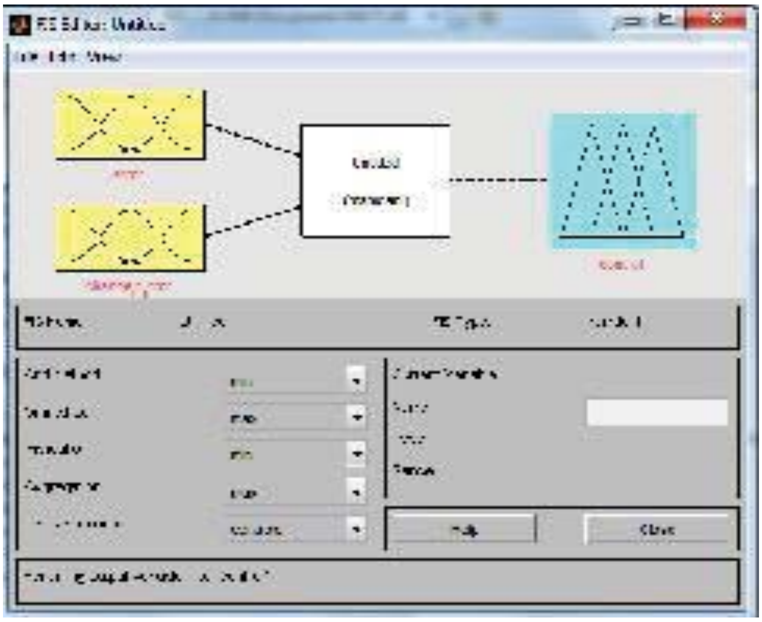

Fig.4. selection of I/O for designing FIS

In this paper two fuzzy membership functions are used for two inputs error and change in error and one output i.e. control as shown in Figure 4.

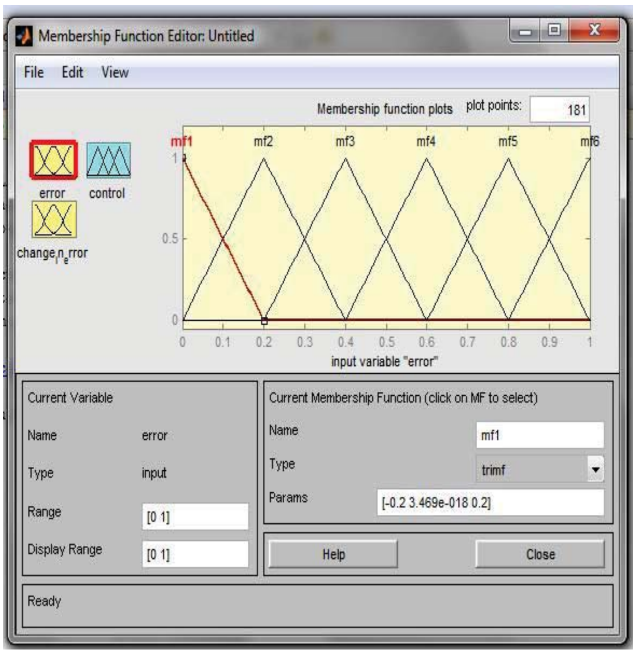

Fig.5. membership function editor for fuzzy controller

Figure.5 shows the fuzzy membership function editor where the number of membership function and type of membership function is choose, such as trapezoidal, triangular and Gaussian according to the process parameter. In this paper it is suitable to choose triangular and trapezoidal.

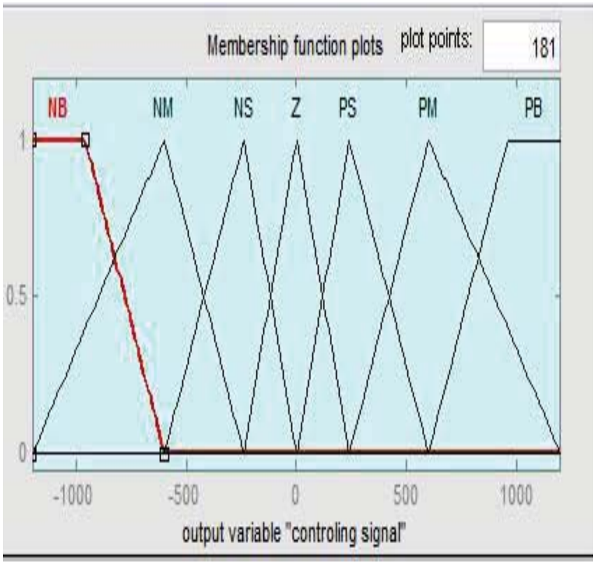

Fig.6. membership function for output

The fuzzy membership-function for the output parameters are shown in figure.6.

Here NB = Negative Big, NM = Negative Medium, NS = Negative Small, Z = Zero, PB = Positive Big, PM = Positive Medium, PS = Positive Small

[2]. *Fuzzy rules for Developing FIS*

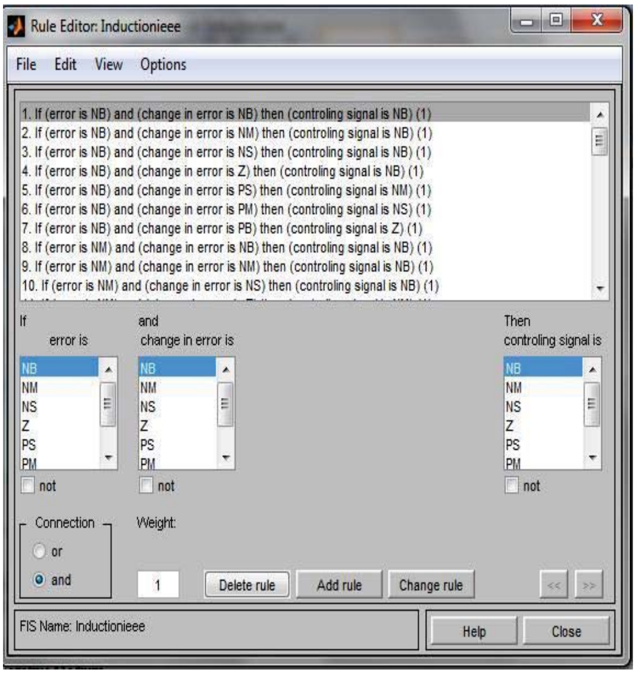

Fig.7. fuzzy rules for FIS

Fuzzy rules operate using a series of if- then statement. Figure 7. shows the fuzzy rules for developing FIS. The fuzzy control rule is based on fuzzy decision making, which satisfies some input conditions and has an output results [11].

4. SIMULATION RESULTS

The figure 8, 9 and 10 shows the response of PD, conventional PID controller and the response of the fuzzy logic controller to the step input.

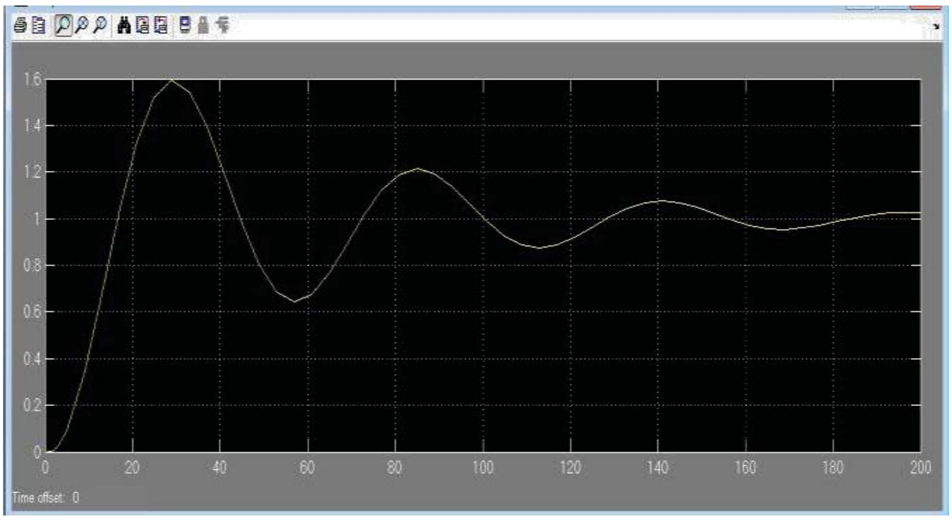

Fig.8. The step response of the PD controller

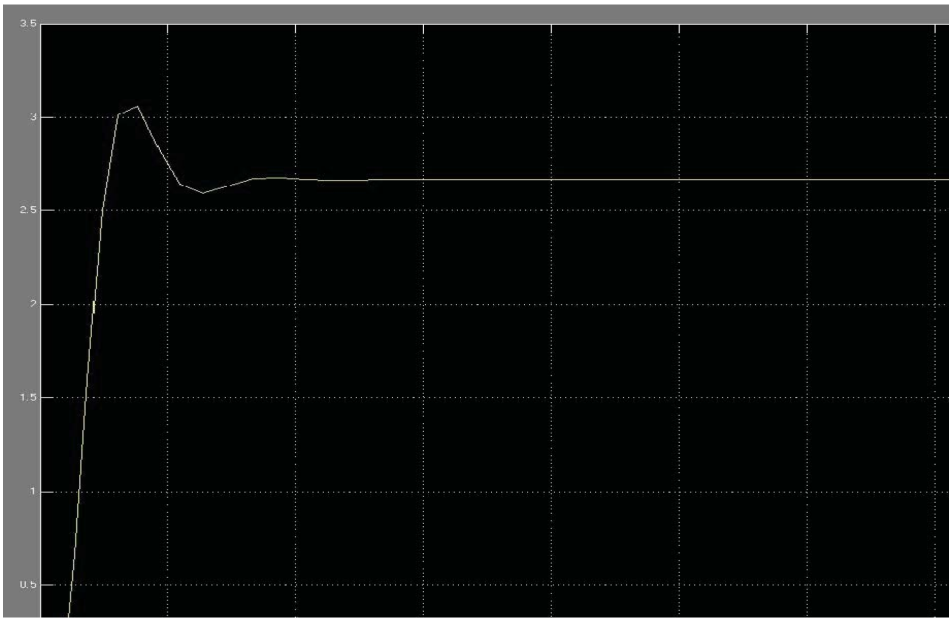

Fig.9. The step response of the PID controller

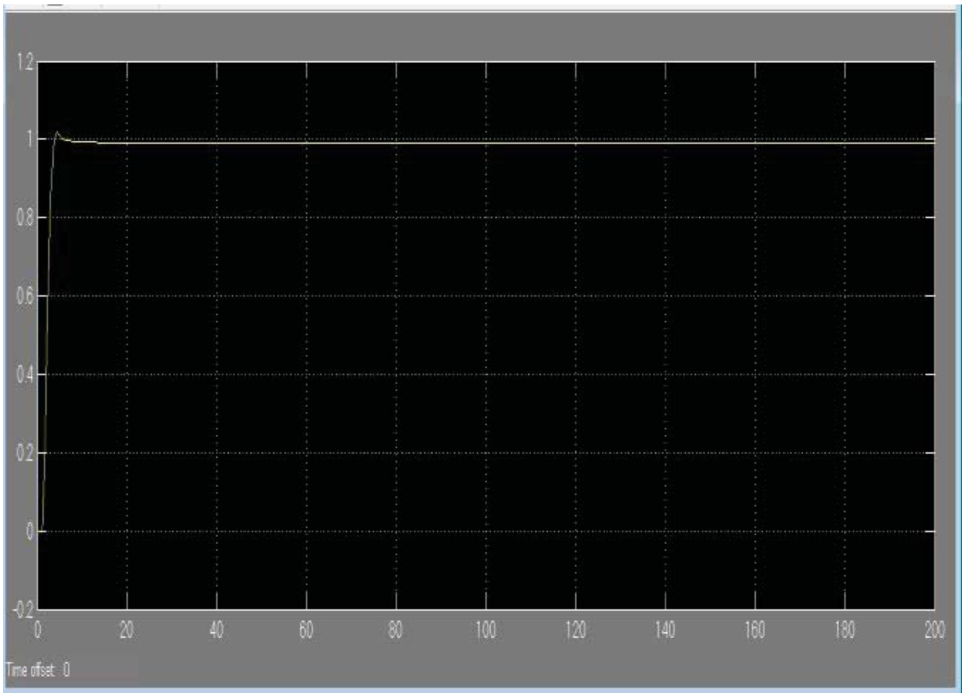

Fig.10. The step response of the fuzzy controller

From figure 8, 9 and 10 it is clear that fuzzy logic controller has small overshoot and is having the fast response as compared to PD and PID Controllers.

5. CONCLUSION & DISCUSSION

In this paper, we design three kinds of controllers which is PD, PID and fuzzy logic controller. From the figure, results shows that the response of PD and PID Controller is oscillatory which can damage the system. But the response of FLC is free from these dangerous oscillations in the transient period. Hence the proposed FLC is better than the PD and PID controller.

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