Development and Performance Analysis of Fuzzy Logic Tuned PID Controller for Level Process using PLC

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Abstract

Level process is mostly used in all the process industrial depend on this tank system In this paper, deal with the level process system is converted into first order system by using open loop response of the level process station. And the performance analysis of P,PI,PD and PID gain values are tuned by the Cohen Coon method. This tuning method give the maximum gain value of the controller for level process system. Above tuned gain value of the controller the system is unstable, blow tuned gain value the system is stable. Depend on those simulation result to developed the PID controller by soft computing method of fuzz logic control. Proposed fuzzy logic tuning PID controller works on the fast response of system compared to the convention PID. Proposed controller model using the software help of MATLAB SIMULINK.And simultaneously real time experimental results using by automation of programmable logic controller (PLC).

Keywords —*Level transducers, process control, Cohen Coon tuning method, fuzzy logic tuning PID controller,Open loop response,P,PI,PD,PID.*

I. INTRODUCTION

Level process is the important process parameter of the industrial process and the controller level measurement is done by different methods [1-4]like ,ultrasonic level detector ,optimal based, ect. In order to compare the conventional PID and fuzzy logic control to improve the control techniques [5][6] improve the PID controller performance designed a adaptive PID controller by using IMC tuning method. Another comparison of the fuzzy PID controller and Gain scheduled PID controller for level process. To reduced the complexity of non liner horizontal cylindrical tank level [8]. fuzzy-based monitoring and controller for smart farm water tank monitoring and control using irrigation system[9][10]new monitoring and control system are developed by image processing method to replace indicate level sensor to linear variable differential transformers(LVDT).The comparative analysis of conventional model reference adaptive controller(MRAC) and modified model reference adaptive controller(MMRAC) using PID with model reference adaptive combination[11].

The proposed approach is modeling the fuzzy logic tuning PID controller for level presses by comparison of P,PD,PI and PID controller performance analysis of time domain specification rise time, peak time, overshoot and steady state error and analysis the IAE,ITAE and ISE error of the controllers then choose the best controller for the simulation result. Developed the controller using the soft computing method of fuzzy logic controller. To improve the output response of the system and accurate control the level process is achieved.

In section 2, the topology and the operation of performance analysis methods are discussed. Insection 3, the detailed development of proposed controller. In section 4 simulation result and comparison analysis. In section 5, experimentalresult with real time implementation using programmable logic control and finally, in section 6,the main results are concluded.

II. PERFORMANCE ANALYSIS METHODS

A. Open Loop Response

The level process station without controller output is the Open loop response of the system because the input of the value is fully open and not set theany certain value of set point in the level of the tank. When the inlet volume of water and outlet volume of water is equal the level is settling particular level of the tank figure(1) Open loop response get same date from the level process station for mathematical model, here first order systemof the transfer function is model of the tank. The three parameters are used to from the transferfunction of the system there, are Gain, Dead time, Time constant.

The mathematical model of transfer function for open loop response with time delay(1).

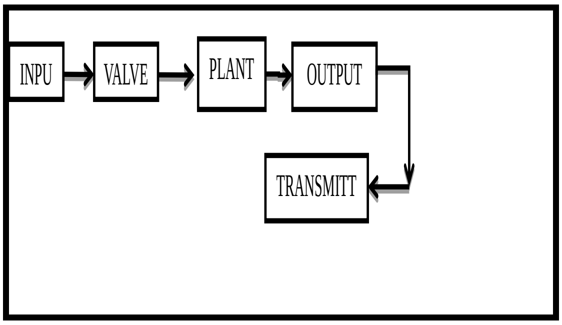


Fig1.Open Loop response block diagram for level process

$$\text{open loop response T.F} = \frac{Ke^{t_d}}{\tau s+1} \text{......} \quad (1)$$

The parameters of the transfer function values are used to mathematical calculation of tuning value for controllers. Tuning value of the controller is very important of the level process station.

B. *Tuning Method*

Tuning method is very important to the controller because which condition the system is stable or unstable for any process control station. Different types of tuning methods are used for tuning the controller. Here, Cohen –Coon Tuning method is used. Because of the analysis the Cohen Coon tuning is the best result output of the controller. So, this technique is use to tuned the gain values of the controller. This method provides accurate maximum gain value of the controller and analysis of which condition system is bounded output and unbounded output. Compared the performance analysis of P,PI,PD and PID controller by time domain specification and time integral performance criteria for level process station.Table-1 is the formulae of Cohen-Coon tuning method.

Table I

CONTROLLER	CONTROLLER GAIN	INTEGRAL TIME	DERIVATIVE TIME
P Controller	$K_c = \frac{1.03}{k}(\frac{\tau}{t_d} + 0.34)$	0	0
PI Controller	$K_c = \frac{0.9}{k}(\frac{\tau}{t_d} + 0.092)$	$T_I = 3.33 t_d (\frac{\tau + 0.092 t_d}{\tau + 2.22\, t_d})$	0
PD controller	$K_c = \frac{1.24}{k}(\frac{\tau}{t_d} + 0.129)$	0	$T_D = 0.27 t_d (\frac{\tau - 0.324 t_d}{\tau + 0.129\, t_d})$
PID Controller	$K_c = \frac{1.35}{k}(\frac{\tau}{t_d} + 0.185)$	$T_I = 2.5 t_d (\frac{\tau + 0.185 t_d}{\tau + 0.611\, t_d})$	$T_D = 0.37 t_d (\frac{\tau}{\tau + 0.185\, t_d})$

Table-I Cohen Cohn tuning formulae

C. *Types of controller*

The propose technology first step performanceanalyzing the different controllers for level process station. Here, four types of controller are used they are:

- Proportional controller(P)
- Proportional Integral controller(PI)
- Proportional Derivative controller(PD)
- Proportional Integral Derivative controller(PID)

1) *P controller*

Proportional control is a type of liner control and the output according to present instantaneous error of the system. Such as a condition the control valve at a level which avoids instability, but applies minimised error as fast as feasible by applying the best quantity of proportional gain. The output of a proportional controller is the not settling the set point. And improve the gain value of the controller the system is unstable. This simulation result dissected in section -3 P controller mathematically expressed in (2),

$$U(t) = K_P e(t) + P_0 \quad (2)$$

Where,P_0- Controller output with zero error, U(t)-Output of the proportional controller,K_P-Proportional gain, e(t) -Instantaneous process error at time t, SP- Set point, PV -Process variable. A drawback of proportional control is that it cannot eliminate the remaining SP − PV error in processes with compensation is proof the simulation part of the level process station

2) *PI controller*

A PI (proportional –integral) controller is the comprises of both P and I element components. The controller output according to present and past or history of error calculation are perform in the system. And PI controller result is better than P and PD controller and also PI controller is settling point is reached fast response for level process but the it not match the slow process control in real time. (3) is the mathematical PI controller expression.

$$U(t) = K_p e(t) + K_i \int e(t) + P_0 (3)$$

Where,P_0- Controller output with zero error, U(t)-Output of the proportional controller,K_P-Proportional gain, e(t) -Instantaneous process error at time t,K_i-integral gain.

3) PD controller

PD controller is comprises of both P and D element .The proportional derivative controller is better than the P controller and it not settling the set point. Improve the gain value of the controller the system is unstable. This simulation result dissected in section -3 PD controller mathematically expressed in (4),

$$U(t) = K_p e(t) + K_D \frac{de(t)}{dt} + P_0 \qquad (4)$$

Where, P_0- Controller output with zero error, U(t)-Output of the proportional controller, K_P-Proportional gain, e(t) -Instantaneous process error at time t, K_d-Derivative gain.

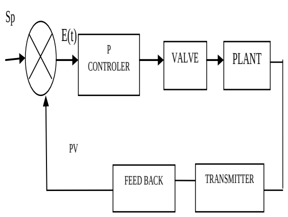
4) PID controller

PID controller has been widely used for industrial control in any application of controlling process.PID controller continuously calculates an error values the difference between a desired set point (SP) and a measured processvariable(PV).Comparison of the those controller output PID is the best result for level process station. (5) is the mathematical PI controller expression.

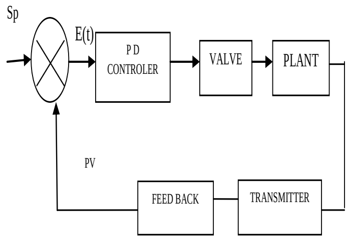
$$U(t) = K_p e(t) + K_i \int e(t) + K_D \frac{de(t)}{dt} + P_0 \qquad (5)$$

Where, P_0- Controller output with zero error, U(t)-Output of the proportional controller, K_P-Proportional gain, e(t)–Instantaneous process error at time t, K_d-Derivative gain. K_i-integral gain.

Those controllers are compared the output response which one is the best of the level presses station is discussed in section -4 .And also compared the time domain specification and time integral performance criteria the proposed PID controller are designed for soft computing technique



(a)



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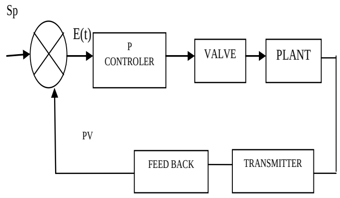

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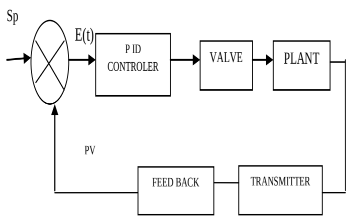


(d)

Fig2.(a) Block diagram of P controller for level processing ,(b) Block diagram of PI controller for level processing,(c) Block diagram of PD controller for level processing, (d) Block diagram of PID controller for level processing.

III. DEVELOP THE CONTROLLER METHOD

A. Fuzzy logic tuned PID controller

Fuzzy logic control have emerged over the years and become one of the most active areas of research. There are many works in literature addressed the water level control issues using fuzzy logic. Due to its simplicity, fuzzy logic control method became most famous in this application. Fuzzy logic controller is derived from fuzzy set theory. FLC consists of three main principle elements like fuzzier, rule base and inference andDefuzzier

The proposed method FLC have two inputs one is the error signal second one is controller output from the PID . FLC output of K_p,K_i,K_d, gain value to the PID controller for the level processing is shows in Figure(3).the mamdani model of Fuzzy logic controller is designed. membership function input and outputs are shows in table(2).and is conditions are connected the rule based design is shown in table-II.

ZEE-Zero Error, CO-Controller Output, K_p-Proportional gain, K_i-integral gain, K_d-Derivative gain

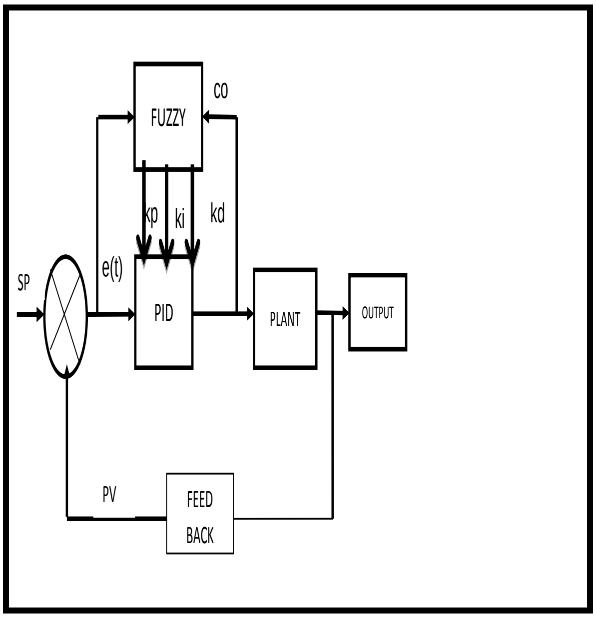


Fig (3).Block diagram of fuzzy tuned PID controller

Table-2

S.NO	ZEE	CO	K_p	K_i	K_d
1	ZEE	LOW	MED	LOW	LOW
2	ZEE	MED	MED	LOW	LOW
3	ZEE	HIGH	MED	LOW	MED
4	PSE	LOW	MED	VLOW	LOW
5	PSE	MED	MED	MED	MED
6	PSE	HIGH	MED	MED	MED
7	PME	LOW	MED	VLOW	MED
8	PME	MED	HIGH	LOW	HIGH
9	PME	HIGH	HIGH	MED	VHIGH
10	PHE	LOW	MED	VCLOW	LOW
11	PHE	MED	HIGH	VLOW	LOW
12	PHE	HIGH	VHIGH	MED	HIGH
13	PVHE	LOW	HIGH	VLOW	VLOW
14	PVHE	MED	VHIGH	LOW	MED
15	PVHE	HIGH	VHIGH	MED	HIGH

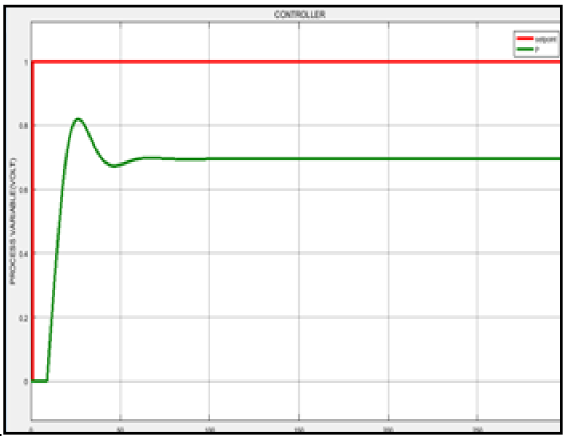
Table-ii Rule for fuzzy logic tuned PID

IV. SIMULLATION RESULTS

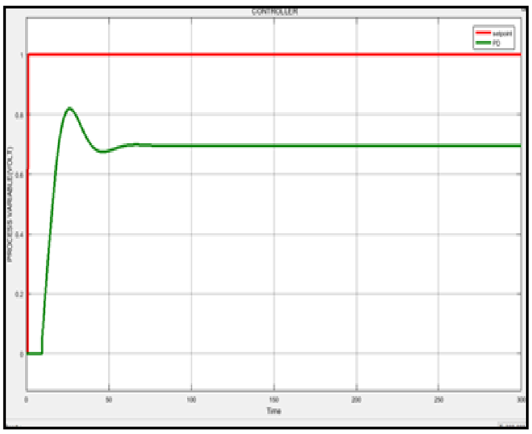
Simulation result of the both P,PI,PD and PID controller performances analysis and compression of the controller outputs by using help of MATLAB software tool.

P controller out put the level process station it cannot reach the set point level andthe value are high the tuning value the system is table ex, the tuning gain value is 4and maximum value is given 12 the system is unstable this condition applicable for another three controllers in fig6(a).The PD controller for the same system it also cannot reached the certain value of the set point fig6(b).the PI and PID is reached the set point in particular time. And compare the fig 6(c)and (d) PID controller is reached the set point is fast response. Fig(7) MATLAB model of the level process station with PID controller.

Performances analysis of both P,PD,PI and PID controller shown in table –III.And compression of the time domain specification of controllers in table- IV. The values are take form the simulation result .



(a)



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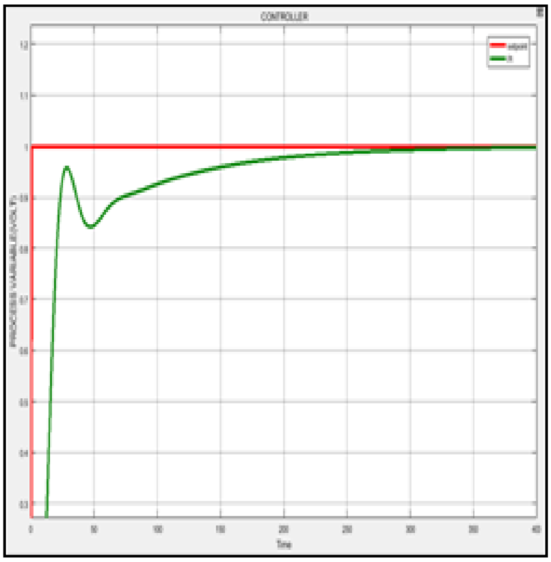

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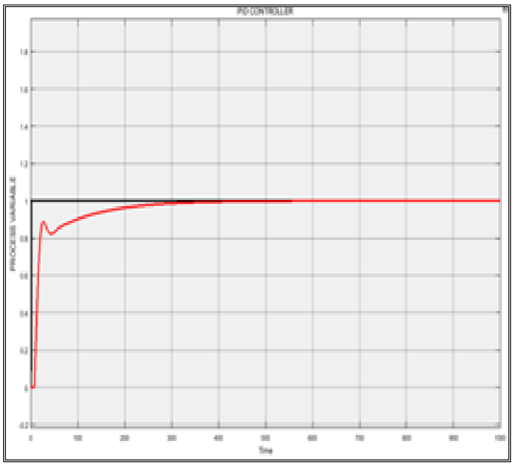
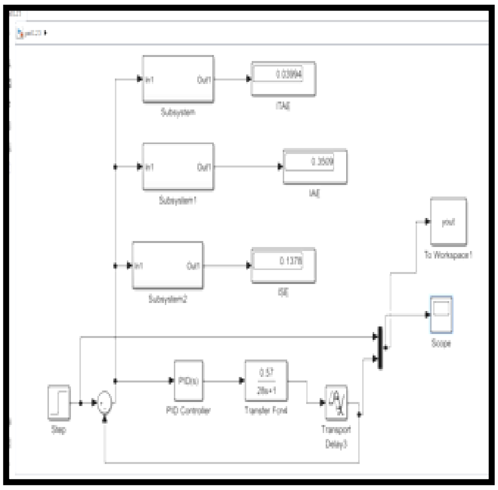


(d)

Figure (6).(a) simulation result of P controller.(b) simulation result of PD controller, (c) simulation result of PI controller, (d)simulation result of PID controller.



Fig(7) model of PID controller block using MATLAB

TABLE- III

CONTROLLER	IAE	ISE	ITAE
P	0.98%	0.37%	0.45%
PI	0.28%	0.13%	0.04%
PD	0.98%	0.37%	0.45%
PID	0.35%	0.13%	0.03%

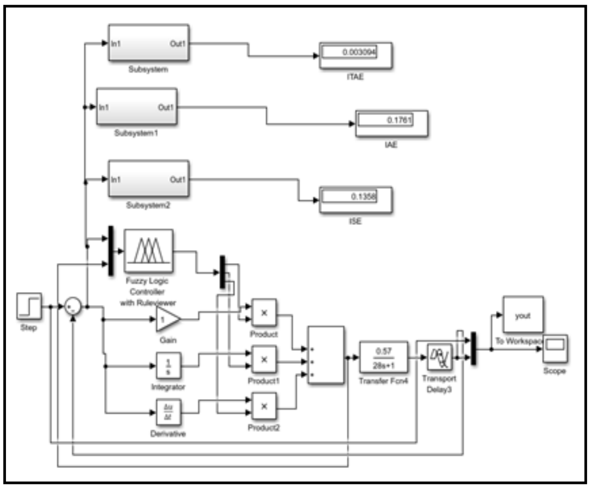
Table-iii.performance analysis

TABLE-IV

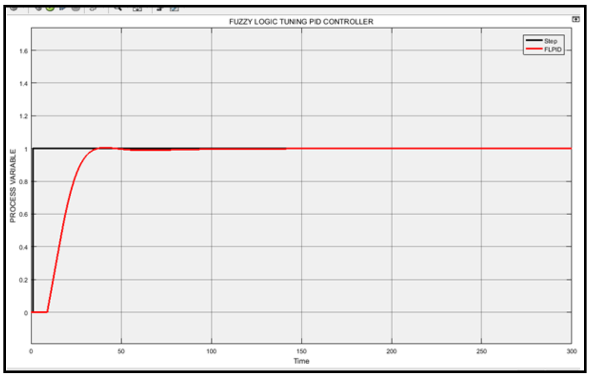
CONTROLLER	RISE TIME(sec)	SETTLING TIME(sec)	PEAK OVERSHOOT (%)	STEADY STATE ERROR(%)
P	9.09	0	0	30
PI	9.01	300	0	0.5
PD	9.5	0	0	30.5
PID	9	310	0	0.4

Table iv. Time domain specification

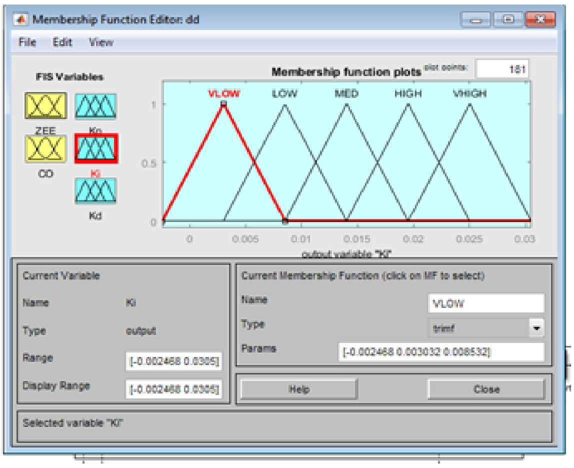
Fuzzy locig controlled designed in simlink designfig(9), and tabel-3 are showing the opreation of the controller rulle based perfomed here.and input and outputs are assined the value based real time level process.the current is converted in pressure value of the pnematic value of the level sation and 4-20 ma current rated valu of value,and the error values are assined by the using real time occuring instaent error of the process station.Coventional PID and Fuzzy Logig Tuning PID perfomance also compared the simulation result.



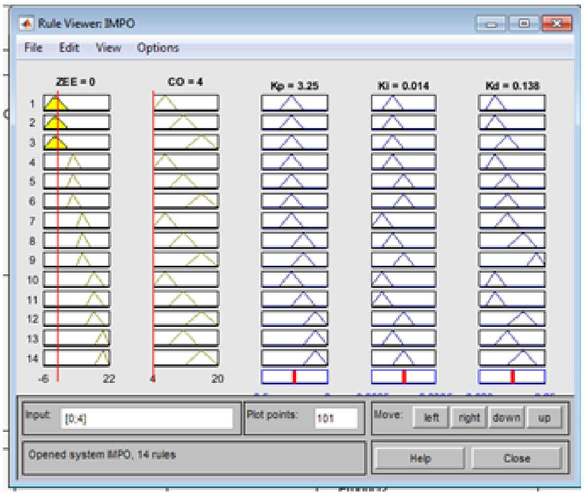
Fig(8) Model of Fuzzytuning PID controller by using matlab



Fig(9) simulation result of FLPID



Fig(10) fuzzy membership function



Fig(12) output value of the fuzzy logic controller rule based viewer

TABLE-V

controller	IAE(%)	ISE(%)	ITAE(%)
PID	0.35	0.13	0.03
Fuzzy Tuning PID	0.13	0.07	0.003

Table-V. Performance analysis for PID and Fuzzy Logic PID

TABLE –VI

CONTROLLER	RISE TIME(SEC)	SETTLING TIME(SEC)	PEAK OVERSHOOT%	STEADY STATE ERROR%
PID	9	310	0	0.4
Fuzzy Tuning PID	9	85	0	0.02

Table-VI.Time Domain Specification for PID and Fuzzy Logic PIDcontroller.

V. CONCLUSION

This paper present the performance comparison of P,PI, PD and PID controller for the level process station by using the open loop response and tuning method. The simulation is done with the help of the MATLAB SIMULINK software. Based on the simulation result to develop the PID controller for intelligent controlled method. Fuzzy logic tuning PID controller are designed and performed best result of level control for the liquid of tank. using the help of the real time automation of the PLC is used to Fuzzy tuned PID controller. it provide the accurate control of the liquid level any industrial application.

ACKNOWLEDGMENT

The author like to tank the Department of Applied Electronics and Instrumentation Engineering

Mahalingam College of Engineering and Technology, MCET providing the faculties to carry out this work.

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