Design & Development of Temperature Control System Using Fuzzy-Pid Controller

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Abstract :

Temperature control has eventually been an important issue in process industries. Outlining of PID based fuzzy controller utilizing proposed smart methods would drastically enhances the speed of reaction of framework, rise time and settling time would be decreased in extent in comparison with conventional PID controller. In this proposed work, a self-tuning fuzzy PID controller is composed through constant refreshing of its yield scaling element. Rather than utilizing a mind boggling three dimensional manage base for acquiring PID activity. Online self-tuning component gives enhanced execution of the proposed fuzzy PID controller contrasted with regular PID controller. Online self-tuning system gives enhanced execution of the proposed fuzzy PID controller contrasted with traditional PID controller. Fuzzy standards are used on-line to decide the controller parameters in light of blunder and its first time derivative. Simulation and experimental results of the proposed conspire indicate great exhibitions contrasted with the PID controller with settled parameters as far as unique and unfaltering state qualities of all circles. Simulations are done in MATLAB/ SIMULINK.

Keywords : *Temperature control, Fuzzy PID, Matlab, Simulink.*

I. INTRODUCTION

Temperature control of Process tank framework is an exceptionally troublesome, due to the framework nonlinearities and instabilities. At present, consistent gain PI controllers comprising issues identified with crest overshoot are actualized in different little scale and vast scale ventures where process control is done. Consequently PI controller is stayed away from because of the overshoot and oscillatory issues. Execution change for process Tank temperature control is along these lines in extraordinary need. Application based Process Tank temperature Control is a standout amongst the most difficult control circles in a power plant heater since it is exceedingly nonlinear and has a long dead time and time slack. Legitimate control of Process response tank temperature is critical as high temperature can harm the superheated or low temperature will decrease the item quality in response tank. In this manner, the superheated temperature is to be controlled by modifying the firining edge of thyrister who create legitimate voltage to the warmer inside +/ - 5 deg C amid transient states and +/ - 1 deg C at the steady state. The Control utilizing fuzzy gain adjustment of PID controller is displayed. Fuzzy guidelines are used on-line to decide the controller parameters in view of blunder and its first time subsidiary. Simulation and experimental results of the proposed conspire indicate great exhibitions contrasted with the PID controller with settled parameters as far as unique and consistent state attributes of all circles. Simulations are performed utilizing MATLAB/SIMULINK.

The introduction of the research paper is as per the following: the temperature control circle is talked about in Section II. The outline of fuzzy self-tuning PID controller is given in Section III. simulation results comes about on in view of investigation of the planned calculations are exhibited in Section IV. At long last, conclusions are made in Section V.

II. TEMPERATURE CONTROL LOOP

Fig. 1 shows the picture of prototype temperature control loop used in this work. This system includes pressure tank with 5 liter capacity. In this loop temperature of water inside process tank can be controlled from 0 to 100ºC. For temperature control, PID controller used as Heater control and PT100, sensor is used which is mounted inside the tank. The output of sensors is brought to signal conditioning circuit in CE2 panel using five-pin DIN connector. The process vessel has gauge cover mounted on its lower half. PC is used for data monitoring purpose. For cooling action air is supplied externally. Fig. 2 shows the block diagram for general temperature control loop.

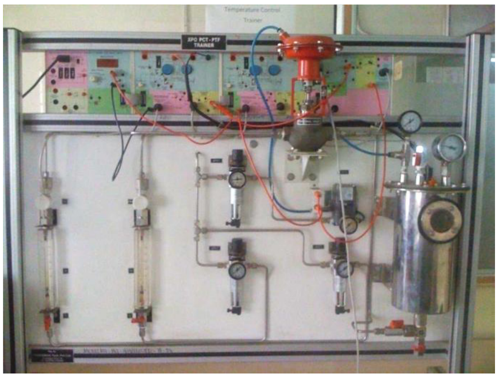

Fig. 1. Process Control Trainer

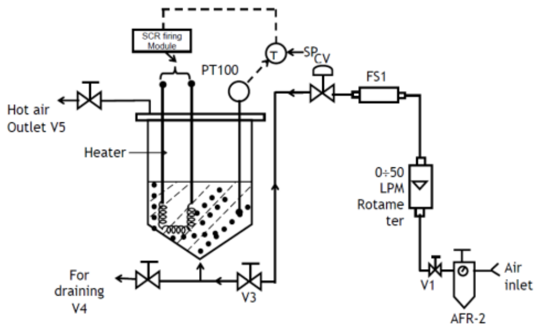

Fig. 2. Block diagram of temperature control Loop

III. DESIGNING OF FUZZY-PID CONTROLLER

The standards planned are subject to the properties of the process level control circle and qualities of the PID controller. Consequently, the fuzzy thinking of fuzzy arrangements of yields is picked up by accumulation operation of fuzzy sets inputs and the composed fuzzy guidelines. The conglomeration and defuzzification strategy are utilized individually max-min and centroid technique.

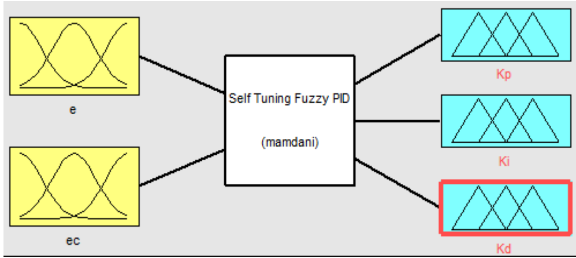

Fig 3. Fuzzy Logic Editor

As to the fuzzy structure, there are two contributions to fuzzy deduction: error e(t) and derivative of it de(t), and three yields for every PID controller parameters separately Kp, Ki and Kd Mamdani model is connected as structure of fuzzy surmising with some adjustment to get the best an values for Kp, Ki and Kd.

The Membership Function Editor shares some features with the FIS Editor. In fact, all of the five basic GUI tools have similar menu options, status lines, and Help and Close buttons. The Membership Function Editor is the tool that lets you display and edit all of the membership functions associated with all of the input and output variables for the entire fuzzy inference system. The primary step for setting membership functions is to select which type of membership function should be used. There are different types of membership functions such as Triangular, Gaussian, Sinusoidal and Trapezoidal. After selecting proper membership function, range of each should be set. The membership functions are assigned with proper names according to its range. **Error e(t)** : The phonetic variable levels are alloted as NB: negative enormous; NS: negative little; ZE: zero; PS: positive little; PB: positive huge. These levels are looked over the qualities and particular of the Level control system.

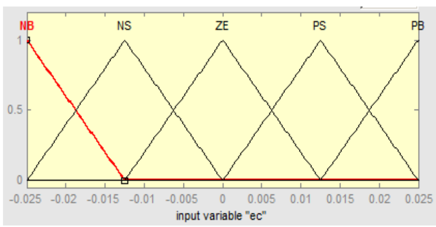

Fig. 4. Membership functions of de(t)

Triangular participation work sorts are utilized for the yield. To start with, set the Range (and the Display Range) to (0, 1), to cover the yield run which is constantly positive for our situation for coupled tank communicating framework. The scopes of these data sources are between - 0. 1 to 0. 1, which are acquired from the total estimation of the framework mistake and its subsidiary through the increases. Though the enrollment elements of yields Kp, Ki and Kd are appeared in Figure underneath.

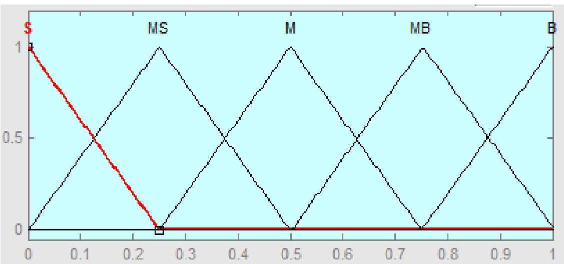

Fig. 5. Membership functions of Kp, Ki and Kd

Building rules utilizing the graphical Rule Editor interface is genuinely undeniable. In view of the depictions of the information and yield factors characterized with the FIS Editor, the Rule Editor enables you to develop the lead articulations consequently, by tapping on and choosing one thing in each input variable box, one thing in each output box, and one association thing. Picking none as one of the variable qualities will bar that variable from a given rule.

Table 1. Standards of fuzzy inference

Change in error	Error						
	NB	NM	NS	Z	PS	PM	PB
NB	PB	PB	PB	PM	PM	PS	Z
NM	PB	PB	PM	PM	PS	Z	Z
NS	PB	PM	PS	PS	Z	NM	NB
Z	PB	PM	PS	Z	NS	NM	NB
PS	PM	PS	Z	NS	NM	NB	NB
PM	PS	Z	NS	NM	NM	NB	NB
PB	Z	NS	NM	NM	NB	NB	NB

IV. RESULTS AND DISCUSSION

The entire Simulink block for entire framework including the control outline and the plant can be seen in Fig. 6

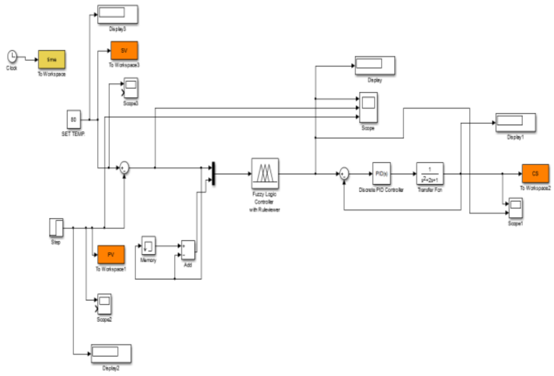

Fig.6 Simulation Block Diagram for Fuzzy-PID Controller

comprised of Fuzzy and PID block with some change alludes to the equation which is connected to adjust the estimation of Kp, Ki and Kd from fuzzy square to get the estimation of Kp, Ki and Kd. Every parameter has it's own adjustment [6, 7, 8]. The estimation of parameter Kp, Ki and Kd are tuned by utilizing signals from fuzzy logic block in light of the adjustments in the error between reference signals and output signals.

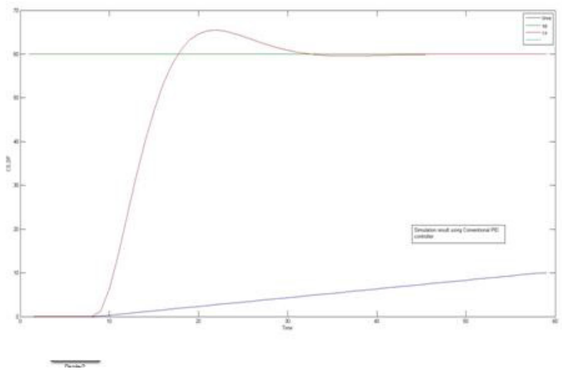

Fig. 7. Response for conventional PID controller

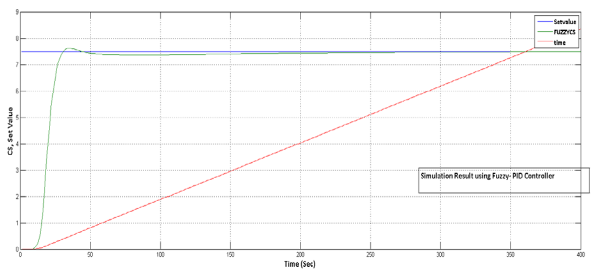

Fig. 8. Response for Fuzzy- PID controller for temperature control

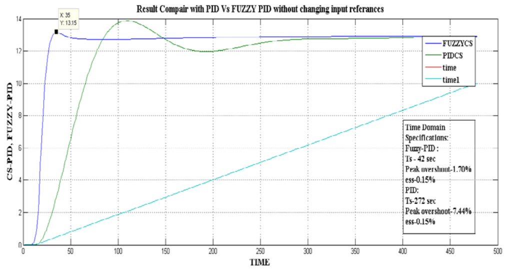

Fig. 9. Comparing Result for conventional PID Vs Fuzzy PID controller

Comparison of PID Vs Fuzzy-PID Controller In Time domain Specification Value are as follow.

1. Fuzzy-PID Controller-
   Settling Time (Ts)- 42 sec
   Peak Overshoot- 1. 70 %
   Steady state Error (ess)- 0. 15%
2. Conventional PID Controller-
   Settling Time (Ts)- 272 sec
   Peak Overshoot- 7. 44 %
   Steady state Error (ess)- 0. 16%

VI. HARDWARE RESULTS

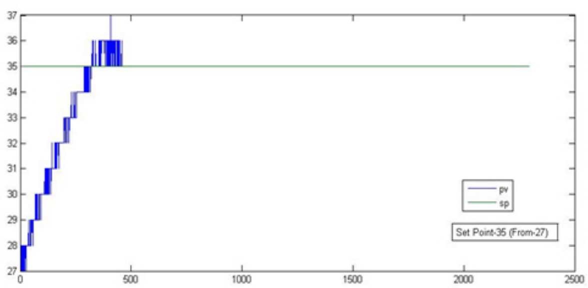

Fig. 10. Hardware response for Set point at 40°C.

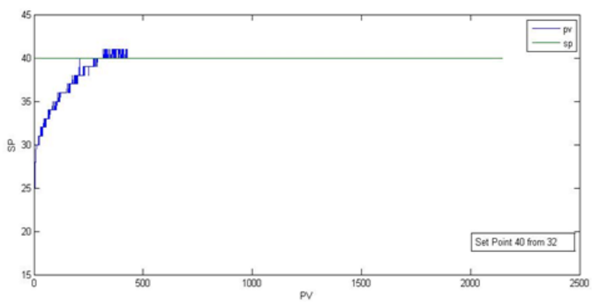

Fig. 11. Hardware response for Set point at 32°C.

As change in Temperature is slower process it takes more samples to achieve desired set point. Fuzzy-PID Temperature controller gives better performance in case of steddy state error, peak overshoot & oscillation as compare with conventional PID controller it can be observed from Fig. 9.

V. CONCLUSION

The outcome indicates noteworthy change in keeping up execution over the broadly utilized PID design strategy in terms of the oscillations produced and overshoot. As observed from the diagrams, rise time if there should be an occurrence of PID controller is less however motions created and overshoot and settling time is more. Be that as it may, if there should arise an occurrence of Fuzzy-PID controller motions, overshoot and settling time are low, so FPID can be connected where motions are not endured in the process. The FPID likewise shows hearty execution for plants with noteworthy variety in flow. Here FLC and PID both are connected to the same precisely displayed temperature control framework and recreation comes about are acquired. The microcontroller based interfacing circuit is precisely good to the framework and temperature of the process tank framework utilizing Fuzzy-PID controller is effectively accomplished. Also simulation based result for Fuzzy PID controller gives much more positive result as compare with Conventional PID controller.

VI. REFERENCES

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