Fuzzy Based PI Control for Level of a 3 Tank System

Aravind R. Varma and Titus J. David

Abstract--- Fuzzy logic controllers are useful in chemical processes where non-linearity is very high. Fuzzy logic controllers are based on approximate values called linguistic variables. These linguistic variables are not sharp and precise. Fuzzy logic uses the concepts of fuzzy sets whose value varies from 0 to 1. The main advantages of using Fuzzy logic are reduction in rise time, settling time, overshoot etc and improved robustness and efficiency in noisy environment. Membership functions are used for inputs and outputs. Fuzzy logic controllers are capable of eliminating errors in modeling of the process. Fuzzy based PI Controllers are used to obtain better response in terms of settling time, rise time and overshoot than PI Controllers. Fuzzy based PI Controllers are using fuzzy logic concept for getting Proportional gain and integral gain for PI Controller. This process consists of two streams are mixed in three series tanks, and the output concentration is controlled by manipulating the flow of stream.

Keywords--- Fuzzy Logic, 3 Tank System, Mixing Process, Outlet Concentration, Fuzzy Based PI

I. INTRODUCTION

Chemical processes usually introduce high non-linearity and the parameters of these processes are time variant in nature. The dead time introduced by these processes is considerable. In these cases where non-linearity is high conventional controllers can be replaced by Fuzzy logic controllers. In fuzzy logic control precise knowledge about the system is not required. Rules developed are approximate in nature rather than exact.

It emulates the ability to reason and uses approximate data to find solution. Fuzzy logic control is a knowledge based control that works on the rules that are created based on the knowledge of experts. “If-Then” principle is used for the creation of rules.

Advantages of using fuzzy logic are the control system can be made robust as it doesn’t require precise, noise free inputs. Failure of system components doesn’t cause system to fail. Flexibility of the system is another feature that helps in modifying the rules.

Fuzzy rules can be defined for any number of inputs and outputs. Complexity of defining rules increase with increase in number of inputs and It would be better to break the system 2. into smaller parts are several small fuzzy logic modules can be created each with limited functionalities.

Fuzzy logic model can be used for non-linear functions of arbitrary complexity. Most commonly used membership functions are triangular, rectangular, trapezoidal membership functions. Each membership functions are provided with linguistic variables.

II. PROCESS MODEL

This process consists of two streams A and B, mixed in three series tanks, and the output concentration A is controlled by manipulating the flow of stream A as shown in Fig 1.

The following assumptions are made:

1. All the tanks are well mixed
2. Dynamics of the valve and sensor are Negligible
3. No transportation delays (dead time) exists

Aravind R. Varma, M.tech(Process Control), Government Engineering College, Thrissur, Kerala. E-mail:aravindrvarma001@gmail.com
Titus J. David, M.tech(Process Control), Government Engineering College, Thrissur, Kerala

4. A Linear relationship exists between the valve Opening and the flow of component A
5. Densities of the components are equal

The present system can be represented by the block diagram given in Fig 1.

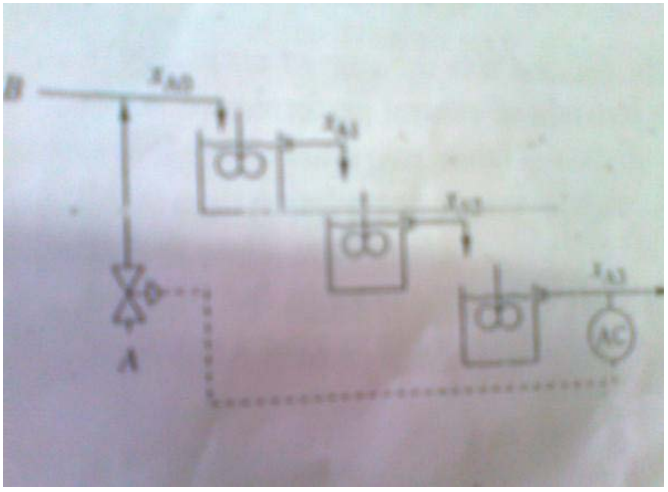

Fig. 1: Block Diagram of 3 Tank System

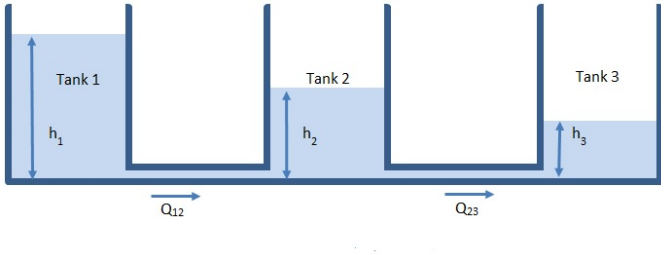

Fig. 2: Schematic of 3 Tank systems

Three tank systems are of the form $G_p(s) = \frac{K_p}{Ts+1}$

From experimental values K_p =0.4 and T=1.5

III. PI CONTROL OF THE PROCESS

$$P(t) = K_p\, e(t) + K_p/T_I \int e(t) + P(0)$$

Propotional control action produces a control signal that is propotional to error signal. Integral action produces signal that accumulates present and past errors. Propotional action improves speed of response and Integral action improves Settling time.

IV. FUZZY BASED PI CONTROL

Fuzzy logic concept is used in controlling the temperature of a Heat Exchanger. Triangular membership functions are used with 7 linguistic variables. Linguistic variables are very very small (vvs), very small(vs), small(s), zero(z), big(b),very big (vb), very very big(vvb). These linguistic variables are used for error, change of error and output. Error a varies from -10 to 10. Output varies from -1 to 1. Change of error varies from -15 to 11.

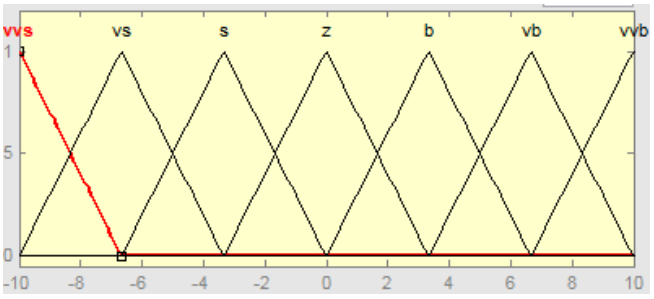

Fig. 3: Membership Function for Error

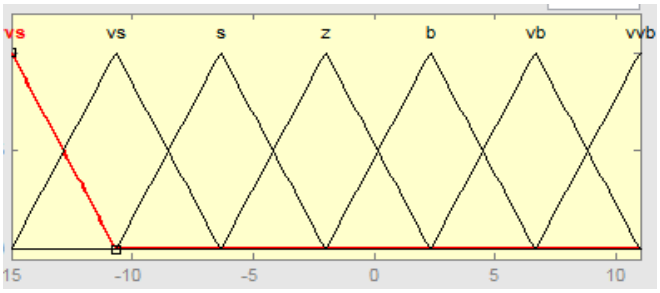

Fig. 4: Membership Function for derror

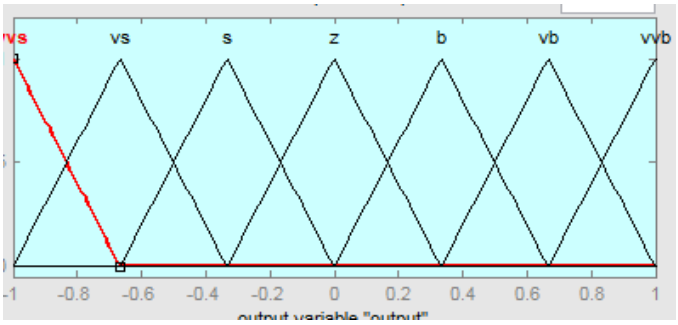

Fig. 5: Membership Function for Output

Table 1: Tuning Data for PI Controllers

PROCESS	CONTROLLER	K_p	K_I	K_D
3Tank System	PI	1	0.025	0.0000001

Table 2: Fuzzy Rules for Integral and Propotional Gain

Error / Derror	vvs	vs	s	z	b	vb	vvb
vvs	vvs	vvs	vvs	vvs	vs	s	z
vs	vvs	vvs	vvs	vs	s	z	b
s	vvs	vvs	vs	s	z	b	vb
z	vvs	vs	s	z	b	vb	vvb
b	vs	s	z	b	vb	vvb	vvb
vb	s	z	b	vb	vvb	vvb	vvb
vvb	z	b	vb	vvb	vvb	vvb	vvb

V. RESULT& ANALYSIS

A unit step input is applied to the control system and response of the system is obtained. The settling time, rise time and overshoot are obtained.

Table 3: Result Analysis

CONTROLLER	SETTLING TIME	RISE TIME	OVERSHOOT
PI	590	205	0%
Fuzzy Based PI	115	38	0%

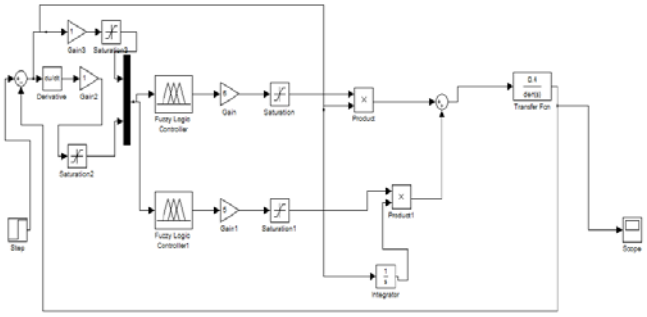

Fig. 6: Block Diagram of Fuzzy based PI Control of Process

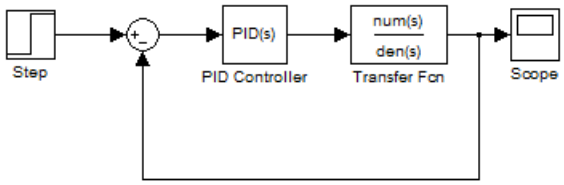

Fig. 7: Block diagram of PI Control of Process

VI. CONCLUSION

Fuzzy based PI Controller gives a better response in terms of rise time, settling time and overshoot when compared to that of PI Controller.

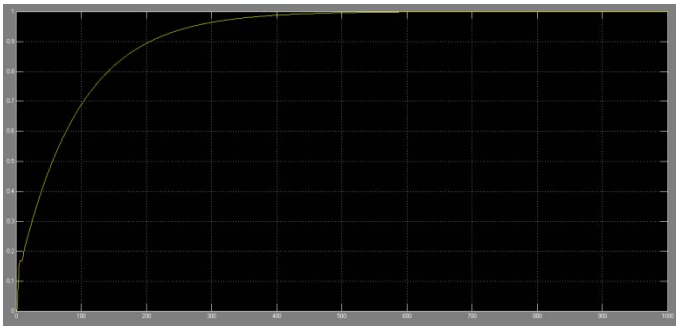

Fig. 8: Response of PI Control of the Process

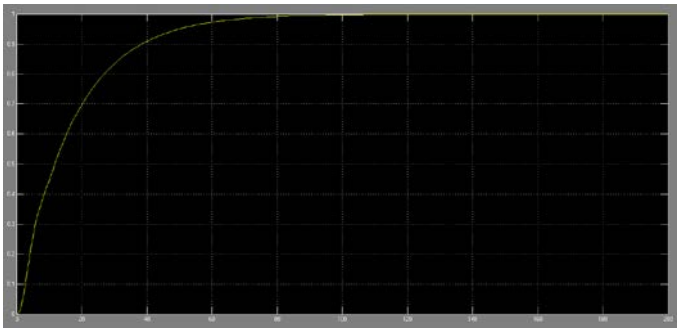

Fig. 9: Response of Fuzzy based PI Control of the Process

REFERENCE

[1] G. Shivagurunathan and Dr. K.B. Jayanthi, "Internal Model Control for a Non Linear Spherical Tank System," IJERA ,2012

[2] D. Coughanar, "Process System Analysis and Control", Second Edition, 2002, TMH

[3] Dale.A.Seborg, Duncan Mellichamp, "Process Dynamics and Control", Third Edition, 2004, PHI.

[4] G.Stephanopoulos, "Chemical Process Control" , Third Edition, 2004, PHI.

[5] C.C. Lee and Newell, "Applied Process Control", Second Edition, 2007, PHI

[6] Krupa Borse Narwekar, Dipesh Shah, "Tuning of PID Controller for Three Tank Mixing Process using Matlab", International Journal of Engineering Research and Applications, April 2012.

[7] Astrom, K.J. and T. Hagglund, "PID Controllers: Theory, Design and Tuning". Instrument Society of America. Research Triangle Park, N.C, 1995