LEVEL CONTROL FOR INTERACTING TANK SYSTEM USING INTELLIGENT CONTROLLER

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Abstract

In Process Industries like petroleum refineries, chemical, paper industries, water treatment industries the control of liquid level in a tank system is a major concern. The Level of tank and flow between tanks can be controlled using different controllers like conventional, compensator and intelligent controller. The Proportional Integral Derivative controllers are used for a wide range of process control like motor drives, magnetic and optic memories, flight control, instrumentation, automotive etc. The fuzzy Logic Controller provides a mechanism if an event will occur, measuring the chance with which a given event is expected to occur. The fuzzy sets have the ability to model an ambiguous data. In this project the comparison of controllers are done for the best result of level settling time. From the simulation result it is concluded that the two tank interacting system with PID controller gives relatively slow response with peak overshoot for unit step input. To achieve an optimal response with better settling time, fuzzy logic controller is designed for the interacting tank system. The comparative analysis is done for the simulation of two tank interacting system with conventional controller and fuzzy controller. Based on the simulation result the superiority of fuzzy controller is more compare to PID controller.

Index Terms: Interacting tank system, Level Control, Flow control, PID controller and fuzzy controller.

I. INTRODUCTION

A major problem in process industries is the control of fluid levels in storage tanks, chemical blending and reaction vessels. The process industries require the liquids to be pumped and stores in tanks thereafter pumped to another tank[1]. Many times the liquid will be processed by chemical or mixing treatment in the tanks, but always the level of fluid in the tanks must be controlled. The rate of change of flow from one vessel to another as well as the level of fluid is two important operational factors. In industries conventional controllers were widely used. Proportional- Integral-Derivative (PID) control provides the simplest and most efficient solution for real-world control applications[2].

PID controllers use three behavior modes that is P - proportional, I - integrative and D - derivative. Where proportional and integral modes are used as single control modes and derivative mode is rarely used on it's own in control systems. Combination of Proportional and integral controller are very oftenly used in practical systems. There are several methods are available for tuning of controller parameters in PID controller. The drawback in PID controller is it cannot give corrective action in advance. It has the capability of initiating the control action after error has developed. In order to avoid the drawback of conventional controller the fuzzy logic controller is used[3].

In contrast to conventional control techniques, fuzzy logic control (FLC) is best utilized in complex ill-defined processes that can be controlled by a skilled human operator without much knowledge of their underlying dynamics[4].

II. PROCESS MODEL

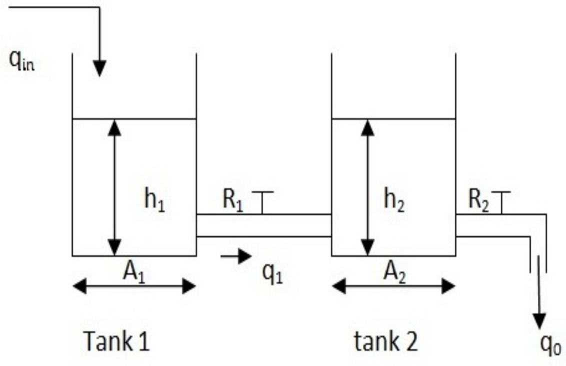

Fig. 1 Interacing tank system

qin Volumetric flow into tank 1 (cm³/min).
h1 The height of the liquid level in tank1 (cm).
A1 Cross sectional area of tank1 (cm²).
R1 Resistivity of tank1(sec/m²).
q1 volumetric flow rate from tank1 (cm³/min).
h2 The height of the liquid level in tank2 (cm).
A2 Cross sectional area of tank2 (cm²).
R2 Resistivity of tank2(sec/m²).
qo the volumetric flow rate from tank 2 (cm³/min).

III. MATHEMATICAL MODEL FOR INTERACTING TANK SYSTEM

Tank 1

$$A1\frac{dh1}{dt} = q_{in} - q_1 \tag{1}$$

Time constant for tank1

$$T_1 = A_1R_1 \tag{2}$$

$$T_1\frac{dh_1}{dt} + h_1 - h_2 = R_1q_{in} \tag{3}$$

By taking Laplace Transform for equation(3)

$$T_1sh_1(s) + h_1(s) - h_2(s) = R_1q_{in}(s) \tag{4}$$

$$h_1(s) = \frac{R_1q_{in}(s) + h_2(s)}{T_1s + 1} \tag{5}$$

Tank2

$$A_2\frac{dh_2}{dt} = q_q - q_0 \tag{6}$$

$$A_2\frac{dh_2}{dt} = \frac{h_1 - h_2}{R_1} - \frac{h_2}{R_2} \tag{7}$$

Time constant for Tank2

$$T_2 = A_2R_2 \tag{8}$$

$$R_1T_2\frac{dh_2}{dt} + h_2R_2 + h_2R_1 = h_1R_2 \tag{9}$$

By taking Laplace Transform for equation(9)

$$R_1T_2sh_2(s) + h_2(s)R_2 + h_2(s)R_1 = h_1(s)R_2 \tag{10}$$

The Transfer function (or) the model for the interacting tank system[5]

$$\frac{h_2(s)}{q_{in}(s)} = \frac{R_2}{T_1T_2S^2 + s(T_1 + T_2 + A_1R_2) + 1} \tag{11}$$

I. *Experimental results taken from real time system*

Flow in lph	Height of tank1(cm)	Height of tank2(cm)
193	56	35
305	102	55

By substituting the values in above equation (11), the final model of the interacting tank system is developed.

$$\frac{h_2(s)}{q_{in}(s)} = \frac{642.86}{199.42S^2 + 40.04S + 1}$$

IV. SOFTWARE AND MODULE

The name MATLAB stands for Matrix Laboratory. MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (linear system package) and EISPACK (Eigen system package) projects. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming environment. Furthermore, MATLAB is a modern programming language environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. These factors make MATLAB an excellent tool for teaching and research. MATLAB has many advantages compared to conventional computer languages (e.g., C, FORTRAN) for solving technical problems[6].

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. The software package has been commercially available since 1984 and is now considered as a standard tool at most universities and industries worldwide. It has powerful built-in routines that enable a very wide variety of computations. It also has easy to use graphics commands that make the visualization of results immediately available. Specific applications are collected in packages referred to as toolbox. There are toolboxes for signal processing, symbolic computation, control theory, simulation, optimization, and several other fields of applied science and engineering[7][8].

V. CONVENTIONAL CONTROLLER

A. Proportional Integral Derivative Controller

Conventional controller like PID controller is used when the process deals with higher order capacitive processes (processes with more than one energy storage) when the system dynamics are not similar to the dynamics of an integrator (like in many thermal processes).

B. Tuning of PID Parameter by Zeigler-Nicholas Method

This method applies if the response of a step input exhibits an S-shaped curve. Such S-shaped curve can be generated experimentally or from a dynamic simulation of the respective system.

II. Estimation of parameters for Ziegler-Nicholas method

Kcu=5.2;Pu=3.8s

Controller	Kc	Ti	Td
PID	0.6Kcu	Pu/2	Pu/8

C. Tyreus-Luyben Method

Like close loop Zeigler-Nichols method, Tyreus-Luyben method is also dependent on ultimate gain(Ku) and oscillation period(Pu) to compute the PID gain.It is the modified form of Z-N method. But the final controller settings are different.

III. Estimation of parameters for Tyreus luyben method

Kcu=5.2;Pu=3.8s

Controller	Kc	Ti	Td
PID	Kcu/3.2	2.2Pu	Pu/6.3

D. Design of Fuzzy Logic Controller

- Defining input and output variables.
- Deciding on the fuzzy partition of the input and output spaces and choosing the membership functions for the input and output linguistic variable.
- Deciding on the types and the derivation of fuzzy control rules.
- Designing the inference mechanism, which includes a fuzzy implication and a compositional operator, and the interpretation of sentence connectives.
- Choosing a defuzzification operator[9][10].

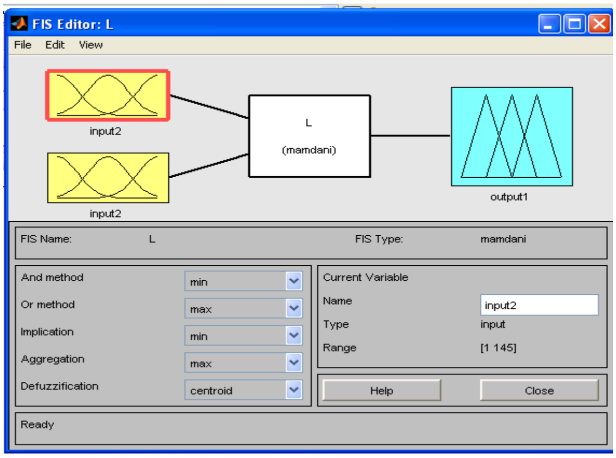

Fig. 2 FIS editor window

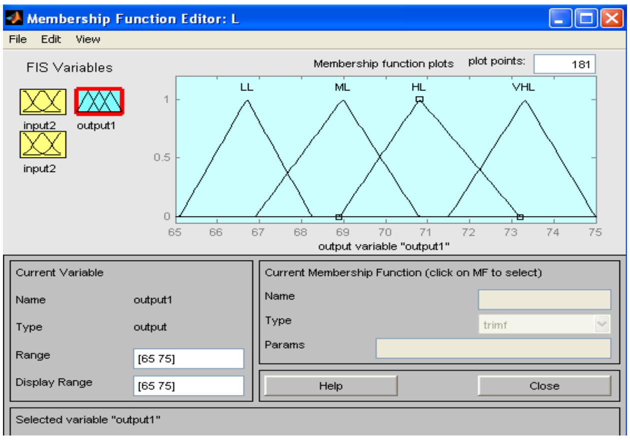

Fig. 3 Membership function editor window

IV. Fuzzy Rules

e\∆e	E1	E2	E3	E4
LWF	LL	LL	LL	LL
MWF	ML	ML	LL	LL
HWF	VHL	HL	ML	LL
VHWF	VHL	VHL	HL	ML

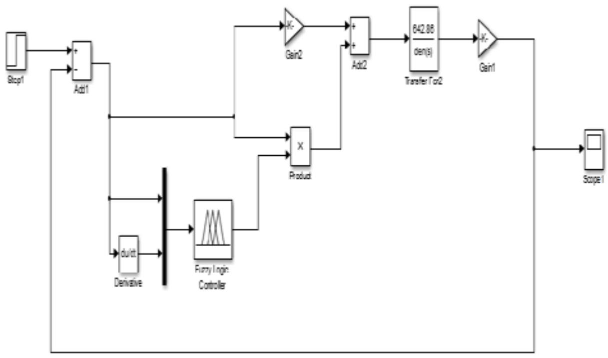

Fig. 4 Simulink model of Fuzzy Logic Controller

VI. SIMULATION & RESULT

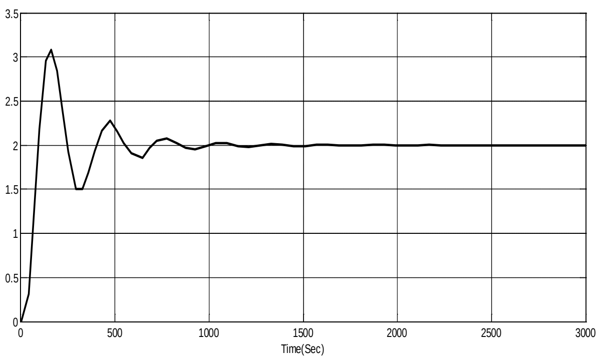

Fig. 5 Simulation result for Zeigler-Nicholas Method

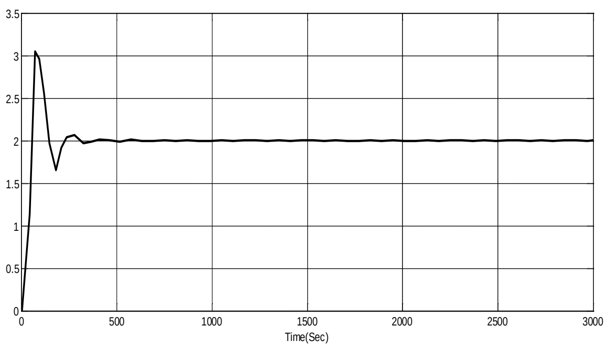

Fig. 6 Simulation result for Tyreus Luyben method

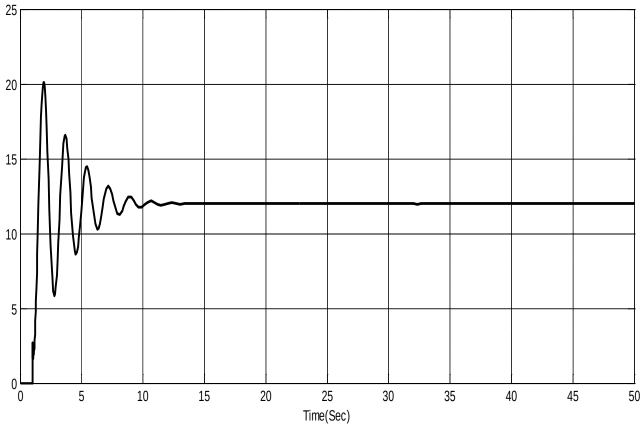

Fig. 7 Simulation result for Fuzzy Controller

V. Comparison of Controllers

Controllers	PID	IMC based PID	FLC
Level Settling time(sec)	1500	800	30
Peak overshoot	3	1.5	4

VII. CONCLUSION

Two tank interacting system Model is derived and it is simulated with Conventional controller and Fuzzy controller using MATLAB. From the analysis of tableV it is concluded that the two tank interacting system with PID controller gives relatively slow settling time. To achieve an optimum response, Fuzzy Logic Controller with fuzzification and defuzzification technique is simulated.

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