Modelling and Controller Design for Non- Linear Two Tank Interacting System

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Abstract- This paper explains the mathematical modelling and controller design of Two Tank Interacting System (TTIS) for a non-linear process. To design the non-linear process using Matlab Simulink and control the process using conventional PID controller and Fuzzy Logic Controller (FLC). A comparative study was conducted extensively made to examine which controller suits well for the non-linear process through the response observed.

Index Terms – Two Tank Interacting System (TTIS), Fuzzy Logic Controller (FLC), PID controller, Controllers.

I. INTRODUCTION

The first step in development of system includes mathematical modelling of the process and designing of a controller for that process. However, in the presence of nonlinear property it limits their performance and it tends to change. Fuzzy controllers are connected to a non-linear framework of their learning based nonlinear characteristics. Chemical process and petroleum industries present many challenges in controlling due to their nonlinearity, uncertainty and time dependent behaviour of parameters, unpredictable changes among manipulated and controlled variables, input and dead time. To overcome these troubles in controlling a non linear and time dependent system, a controller dependent on fuzzy Logic controller is utilized for their ability to give extremely great control for connecting kind of frameworks.

Basically, level control exists in the control loops of a process control system in some industries. Mixing of reactant is a very common method in chemical process industries and food processing industries. And in these industries controlling of level and flow is highly tedious, and the control loop for this level and flow control can be a single loop or multiple loop control system. Henceforth, level maintenance is one of the important control variable in the process industries. The following mentioned industries are the essential industries where liquid level and flow control are important. Usually the fluid level will be from chemical or mixing treatment process in the tank is prevented by level maintenance. In the chemical tanks fluid level has to be controlled and the flow of the tanks must be regulated. In fluid tanks, Level and flow control is the major part of all chemical engineering systems. In the most of industrial application controlling the liquid level of fluid is highly tedious process in chemical industries, petroleum industries, paper chemical,

mixing treatment industries, pharmaceutical and food manufacturing industries. Usually the fluid flow rate and the level of the process is controlled by the traditional controllers like that PI, PID, Fuzzy etc, the most commonly used controller for flow and level measurement is PI controller.

This is because it provides satisfactory results and it is easy to setup and install in industries. Though in case of non linear system, the performance of PI controllers might change and hence it is essential to develop nonlinear PI controllers to control nonlinear process. PI controller do have some disadvantages, it provides the response with larger overshoot and in order to overcome this we use PID controllers in industries. The PID controller has wide variety of applications like, controlling the temperature of any process, speed control of the systems and in aviation and in industrial applications also the PID controller is widely used. With its three state of functionality assisted with both transient and steady-state response, PID control gives the simplest and largely efficient output to many real-time control solutions. The PID controller is not able to give required action in advance control process, it could be able to initiate only the control action after error has occurred. The way to achieve better performance is then found by using fuzzy logic controller instead of classical controllers.

II. LITERATURE REVIEW

Kalyanjee Barman, LabanyaBaruah, HimadriDeori, Santu Brahma [1] this paper tells the design of interacting and non interacting two systems and traditional PID controller design has been made. Here the PID controller performance has been made which shows that the PID controller produce large overshoot. Y.Christy, D. Dinesh Kumar [2] from this paper the modelling of highly nonlinear tank system is explained and then controller comparison is made between PID controller and Honeywell PID controller. Here the Honeywell PID shows satisfied results with minimum settling time, rise time and peak overshoot. Disha, Mr. Pawan Kumar Pandey, Rajeev Chugh [3] explains the design of fuzzy logic controller to improve the efficiency of the system in terms of rise time and settling time and peak overshoot. Here the fuzzy logic controller provides the response with less overshoot that prevents the systems to reach unstable condition. Harshdeep Singh [4] and Mohd Iqbal, Dr.K.A.Khan [5] explains the designing of fuzzy logic controller for single tank system to control the level of the tank. Here the fuzzy logic controller design is explained in detail. MiralChangela, Ankit Kumar [6] here the author explains the mathematical modelling and designing of two tank interacting system using traditional and fuzzy logic controller.

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Here the fuzzy logic controller provides optimum results with minimum steady state error and no peak overshoot

III. PROPOSED SYSTEM

To control the height of the fluids and flow of the tank is a fundamental parameter in the continuous process industries. The continuous process industries needs to pump the liquid, store in the tank and pump them to different tanks . Usually the liquid will be maintained by chemical or mixing treatment in the tank itself, but the level of the fluid in the tank has to be maintained. Controlling of fluid level is a vital and common method in continuous process industries, during this level process the tank is cylindrical in shape which the level of liquid has to be maintained at constant. This solution can be achieved by maintaining the inlet flow into the tank. The level in a tank is the control variable and the inflow to the tank is the manipulated variable. Cylindrical tanks has wide applications area in process industries like hydro metallurgical industries, food processing industries, concrete mixing industries and treatment of waste water industries.

A. TWO TANK INTERACTING SYSTEM

The Two Tank Interacting System has two tank which is connected to each other through a cross section connecting valve and these valves introduce nonlinearity within the system. For the dynamic model, the input of the system is the flow rate Fin1 and Fin2, while the output is the measurement h_1 and h_2 i.e. the height of tank1 and tank2 is considered as output. The mathematical equation for two tank interacting system is given below,

For Tank 1,

$$A_1 \frac{dH_1}{dt} = Fin_1 - b_1\sqrt{h_1 - h_2} \qquad (1)$$

For Tank 2,

$$A_2 \frac{dH_2}{dt} = Fin_2 + b_1\sqrt{h_1 - h_2} - b_2\sqrt{h_2} \qquad (2)$$

Where the coefficients of valve for Tank 1 and Tank 2 $b_1 = S_1 a_1 \sqrt{2g}$ and $b_2 = S_2 a_2 \sqrt{2g}$. The Table 1 displays the system parameters of TTIS.
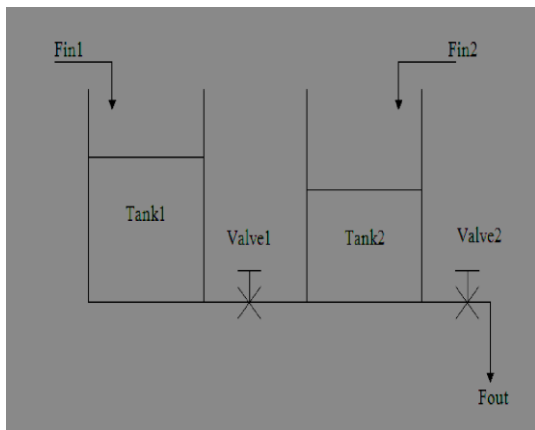

Fig 1 Two Tank Interacting System

Table I Two Tank Interacting System Parameters

PARAMETER OF THE SYSTEMS	SYMBOLS
Area of tank1 and area of tank2	A_1, A_2
Acceleration due to gravity	g
Maximum height of the tank	H_{max}
Connecting pipes cross section area	a
Coefficient of connecting pipes	s
Initial height of the system	H_1, H_2

III. PID AND FUZZY LOGIC CONTROLLERS

A proportional– integral–derivative controller (PID controller) is a traditional controller which is used for controlling any kind of process. Here , in this process our aim is to control the height of a tank two that is at 0.3m. Normally , a controller is selected based on the values of the following time domain parameters like rise time (tr), peak time (tp) and settling time (ts).

Usually, the response is denoted by measuring wave characteristics of the controllers. Rise Time is the amount of time taken by the system to reach 10% to 90% of the steady-state value, or final value. Peak Overshoot is the amount during which the manipulated variable overshoots the set point. Settling time is the time taken by the process variable to reach the set point. Here the PID controller used for controlling the non-linear two tank interacting system, show the responses with higher peak time, rise time and settling time. Fuzzy controllers are very simple in their concept. It has an input stage, a processing stage, and an output stage. The input stage is from the sensor, switches, thumb wheels etc., to match the membership functions and true values. The processing stage has certain rule and provides a result for every rule, and produce accurate results. Finally, the output stage converts both results into an output value. Here we had defined two inputs and one output for the controller. One is change in change in flow rate and the other is the rate of change of error. These inputs are applied to the Rule Editor in fuzzy. The controller output is the position of "valve". The membership function Editor may be a platform that displays and edits the membership functions assisted with all of the input and output variables for the whole fuzzy inference system. When the membership function Editor is operated to figure on a fuzzy inference system which isn't exist already within the workspace of fuzzy, there's no membership functions assisted with the variables which is defined with the FIS Editor. The input flow rate is given in Gaussian membership function that has three divisions 'high', 'zero' and 'low'. The input rate of change of error is given in Gaussian membership function that has three divisions 'positive', 'zero' and 'negative'. The output valve position is given triangular membership function that has five divisions 'close_fast', 'close_slow', 'no_change', 'open_fast', 'open_slow'.

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Hence a modern controller like Fuzzy logic controller has been chosen and modelled to control the height of the two tank interacting system and comparison of the above mentioned time domain parameters has been made to decide which controller is suitable for the given non linear process.

IV RESULTS AND DISCUSSION

The simulation was performed for two tank systems with conventional PID controller and fuzzy logic controller. The comparison was made by analysing the parameters which includes rise time, peak time, settling time and peak overshoot. By comparing these parameters the fuzzy logic controller provides optimum results in controlling non-linear two tank interacting system.

OPEN LOOP RESPONSE OF TTIS

The fig shows the open loop response of two tank interacting system. The results have been taken under different operating conditions.

Case (i) The flow rate of tank1 and tank2 is respectively, from the response it is observed that the level of tank1 and tank2 is settled at the steady state 0.4m and 0.3m.
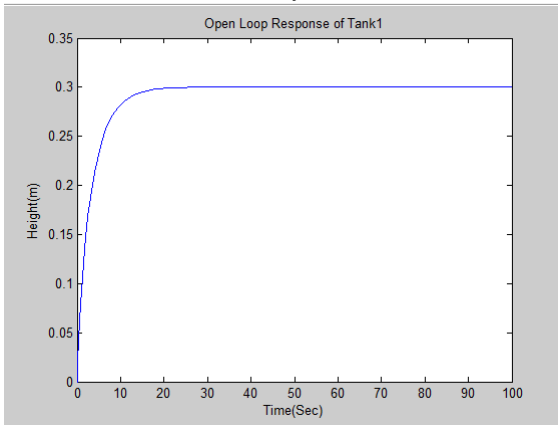

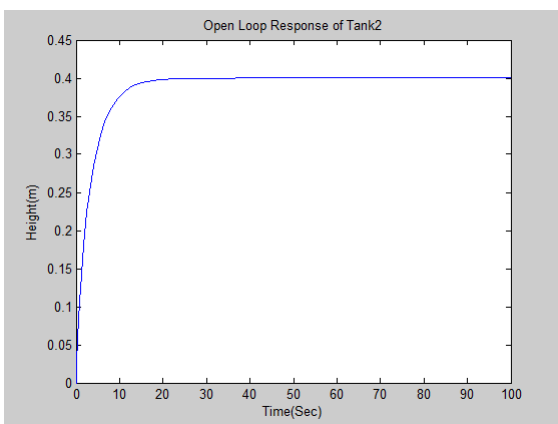**Fig. 2 Open Loop Response of TTIS Tank1**

Fig. 3 Open Loop Response of TTIS Tank2

Case (ii) Under the condition when the flowrate of tank1 is changed, it is found that the level of tank1 is changed from the nominal height and because of their interacting in nature, the level of tank2 is also changed, but the system is stable because the height of the tank settled at some point.
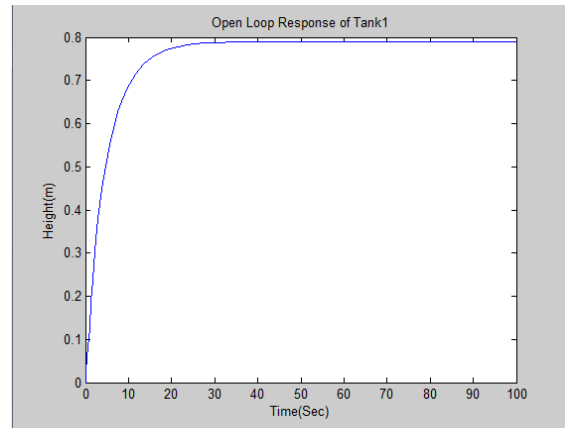

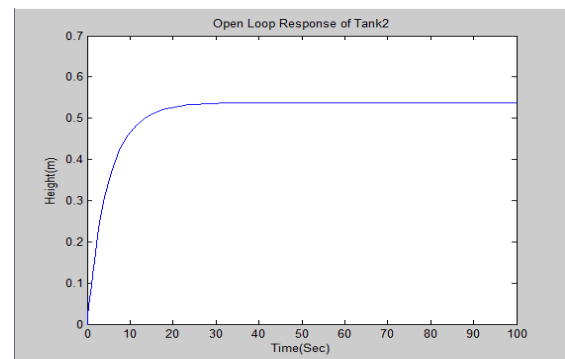**Fig.4 Open Loop Response of TTIS Tank1**

Fig.5 Open Loop Response of TTIS Tank2

Case (iii) Under the condition when the flowrate of tank1 is changed to, it is observed from the response that the level of tank1 and tank2 becomes non-linear.
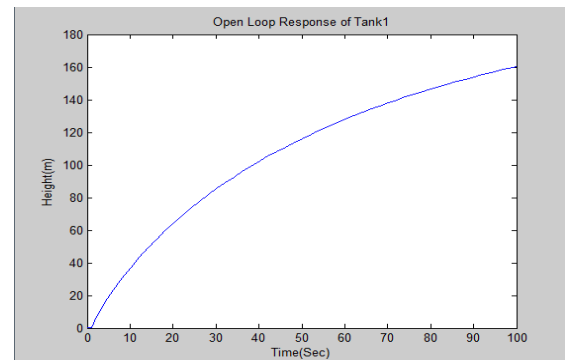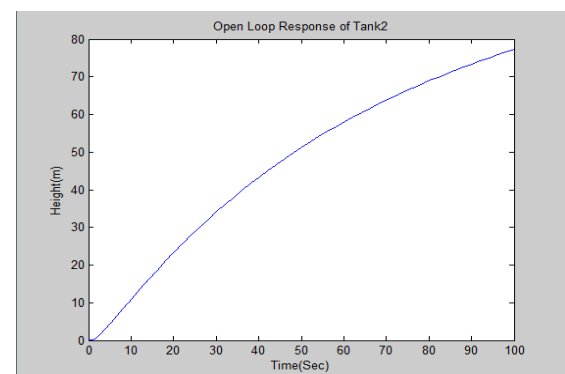

Fig.6 Open Loop Response of TTIS Tank1

Fig.7 Open Loop Response of TTIS Tank2

CLOSED LOOP RESPONSE OF TTIS

The closed loop response for using fuzzy logic controller and traditional PI, PID controller is shown. It is observed from the response and by comparing the parameters that includes rise time, peak time and settling time. It is found that the fuzzy logic controller shows optimum results than traditional controllers like PI and PID. It has been observed that the response observed through PI and PID controller shows high peak overshoot than fuzzy logic controller and also rise time is higher in traditional controller.
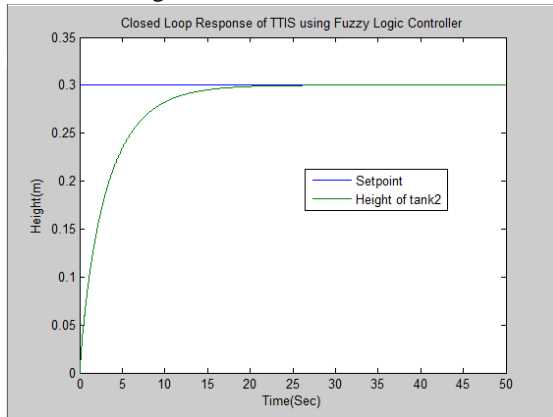

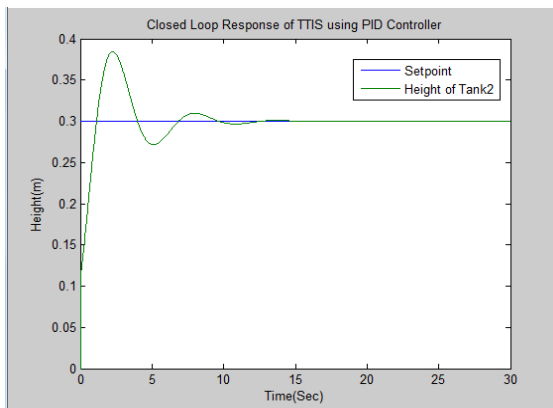**Fig.8 Closed Loop Response of Fuzzy Logic Controller for TTIS**

Fig.9 Closed Loop Response of TTIS using PID Controller

V CONCLUSION

The mathematical modelling and controller design for two tank interacting system has been made . The fuzzy logic controller was designed and the controller response of conventional PID controller and fuzzy logic controller has been done and it is observed that the fuzzy logic controller allows the system to reach the steady state faster with no overshoots, while the conventional controller gives a large overshoot response.

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