Real time control of conical tank system using Adaptive fuzzy PID using Lab VIEW

V.Manimekalai, K.Srinivasan, K.Umashankar

Abstract: Implementation of control algorithms for a highly non linear system is often complicated due to variations in process dynamics. In this paper a control scheme based on Adaptive Fuzzy PID is implemented for a non linear conical tank system and monitored in real time using Lab VIEW. It is observed that the Adaptive fuzzy PID controller gives better performance in real time compared to conventional controllers like PID, FLC. A comparison is made between fuzzy logic controller and adaptive fuzzy PID controller.

Keywords: Conical tank; controller; FLC; PID; Lab VIEW

I. INTRODUCTION

Many Process industries use conical tank system for either mixing chemicals or other fluids. These process industries face a major problem in controlling the level of liquid in the conical tanks. The key objective is to maintain the liquid level at a desired set point value. In level control process, the tank systems like cylindrical, cubical are linear one, but these types of tanks does not provide a complete drainage. For complete drainage of fluids, conical tanks are used in the process industries, where its nonlinearity might be at the bottom only in the case of conical bottom tank.

The controlling of a process requires every possible way getting a desirable output without error, even if it occur bring the output of the system back to desired response basically the type of the system uses feedback signals to control and adjust the system itself is called closed loop system. In closed loop system we try to maintain the desired output condition by comparing it to the actual condition[12] we may say that the main advantage of using a closed loop system is its ability to reduce a system sensitivity to external disturbances like physical parameters by using a closed loop system we can obtain increased stability, enhanced robustness and reliable performance.

Since conical tank is highly non-linear in nature, controlling such plants is very difficult. C. Dinesh et.al compared classical PID controller with Fuzzy logic controller [1] and it is been observed that FLC shows better response time compared to classical PID. The classical PIDcontrollerdoes not give good results for such systems which consist of disturbances. In fuzzy logic controller [3] we can control the process by required conditions using "if-then" rules. Most of the real time processes are higher order and complex. So by the simple set of rules [4] in Fuzzy controller we can get desired response.

While controlling a process which involves larger plants the environment affects the response

Adaptive controllers change the response according to the physical parameters.Adaptive fuzzy PID controller [5] is applicable and more effective for complex processes. The shape of the conical tank is the reason for the non-linearity in the process.

In [6], Relay based PID tuning is used to maintain the process at a desired set point and to achieve optimumperformance.

In [7], Conventional PI controllers when applied for real time tank system a large overshoot and high settling time occurs and it is overcome by by using Adaptive fuzzy PI controller to get better performance and better response. An IMC controller [8] is used in non-interacting conical tank system to analyze the performance and their response and it gives better result compared with conventional PID controllers. Adaptive controllers (MPC) predicts the future outcome and changes the input according to that. So compared with conventional PID controllers [9] Adaptive controllers are way more effective in plant process. In most of the papers performances of the controllers are analyzed using MATLAB software. Since simulation or model based output may not suite the real time requirement, here in this paper the height of the conical tank is controlled real time using LabVIEW to validate the simulation results of[10].

Therefore, a new approach which is a combination of fuzzy and PID control [11]is proposed that can deal with these limitations. This paper has two contributions. Firstly a Fuzzy logic controller has been designed for conical tank system and implemented real time. Secondly for the same system Adaptive fuzzy PID is implemented realtime.

The organization of the paper is as follows: section 2 discusses the process plant description. The design of adaptive fuzzy PI is discussed in section 3. The real timeimplementation of proposed control scheme is discussed in section 4. Simulation results of FLC and adaptive fuzzy PID is discussed in section 5.

II. PROCESS PLANT DESCRIPTION

The experimental setup of conical tank system is shown in Fig.1. In this process system one single conical tank is chosen and the proposed control algorithm is implemented. Water is chosen as the liquid medium. The details of the plant are given below.

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A. Experimental setup of conical tank system:

The experimental setup which consists of a two storage conical tank, a pneumatic control valve, a pump, an I/P converter, a Differential Pressure Level

Transmitter (DPLT), interfacing DAC card and I/V & V/I converter. Water from storage tank is pumped continuously to the conical tank through a pneumatic control valve.

The DPLT transmits a current signal (4-20mA) to the I/V converter. The output of the I/V converter (0-5V) is given to the DAC for interfacing with LabVIEW. The LabVIEW simulates output in range (0- 5V) which is converted to 4-20mA of current through V/I converter. The current of 4-20mA is converted to 3-15 psi for actuating the control valve, which regulates the flow of liquid into the conical tank.

Fig.1 Experimental setup of conical tank system

B. Closed loop control of Processplant

The control algorithm is implemented in LABVIEW and the plant output in monitored for various set point values. The controller takes necessary action based on two parameters. One is error between set point and process variable. Other is the rate of change of error. The output of controller is given to final control element, which is the pneumatic control valve.

III. ADAPTIVE FUZZY PID CONTROLLER

Adaptive controllers are used to provide automatic Adjustment of controller in real time process, so we could maintain performance of the plant at a desired level. Mostly these controllers are used widely in such applications where parameters of the plant dynamic model are unknown. Conventional PID controller depends on the values of proportional gain Kp, integral gain Ki and derivative gain Kd.

Here in adaptive fuzzy PI controller the Kp and Ki and Kd values are chosen based on the output of fuzzy logic controller. The adaptive fuzzy controller consists of two parts,one is the conventional PID controller and other is fuzzy logic controller.

In closed loop controller of adaptive controller we have direct and indirect adaptive control. Model reference adaptive controller (MRAC) is a type of direct adaptive controller where we have to maintain the desired performance of the plant. In indirect adaptive control we have on-line estimation of the plant model. The main difference between these two adaptive controllers are in direct adaptive controller the parameters of the controller are directly estimated by the adaptive mechanism, but in indirect adaptive control, we are using an adjustable predictor after the adaption mechanism and control the parameters of the controller.

A. Fuzzy logic controller

Most of the process control applications have common issues such as time delay, and soak function response. In non- linear processes the target values changes fastly, if we use PID controllers for correcting factors we may have large overshoot which is undesirable unlike conventional PID controller’s fuzzy logic controller deals with artificial intelligence. Main purpose why we use a fuzzy controller is because it can quantify the input signal when dealing with noisy environment. In fuzzy controllers the inputs are passed to an inference engine and experienced based rules are applied so we could produce an desired output. The closed loop processes which are required step changes control are difficult to handle where PID tuning is tricky so we fuzzy logic controllers for auto tuning.

The fuzzy control systems are rule-based systems in which a set of fuzzy rules represent a control decision mechanism for adjusting the effects of certain system stimuli. The rule base reflects the human expert knowledge, expressed as linguistic variables, while the membership functions represent expert interpretation of those variables. In this paper single input multiple output (SIMO) fuzzy logic tool box is chosen in Lab VIEW. One input variable is height of the tank h and the three output variables are Kp, Ki and Kd. Fuzzy controller makes the input accurate quantity to fuzzy quantity. Mainly fuzzy logic controllers are implemented on non-linear systems which yield for better results. For designing, the controller number of parameters needs to be selected and then membership function and rules are selected based on heuristic knowledge.

B. Membership Functions for Input and output Variables

- Symmetrical triangle membership function with linear distribution is considered for input variableh.
- Four singleton membership values are defined for the output variable Kp, Ki and Kd. The centre points of the member function are based on the gain scheduling scheme in[3].
- The notations used for membership functions are Absolute Zero (AZ), Positive Small (PS), Positive Medium (PM), Positive Big(PB).
- Input and output membership values are assigned in the Fuzzy system designer tool box inLabVIEW.
- The input membership function and output membership function values are given in Fig. 2 andFig.3

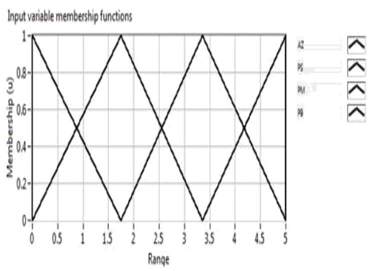

Fig.2. Input Membership Function For The Fuzzy Controller

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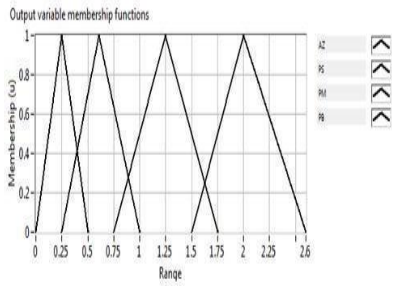

Fig.3. Output Membership Function For The Fuzzy Controller

C. The Fuzzy Rules

In this paper 4 fuzzy rules were introduced to the fuzzy logic system. They are,

1. If h is AZ then Kp, Ki is AZ and KdisAZ.
2. If h is PS then Kp is PS, Ki is PS and KdisPS.
3. If h is PM then Kp is PM, Ki is PM and KdisPM.
4. If h is PB then Kp is PB, Ki is PB and KdisPB.

IV. REAL TIME INPLEMENTATION OF THE PROPOSED CONTROL SCHEME

The connections are given as per the block diagram shown below. The Data acquisition block of LABVIEW receives the level transmitter output in terms of (0 -5V DC). The output of the fuzzy logic tool box is fed to PID tool box. The output of PID block is given to SCB 68 CONNECTOR DAQ – PCI 6221 to send the control signal to the final control element which is control valve for this setup. The block diagram for FLC controller is shown in Fig.4 and the block diagram for interfacing Adaptive fuzzy PID is shown in Fig.5.

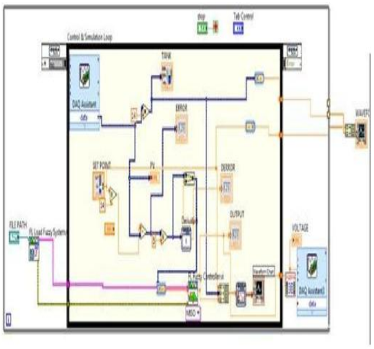

Fig.4 Block Diagram Of FLC Implemented Using Labview

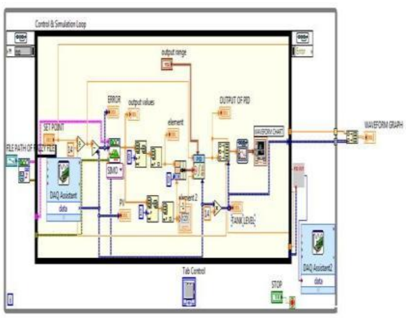

Fig.5 Block Diagram Of Adaptive Fuzzy PID Controller Implemented Using Lab VIEW

A. Simulation results of fuzzy logic controller

The conical tank is interfaced with LabVIEW through DAC and height of the tank is monitored to check whether it has reached the set point Value. A graph is plotted between time and Process variable (height of the tank).The output of FLC drives the controller through V/I converter. The simulation result of FLC is shown inFig.6.

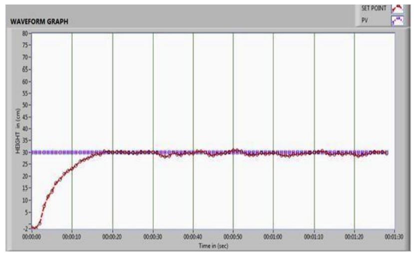

Fig.6 Simulation Result Of FLC Controller Implemented Forconical Tank Using Lab VIEW

B. Simulation result of adaptive fuzzy PIC controller

The graph below shows the response of Adaptive fuzzy PID. The height of the conical tank change based on the controller output. The simulation result of Adaptive fuzzy PID is shown in Fig.7.

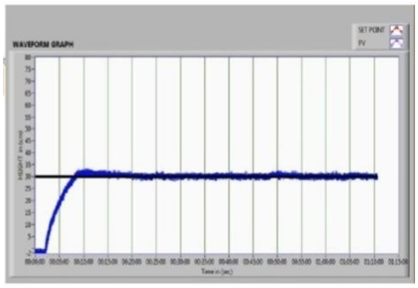

Fig.7 Simulation Result Of Adaptive Fuzzy PID Controller Implemented For Conical Tank Using Labview

C. Inference

It's been observed that adaptive fuzzy PID controller responds faster when compared to FLC without any overshoot or oscillations for set point of 30 cm.

Time (sec)	Heightof the conical tank in (cm) (FLC controller)	Height of the conical tank in (cm) (Adaptive fuzzy PID)
0	0	0
30	3	5
60	14	20
90	23	30
120	26	30
150	29	30
180	30	30
210	30	30

Table I. Performance OfFlc And Adaptive Fuzzy Pid Controller

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V. CONCLUSION

In this paper the level of the conical tank is controlled by FLC and Adaptive fuzzy PID controller. The effectiveness of the response was determined by the settling time and peak overshoot. From the results it is concluded that the settling time is high for about 180 seconds for Fuzzy Logic Controller, whereas Adaptive fuzzy PID controller response has minimum settling time of 90 seconds compared to FLC. In the Adaptive fuzzy PID controller the Fuzzy algorithm determines the values of Kp, Ki and Kd for PID controller. From the resultitis been concluded that Adaptive fuzzy PID controller is more effective in reaching set point value compared with Fuzzy Logic Controller.

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