Modeling and Controlling of Conical Tank System Using Adaptive Controller and Conventional Pid Controller And Comparison Of Their Performances

Mrs.K.Shanthi[1], S.Pavithra[2], K.Heera[3]
[1, 2] Department of Instrumentation and control
[1, 2. 3] Sri krishna college of technology,Coimbatore .India

Abstract-*In process industries, primary task of any controller is to overcome various disturbances to make the process to remain in stable condition. In any process tank, shape plays a vital role for designing the controllers. In this paper we have considered a conical tank because of the following advantages like better disposal of solids, easy mixing, and complete drainage of solvents such as viscous liquids in industries. The controller has to be chosen based on its non-linearity. In conical tank non-linearity exists due to its variations in cross-sectional area. Level control of the conical tank is a challenging task and it demands for implementation in real time.*

This paper deals with how controllers are designed by selecting suitable number of inputs and outputs, membership functions and rules to control the level of non-linearity of conical tank, and the results are compared among them .

Keywords-Conical Tank,PID controller,Fuzzy Control.

I. INTRODUCTION

In practice, all physical processes exhibit some non-linear behaviour. Furthermore, when a process shows strong non-linear behaviour, a linear model may be inadequate; a non-linear model will be more realistic. Unfortunately, this improved closeness to reality is attained at a cost: the convenience and simplicity offered by the linear model is sacrificed. Since many processes exhibit only mildly non-linear dynamic behaviour, linear models can reasonably approximate them. However, even for such systems, the behaviour over a wide range of operating conditions will be noticeably non-linear, and no single linear model is able to represent such behaviour adequately.

The issue of analysing the dynamic behaviour of processes represented by non-linear models is the main concern in this topic; this is motivated by the fact that situations do arise when it is undesirable to neglect the inherent nonlinearities of a process. The objective here is to provide an introduction of how we can expect to carry out dynamic analysis and control when the process models are non-linear.

The nature of non-linear problems is that they are not as easily amenable to the general complete treatment which are possible with linear systems. To keep non-linear dynamic analysis on arealistic and practical level usually involves trade-offs between accuracy and simplicity.

In process industries, primary task of any controller is to overcome various disturbances to make the process to remain in stable condition. In any process tank, shape plays a vital role for designing the controllers. In this paper we have considered a conical tank because of the following advantages like better disposal of solids, easy mixing, and complete drainage of solvents such as viscous liquids in industries. The controller has to be chosen based on its non-linearity. In conical tank non-linearity exists due to its variations in cross-sectional area. Level control of the conical tank is a challenging task and it demands for implementation in real time.

This paper deals with how controllers are designed by selecting suitable number of inputs and outputs, membership functions and rules to control the level of non-linearity of conical tank, and the results are compared among them .

II. CONICAL TANK [2]

Conical tank is extensively used in the process industries due to its advantage as easy discharge of solution inside it. Since the conical tank cross sectional area is constantly varying as shown in Figure 1, level control of conical tank is challenging. Figures to be close to fig ref.. and not at the end; fig captions to be below each figure and not to be listed at the end.

The proposed system consists of a conical tank, which measures 600 mm in height and in the top end diameter is 400 mm, the tapering end is 150 mm. Differential pressure transmitter is present for measuring the pressure and gives output in terms of milliamps. It consists of a reservoir to store water which is pumped to the tank through the pump. Speed of the pump is proportional to the inflow to the tank.

Liquid level is measured by using the gauge pressure which considers pressure head value. Output of this process is same as actual height of liquid that is present in the conical tank. Conical tank height can be measured from the sensor output and is multiplied by specific gravity of the liquid present in the conical tank. Final reading of the level obtained is independent of the volume of conical tank which is considered[1]. Actual level of the conical tank can be viewed by transparent tube that is present outside the system. Control knob is provided at outflow of the tank for maintaining the level of liquid present in the tank. The level of the tank is detected by the Differential Pressure Transmitter and it is converted to current signal. Further it is converted to voltage signal by I/V converter which are given as input to the LabView DAQ assistant through ADC.

III. DESCRIPTION [5]

The tank is made up of stainless steel body and is mounted over a stand vertically. Water enters the tank from the top and leaves the bottom to the storage tank. The System specifications of the tank are as follows:

DETAILS	**PART NAME**
Stainless steel body, height– 65 cm, Top diameter–33.5 cm Bottom diameter – 3.5 cm	Conical tank
Capacitance type, Range 2.5-250mbar, output 4-20 mA	Differential Pressure Level Transmitter
Centrifugal 0.5 HP	Pump
Size ¼ Pneumatic actuated Type: Air to open, Input 3-15PSI	Control Valve

Rota meter
Range 0-460 LPH

IV. LEVEL PROCESS SYSTEM[6]

The mathematical model of the conical-tank level control system in the simulation is formulated based on the real laboratory-scale conical-tank system. The experimental setup which consists of a conical process tank, a pneumatic control valve , a storage tank , a pump, a I/P converter, a Differential Pressure Level Transmitter(DPLT), VMAT interfacing card and I/V & V/I converter. Water from storage tank is pumped continuously to the conical tank through a pneumatic control valve [4]. The DPLT transmits a current signal (4-20mA) to the I/V converter. The output of the I/V converter (1-5V) is given to the VMAT interfacing hardware consisting of multifunction high speed ADC and DAC. The onboard data converters of the VMAT can be directly linked with the Simulink tool of MATLAB thus forming a complete closed loop system. The signal from the PC is transmitted to the I/P converter through V/I converter. The output from the I/P converter is the pressured air in the range of 3-15 psi for the actuating the control valve, which regulates the flow of liquid into the conical tank.

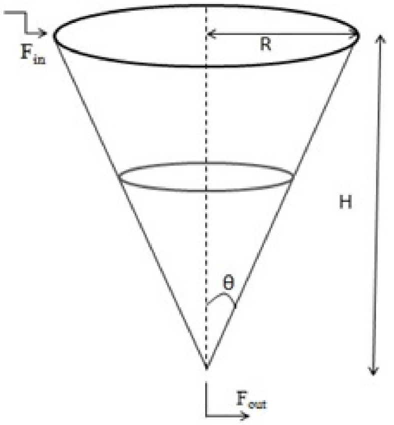


Fig1. Conical tank

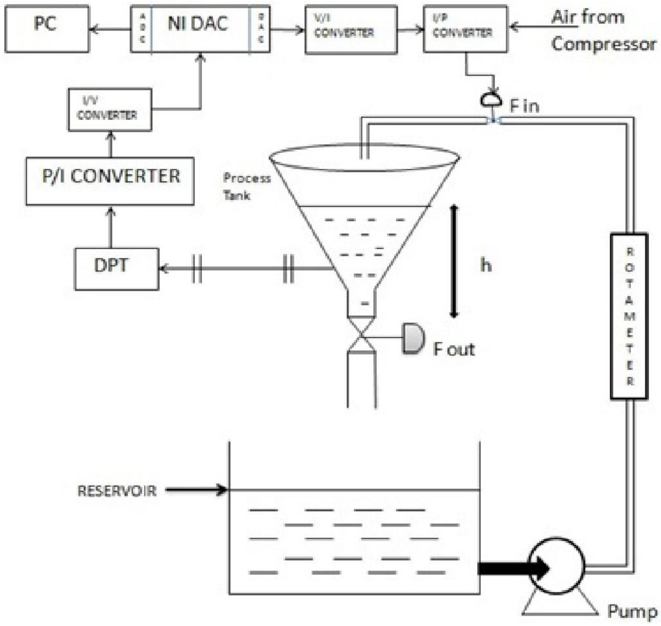


Fig2.level process system

V. MATHEMATICAL MODELING [6]

Here Fi is the inlet flow rate to the tank, F0 be the outlet flow rate from the tank, FL be the disturbance applied to the tank.

The dynamic model of the conical-tank system when nominal operating level h is given by

$Adhdt = Fi - Fo$ (1)
$Fo = b\ 2gh$ (2)
$A = \pi R2h2\ H2$ (3)
Substitute the equation (2) and (3) in (1) $dhdt = Fi - b\ 2gh\pi R2h2\ H2$ (4)

Where h is the height of the liquid level in the conical tank, H is the height of the conical tank,r is the radius of the conical vessel at a particular level of height h, R is the top radius of the conical tank, A is the area of the conical tank, outlet valve ratio b, inflow rate to the tank Fi and outflow rate of the tank Fo. Modeling and Controlling of Conical tank system using controllers:

VI. CONTROL METHODS

PID CONTROLLER: [1]

When the characteristics of a plant are not suitable, they can be changed by adding a compensator in the control system. One of the simple and useful compensators feedback control design is described in this section(fig3). In this paper, the control method is designed based on the time-dimension performance specifications of the system, such as settling time, rise time, peak overshoot, and steady state error and so on.

A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs.

Three parameters of P, I ,D must be adjusted in the PID controller. In guaranteeing stability and performance and shaping the closed-loop response, it is important to select a suitable compensator[3].

A. Proportional gain Kp: Large proportional control can increase response, speed and reduce the steady state error, but will lead to oscillation of the system.

B. Integral gain KI: Integral control is favorable for diminishing the steady state error but it will lengthen the transient response. This paper attempts to design optimal values for controller parameters. Then it obtained the value of PID gains by Ziegler and Nichols method. Ziegler and Nichols provided a technique for selecting the PID gains that works for a large class of industrial systems.

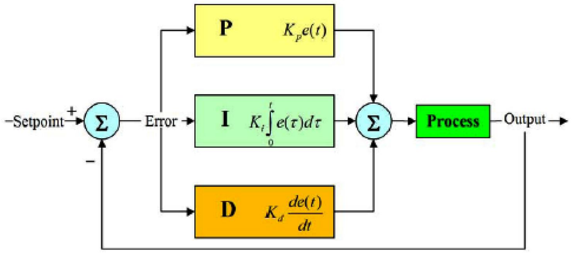


Fig3.PID controller

FUZZY CONTROL:[2]

The fuzzy adaptive system in accordance with the desired response we shall here use the term training for the adaptation activity to align with the terminology used in fuzzy modeling. At the sampling instant n. It reads the error signal ef(t) is defined as ef(t) = uc(t)-u(t) and rate of change of error signal, to find the new PI parameters ΔKP,ΔKI using fuzzy rule base system.A typical structure of a PI control system, where it can be seen that in a PI controller, the error signal e(t)is used to generate the proportional, integral actions, with the resulting signals weighted and summed to form the PI controller is where u(t) is the input signal to the plant model. The self-tuning PI-type fuzzy controller is an auto adaptive controller that is designed by using an incremental fuzzy logic controller in place of the proportional term in the conventional PI controller to tune the parameters of PI controller on line by fuzzy control rules. The controller uses the error and change in error as its inputs and can meet desire of self-tuning parameters based on time-varying eand ce.

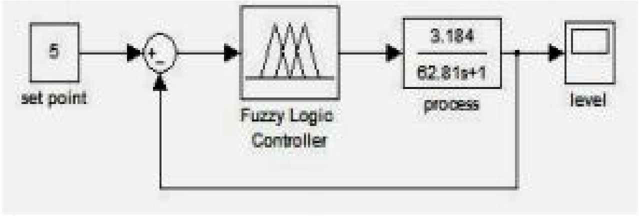


Fig4.Fuzzy logic system

A fuzzy logic system (FLS) can be defined as the nonlinear mapping of an input data set to a scalar output data.

A FLS consists of four main parts [10] :

- Fuzzifier
- Rules
- Inference engine
- Defuzzifier

These components and the general architecture of a FLS is shown in Figure. The process of fuzzy logic is explained in Algorithm

1: Firstly, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step is known as fuzzification. Afterwards, an inference is made based on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification . The input and output of the fuzzy controllers are designed below,

Generally fuzzy controller has two input like error and change in error.The membership function of error and Fig. is the membership function of change in error. The fig. represents the controlling action of

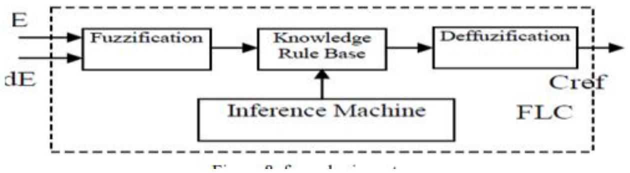
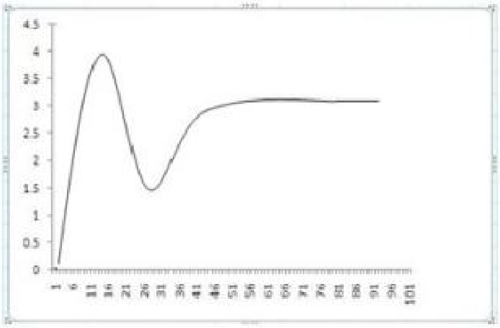


Fig5.fuzzycontroller

the valve. A fuzzy inference system (FIS) essentially defines a nonlinear mapping of the input data vector into a scalar output, using fuzzy rules. The mapping process involves input/output membership functions, FL operators, fuzzy if–then rules, aggregation of output sets, and defuzzificationAn FIS with multiple outputs can be considered as a collection of independent multi-input, single-output systems. FIS contains four components: the fuzzifier, inference engine, rule base, and defuzzifier. The rule base contains linguistic rules that are provided by experts. It is also possible to extract rules from numeric data. Once the rules have been established, the FIS can be viewed as a system that maps an input vector to an output vector.

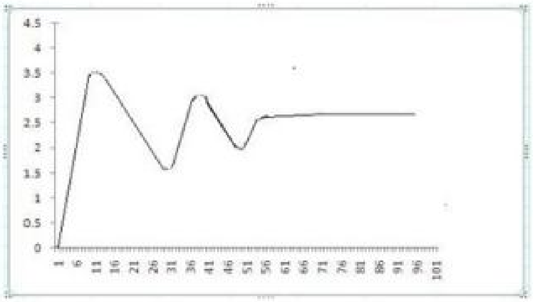
VII. CONCLUSION

Non-linearity of the conical tank is observed and the model is implemented with the help of LabVIEW. Level control of the tank is checked by both PID Controller and Fuzzy Logic Controller. From the simulation results we can observe that Fuzzy Logic Controller gives fast response with less number of oscillations when subjected to change in the level of conical tank compare to PID controller and it enhances the performance of the system



ABOVE IS THE RESPONSE OF FUZZY CONTROLLER

& BELOW IS THE RESPONSE OF PID CONTROLLER



REFERENCES

[1] Modeling and Controlling of Conical tank system using adaptive controllers and performance comparison with conventional PID , T.Pushpaveni, S.Srinivasulu Raju, N.Archana, M.Chandana,International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May-2013

[2] Real Time Level Control of Conical Tank and Comparison of Fuzzy and Classical Pid ControllerC. Dinesh*, V. V. Manikanta, H. S. Rohini and K. R. PrabhuSchool of Electrical Engineering, VIT University, Vellore, IndiaIndian Journal of Science and Technology, Vol 8(S2), 40–44, January 2015

[3] Performance Analysis of Intelligent Controller and Classical PID Controller for Conical Tank System .Rupinder JawandaInternational journal of Engineering Research and Technology

[4] Modeling and Control of Liquid Level Non-linearInteracting and Non-interacting SystemS.Saju1 B.E.M.E.(Ph.D.) , R.Revathi2, K.Parkavi International Journal of Advanced Research in Electrical,Electronics

and Instrumentation EngineeringVol. 3, Issue 3, March 2014

[5] Real Time Implementation of PI Controller for Conical Tank System, Akash A. Patel ,Kuldip H. Tarpara ,International Journal of Scientific Reseach

[6] A MODEL REFERENCE-BASED FUZZY ADAPTIVE PI CONTROLLER FOR NON-LINEAR LEVEL PROCESS SYSTEM A. Ganesh Ram & S. Abraham Lincoln International journal of Recent Research and Applied Studies