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Real Time Level Control of Conical Tank and Comparison of Fuzzy and Classical Pid Controller

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Abstract

This paper describes about the level control of conical tank by using PID control and fuzzy logic algorithm. Many process industries are equipped with conical tanks because of easy discharge of contents present in it. But level control in the conical tank is most challenging parameter which is to be monitored. This non-linearity can be overcome by different controlling techniques. Conventionally used controller in most of the industries is PID controller. Further the controller is updated with fuzzy logic controller for the enhanced response regarding level control. A result of fuzzy logic controller is compared with conventional PID to analyze the performance in terms of high stability, reliability and robustness.

Keywords: Conical Tank, PID controller, Fuzzy Logic Controller, Feedback Control, Controller Analysis

1. Introduction

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.

Industries use mainly conventional controller i.e., PID (Proportional Integral Derivative) controller because of their performance and hence it is called as work-horse of process industries. But in level controlling task of conical tank, PID fails to give fast response because of the non – linearity present in the system. To overcome this drawback, we are using a heuristic method based controller called Fuzzy Logic Controller.

This paper deals with how fuzzy logic controller is 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 compare between PID and Fuzzy Logic Controller.

2. Conical Tank

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.

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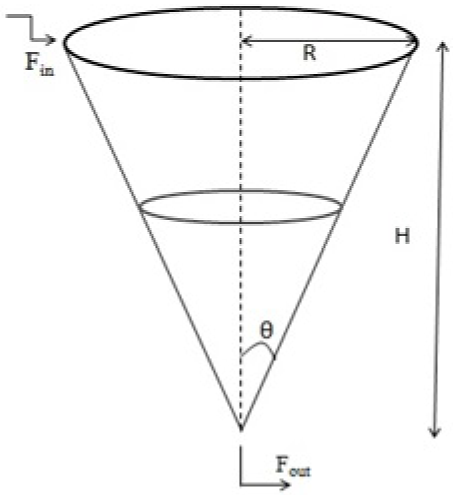

Figure 1. Structure of Conical Tank.

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. 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.

3. Block Diagram

Figure 2 represents the block diagram of level control in conical tank. In this paper water is considered as the liquid to check the non-linearity of the conical tank. Reservoir tank collects the water which is pumped to the conical tank. Level is calculated by using DPT (Differential Pressure Transmitter) with input measuring range of (0–20) mA current signal from DPT is sent to I/V converter with output range of (0–5).

The analog signal from I/V converter is converted into digital signal by Analog to Digital Converter (ADC). The signal from ADC is acquired by using NI DAQ assistant which is available in LabVIEW software tool menu.

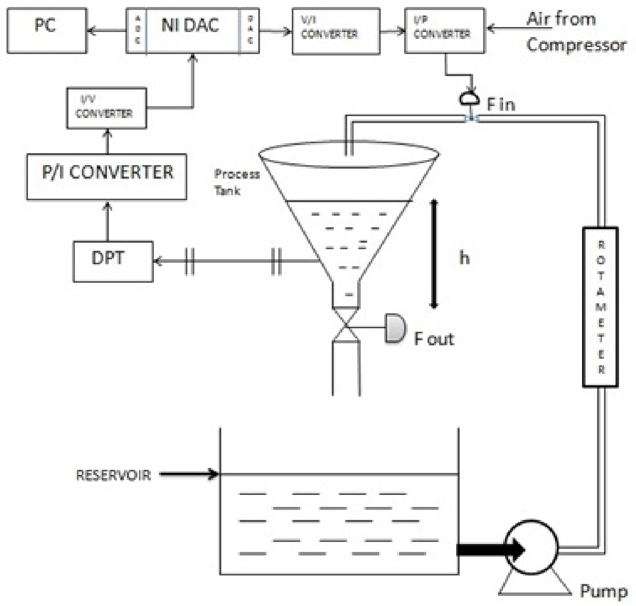

Figure 2. Conical tank level process Block diagram.

Output signal from Personal Computer is given as input to Digital to Analog Converter (DAC) which converts the digital signal to analog signal which is further converted to current signal from V/I converter and given as input to DPT of the range 3–15psi.Control valve gets pressure signal from I/P converter which controls the input flow to the conical tank.

At each instance, process variable is compared with set point and error of the system is calculated and then reduced gradually by using PID or Fuzzy Logic Controller.

4. Controller Design

Our main objective is to control the level of non-linear conical tank. To achieve this we are using two controllers separately and comparing their results to choose the best one.

i. PID Controller
ii. Fuzzy Logic Controller

i. PID Controller:

PID controller is used in the many process industries due to its fast response and quick tuning. While dealing with the non-linear processes the performance deteriorate fast, so we need to develop the non-linear PID.

To obtain the error (e) difference of Set Point (SP) and Process Variable (PV) are considered.

$$e = SP - PV \tag{1}$$

The PID controllers calculates the controller action u(t)

$$u(t) = K_c\left(e + \left(\frac{1}{T_i}\right)\int_0^t e\,dt + T_d\left(\frac{de}{dt}\right)\right) \qquad (2)$$

If the error and the $u(t)$ are same, the proportional band is reciprocal of controller gain.

T_i = Integral time and also name it as reset time

T_d = Derivative time and also name it as rate time

ii. Fuzzy Logic Controller:

Fuzzy logic was introduced by Lofti. A. Zadeh[1]. For the systems where the physical modeling is difficult and information regarding the model is inadequate for applying any control action, Fuzzy logic actions are applied over it. Fuzzy logic systems are based on logical reasoning along with ability to fuzzify any system which helps in easy implementation. In many industrial processes, Fuzzy Logic Controllers is used due to which takes the control action like human and the controlling process is simple once it designed.

Mainly FLC 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.

For the level control of conical tank process, input and output membership functions are designed as shown in Figure 3 both inputs and output consist of 7 functions as shown below.

Totally two membership functions are used while framing the fuzzy control i.e., error and differential error as shown in Figure 3 and Figure 4.

Error Input range is considered from –5 to 5 and differential error input range is considered from –1 to 1. The type of the membership function considered is trapezoidal and center of gravity method

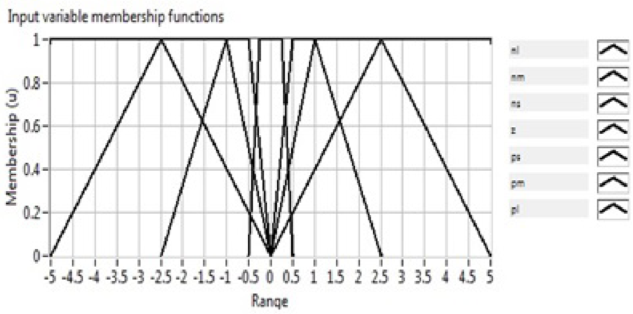

Figure 3. Error input membership function.

Output range is considered from 0 to 5 as shown in Figure 5.

Each of the inputs and output consists of seven membership functions such as negative large [NL], negative medium [NM], negative small [NS], zero [Z], positive small [PS], positive medium [PM], positive large [PL]

Due to 7 membership functions of both inputs and output the total number of rules that has been framed are 49.

Rules are framed by using the logic as shown in Figure 6.

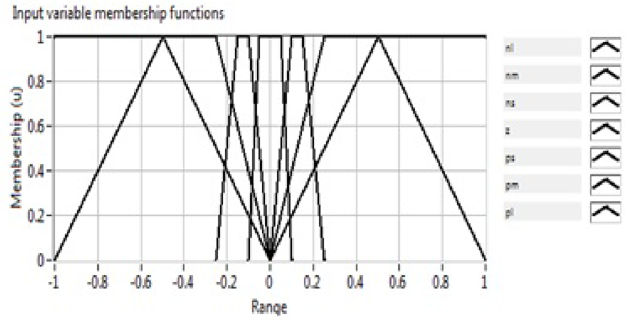

Figure 4. Differential error input membership function.

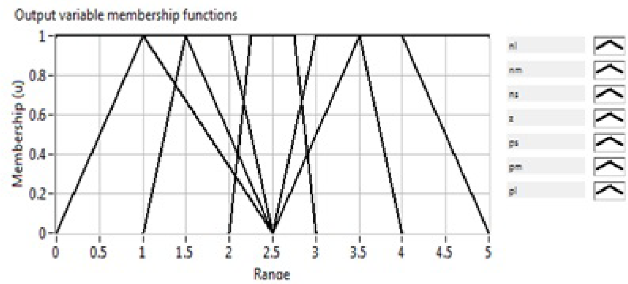

Figure 5. Output membership functions.

ce \ e	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NM	Z	PM	PB
NM	NB	NB	NB	NM	PS	PM	PB
NS	NB	NB	NM	NS	PS	PM	PB
Z	NB	NM	NS	Z	PS	PM	PB
PS	NB	NM	NS	PS	PM	PB	PB
PM	NB	NM	NS	PM	PB	PB	PB
PB	NB	NM	Z	PM	PB	PB	PB

Figure 6. Fuzzy logic rules.

5. Results

The responses of level control of Conical Tank using LabVIEW is as shown above. Figure 7 represents the response of Conical Tank with respect to PID controller where as Figure 8 represents response of Fuzzy Logic Controller. From both the responses we can conclude that Fuzzy Logic gives better and robust response when compared to PID controller as variations in level settles fast and hence the required objective is achieved.

6. 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.

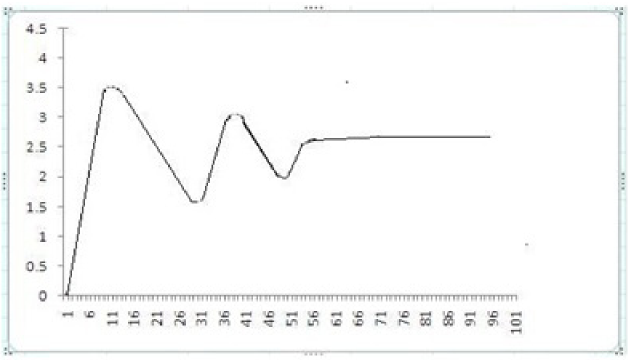

Figure 7. Response of PID.

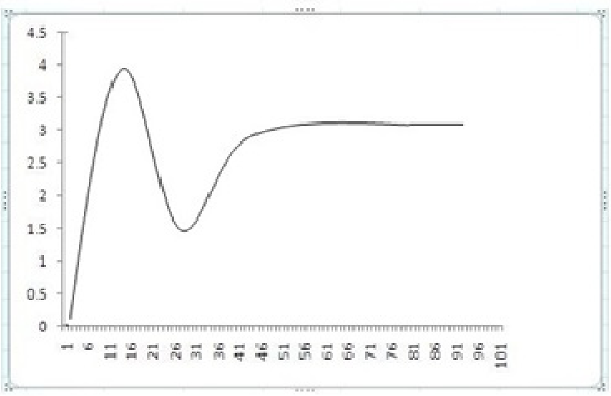

Figure 8. Response of fuzzy logic controller.

7. Future Scope

Optimizing Techniques such as PSO, Ants Colony, Genetic Algorithm can be using for fine tuning of the fuzzy logic membership functions and rules for the robust response of the controller for the increase in non-linearity of level control in conical tank.

8. References

1. Zadeh LA. Life Fellow, IEEE. Fuzzy Logic = Computing with Words. IEEE Transactions on Fuzzy Systems. 1996 May; 4(2).
2. NI Tutorial, Using the LabVIEW PID Control Toolkit with the LabVIEW Control Design and Simulation Module. 2009 Sep 04.
3. Pushpaveni T, Srinivasulu Raju S, Archana N, Chandana M. Modeling and Controlling of Conical tank system using adaptive controllers and performance comparison with conventional PID.
4. Aravind P, Valluvan M, Ranganathan S. Modelling and Simulation of Non Linear Tank. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. 2013 Feb; 2(2).
5. Sabura Banu U, Hemavathy PR, Prabhu L, Kanna B. Real Time Implementation of Enhanced Nonlinear PID Controller for a Conical Tank Process. International Journal of Computer Applications. ICIIIOSP-2013; 43–7.
6. Bingul Z, Karahan O. Tuning of Fractional PID Controllers Using PSO Algorithm for Robot Trajectory Control. IEEE International Conference on Mechatronics; 2011 Apr Istanbul. p. 955–60.
7. Bevrani H, Habibi F, Babahajyani P, Watanabe M, Mitani Y. Intelligent Frequency Control in an AC Microgrid: Online PSO-Based Fuzzy Tuning Approach. IEEE Transactions On Smart Grid. 2012 Jun 6; 3(4):1935–44
8. Valarmathi R, Theerthagiri PR, Rakeshkumar S. Design and Analysis of Genetic Algorithm Based Controllers for Non Linear Liquid Tank System. IEEE-International Conference On Advances In Engineering, Science And Management; 2012 Mar 30–31; Nagapattinam, Tamil Nadu, India. p. 616–20.
9. Ravi VR, Thyagarajan T, Priyadharshni SY. Gain Scheduling Adaptive Model Predictive Controller for Two Conical Tank Interacting Level System. IEEE-20180; 2012 Jul 26–28; Coimbatore. doi:10.1109/ICCCNT.2012.6396058.
10. Subudhi B, Swain AK. Optimization of Membership Functions of Fuzzy Logic Controller for Controlling Liquid Level using Genetic Algorithm. J Indian Inst Sci. 1997 Jan–Feb 5–14; 77.
11. Kim JW, Kim BM, Kim JY. Genetic Algorithm Simulation Approach to Determine Membership Functions of

Fuzzy Traffic Controller. Electron Lett. 1998 Oct 1; 34(20):1982–3.
12. Kumar SJ, Poongodi J, Rajasekaran K. Modelling and Implementation of Labview Based Non-linear PI Controller for a Conical Tank. J Contr Instrum. 2010 Nov; 1(1):1–9.
13. Ravi VR, Thyagarajan T. Application of adaptive control technique to interacting Non Linear Systems. IEEE. 2011; 386–92.
14. Sugeno M, editor. Industrial Applications of Fuzzy Control. North-Holland, Amsterdam: Elsevier Science Publishers B.V.; 1985; p. 231–39.
15. Yen J, Langari R, Zadeh LA, editors. Industrial Applications of Fuzzy Logic and Intelligent Systems. Washington: IEEE Press; 1995.
16. Takagi T, Sugeno M. Fuzzy identification of systems and its applications to modeling and control. IEEE Trans Syst Man Cybern. 1985; 15(1):116–32.
17. Madhubala TK, Boopathy M, Sarat Chandra Babu J, Radhakrishnan TK. Development and tuning of filzzy controller for a conical level system. Proceedings of International Conference Intelligent Sensing and Information Processing; 2004; Tiruchirappalli, India. p. 450–5.
18. Ravi VR, Thyagarajan T. A De-centralised PID Controller for Interacting Non linear Systems. Proceeding of IEEE 2011 International Conference on Emerging trends in Electrical and Computer Technology; 2011. p. 297–302.
19. Novak V. Fuzzy logic, fuzzy sets, and natural languages. Int J General Syst. 1991; 20(1):83–97.
20. Preitl S, Precup RE. An extension of tuning relations after symmetrical optimum method for PI and PID controllers. Automatica. 1999; 35:1731–6.