Modelling and Analysis of Single Conical Tank with Servo and Regulatory Control

Narsim Nandha Kumar.[1], Selvakumar. J[2], Suresh Kumar. R[3], Giri Rajkumar. S. M[4], Aravind.P[5]
[1, 2, 3, 4, 5] Department of Instrumentation and Control Engineering
[1, 2, 3, 4, 5] Saranathan College of Engineering,Tiruchirappalli, Tamilnadu, India

Abstract- *This paper describes the design of a controller for a single conical tank. The main objective is to maintain the liquid level at a specific set point value. Conical tank is a highly non-linear system because the cross section of the tank is being continuously changes in area. Here the system's liquid level is controlled by Proportional (P), Integral (I) modes with various tuning techniques like Ziegler-Nichols Method(Z-N), Tyreus-Luyben Method(T-L), Internal model controller Method(IMC), and Cohen-Coon Method(CC). Here the single conical tank is identified as First order plus dead time model. The identified transfer function is analysed under different tuning techniques and results were obtained. Simulation works are carried out in MATLAB environment. Comparison analysis is done on the basis of time domain specification and best controller settings have been highlighted.*

Keywords- Single conical tank, PI controller, Z-N, IMC, T-L, and C-C.

I. INTRODUCTION

Nonlinear process control is a difficult task in process industries. Conical tank structure is one among them. Many process industries using conical tanks because of its Shape contribute for better solid mixtures, slurries and viscous liquids while mixing, provides complete drainage, especially for viscous liquids in industries such as petrochemical, paper making, and food process industries and constantly changing cross section. So controlling the level of conical tank is crucial role in process industry. Here proportional integral (PI) control method is used for the main purpose of reducing error even though increasing value in the overshoot response. In the industrial process some amount of error or disturbance present in the outcome. To control the obtained response and maintain the set point level so, the disturbance method introduced that is servo and regulatory system. SERVO systems the disturbance is given to the input side. REGULATORY system disturbance is given to process output. Due to the result of this disturbance process whatever the disturbance occurs red the system can have sustained with the user defined set point. Design of PID controller for conical tank system, states the modelling of non-linear control system [1]. The optimal controller design for a level process, this paper describes the simulation operation for the control action implemented in the level process [2]. Modelling and simulation of Non-linear tank, this paper describes non-linear nature of the tank for level control the response obtained by process reaction curve method [3]. Modelling and controlling of conical tank system using adaptive controllers and performance with PID. In this paper states the performance of different type controlling actions [4].

PROCESS SETUP

A. EXPERIMENTAL CONICAL TANK SETUP

The Experimental setup is consisting of conical tank inlet control value, rota meter outlet control valve a sump and storage tanks it gives a closed control loop. The operation of this setup, once the pump is on the liquid is passed through the pipe line and stored in the top of the tank then its passed to the rota meter through the control valve 1(CV1), rota meter is the device used to control the flow rate and monitoring the current flow rate of the liquid. Then the liquid reaches the conical tank here level of conical tank is maintained at various set points using the input and output response the graph has been plotted using Process reaction curve (PRC) method. The excess amount of liquid returned to the sump through control valve 2(CV2) then it's recycled. The described kit is as shown in fig 2.1

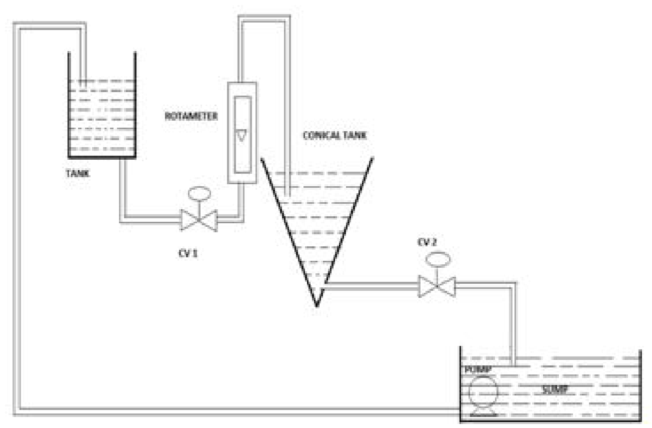

Figure2.1. a process of single conical tank

II. SYSTEM IDENTIFICATION

The system identification of the single conical tank level process. The technique used to determine the system model is process reaction curve (PRC). The PRC method contain some procedure to implement the system identification. The initial step is place the controller in manual mode and wait for the process variable (PV) to obtain a steady state valve.

The steady state value is known as our set point value (SP). The result of the process gives some amount of value. The process variable (PV), will after a time, begin to change and if it is a typical loop, the process variable will approach some new values,

The PRC method execution of output to determine the transfer function is,

$$\textbf{TRANSFER FUNCTION} = \frac{0.18}{S+0.71}e^{-0.3s}$$

We can use of MATLAB software to implement to find out the frequency and gain. There various tuning methods used to find the optimum of level control process to predict the values.

III. CONTROLLER DESIGN

A. PERFORMANCE OF TUNING METHODS

These are the tuning method which used in Single conical tank level process,

1. Ziegler-Nichols Method
2. Internal Model Controller Method
3. Cohen-Coon Method
4. Tyreus – Luyben Method

1. ZIEGLER-NICHOLS METHOD

The controller parameter can be tuned using Z-N method it is also called as process reaction method because it tests the open-loop reaction of the process to change the control variable output. Once certain process response values are found, they can be substitute into the Z-N formulas with specific multiplier constant for the gains of a controller Z-N open loop tuning formula for pi controller is given in the equations.

Table 1. Closed loop Ziegler-Nichols formulas

Controller	K_C	τ_I
PI	0.45Kcu	Pu/1.2

2. INTERNAL MODEL CONTROLLER

The controller is designed to provide nominal performance and a non-linear filter is added to make the controller implementable and to account for model mismatch. The proposed IMC strategy possesses the same stability, perfect control and zero offset properties as linear IMC the PI parameters are calculated as,

Table 2. Internal Model Controller formula

Controller	K_C	τ_I
PI	$\frac{\tau}{\lambda}$	τ

3. COHEN-COON METHOD

The Cohen-coon tuning rules are suited to a wider variety of processes than the Z-N. The Cohen coon tuning rules work well on processes where the dead time is less than two times the length of the time constant. These tuning rules use three process characteristics process gain, dead time, time constant these are determined by doing a step test and analysing the results,

Table 3.cohen–coon method formula

Controller	K_C	τ_I
PI	$\frac{1}{K_m}\frac{\tau_m}{d}(\frac{9}{10}+\frac{d}{12\tau_m})$	$d\frac{30+3d_m/\tau_m}{9+20d_m/\tau_m}$

4. TYREUS-LUYBEN METHOD

Tyreus - luyben rules like the Ziegler-Nichols, they use ultimate gain Ku and ultimate period Pu. For only proposed in PI and PID controllers. In Ziegler -Nichols method time consuming and forces the system to margin if in stability. This setting is based in ultimate gain and period is given table. Here we are using the PI control tuning.

Table 4.Tyreu-luyben method formula

Controller	K_C	τ_I
PI	K_{Cu}/3.2	2.2Pu

IV. RESULT

The following description deals with the results of tuning methods used to control the level of our conical tank.

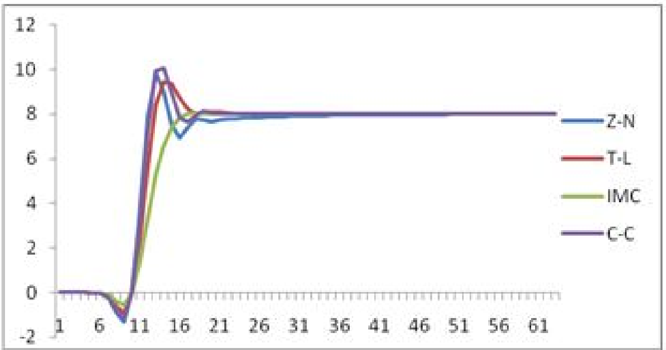

Figure 5.1 comparing the response of curve

In fig 5.1 describes the comparison of response of various tuning methods for non-linear level control process. The results have been described

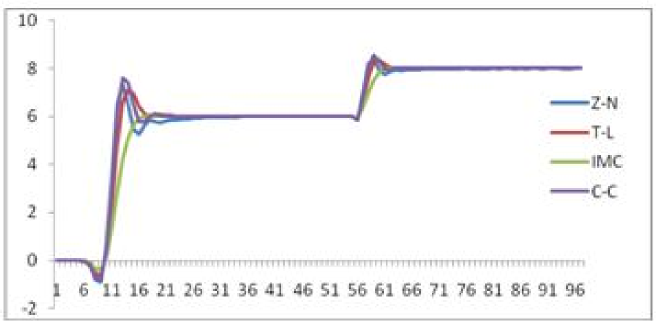

Figure 5.2 comparing the response of servo curve

In fig 5.2 explains the servo process and its response in a real time non-linear environment.

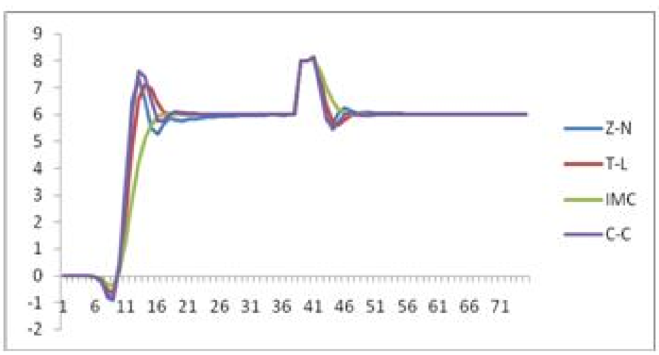

Figure 5.3 comparing the response of regulatory curve

In fig 5.3: denotes the regulatory process and its corresponding response for non-linear level control process, various tuning methods were utilised to find the efficient result.

V. CONCLUSION

Thus the controller has been designed for the single conical tank level control system. Implementing the simulated parameter for the real time controller yield the optimal control for the process. In this system response, internal model controller method gives the optimal output with a reduced error and stable steady state response. Even if any disturbance occurs across a process area its effect is nullified by using the SERVO and REGULATORY methods as we have implemented here.

REFERENCES

[1] G. O. Young, M. Janaki , G. Lathajeyanthi , E. Kesavan , J. Arulvadivu, "Design Of PI Controller For Conical Tank system'', Karpagam Journal of Engineering Research (KJER) IEEE Sponsored International Conference on Intelligent Systems and Control (ISCO'15), Vol - 2, issue - 2.

[2] J. Selvakumar, M. Dhayanithi, S. Ruthapathy, S. Ramachandran, "The Optimum Controller Design for a Level Process'', International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol - 4, Issue - 12, December 2015..

[3] Aravind, M. Valluvan, S. Ranganathan, "Modelling and Simulation of Non Linear Tank'', International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol - 2, Issue - 2, February 2013.

[4] Pushpaveni, S .SrinivasuluRaju, N. Archana, M. Chandana ,"Modelling and Controlling of Conical tank system using adaptive controllers and performance comparison with conventional PID'', International Journal of Scientific & Engineering Research, Vol - 4, Issue - 5, May-2013.