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Level Control of Non Linear Tank Process Using Different Control Technique

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ABSTRACT: PID controller plays very important role in many process control industries. In this paper Ziegler-Nichols controller, Tyreus and Luyben controller, Cohen Coon controller are used to control the level of the conical tank. The controller is designed based on the mathematical model of the system. Non-linear variation is exigent in conical tank because of some of the awkwardness compared to linear system based on analysis, non-linear system is preferred by number of industries. For disposal of solid material non-linear is the system will be best supporter for controller used for conical tank. In this work, a non linear tank process is identified as first order plus dead time model and identified model is used for controller implementation. The closed loop response of process system is obtained using MATLAB simulink. Based upon obtained results and time domain specifications best tuning PID controller parameter is highlighted.

KEYWORDS: Non linear tank, Level process, PID controller, Control System

I. INTRODUCTION

Each and every industry phase the flow control and level control problem. So that canonical tank level process is used. Canonical tank level process is used. Canonical tank is the highly non-linear system. Because of this, reason sometimes output may be affected. Due to its shape, the conical tank is lead to non-linearity control of conical tank is the challenging problem so many researchers have been carried out in the level control of conical process. S. M. Giri Raj kumar, K. Ramkumar, Sanjay Sharma [1] explained Ants colony optimisation in level control of conical tank. N.S. Bhuvaneswari, G. Uma , T.R. Rangaswamy[2] carried out experiments in conical tank level control using Neural Network controllers. Swati Mohanty[3] designed Model Predictive Controller for floatation column . Artificial Neural Controllers are designed by Rahul Shridhar, Douglas. J. Cooper [4]. Unconstrained multivariable Tuning was proposed by R. Shridhar, D. J. Cooper [5]. The detailed description of designing MPC is explained by E. F. Camacho, Carlos Bordons[6].Conical Network modelling and multivariable Model Predictive tank is used in various process industries, food and packaging section, chemical industry, coal & mine industry and waste water management.

In process control industry, control of the level is very important one. Fluid level in the tank must be controlled. This is achieved by controlling the input flow into the tank. For maintaining the level in the tank, the inflow and outflow must be maintained. Proportional controller, which has more offset and error values more accuracy will not take place in this controller and take more time for settling. To reduce the offset in the process PI controller is used. It takes enormous time for achieving the set point. To reduce the time taken to reach the set point in process PID is used. PID used to reduce the oscillation, and eliminate the offset. In this tuning method, PID controller for different process based on dead time and the different order process with dead time. PID controller is common feedback controller component used for controller system. Anticipate the future error by the derivative action. In this work, control technique is deals with conical tank using Z-N tuning setting. Z-N gives better performance in tracking the set point and load changes with faster settling time.

II. SYSTEM IDENTIFICATION

A. Modelling

Mathematical modelling is used to describe the process in mathematical manner. Here, mathematical model of the level process is shown in figure 1.

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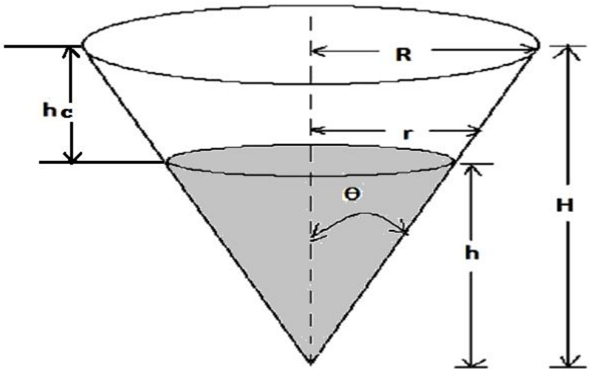

Figure:1: Schematic diagram of conical tank

The area of the conical tank is given by, A=π r² (1)

Tan =r/h=R/H (2)

r=R *h/H

According to law of conservation of mass,

Inflow rate - outflow rate = accumulation (3)

Fin - Fout =A (dh/dt) (4)

Fout=k√h (5)

Where k is the discharge coefficient

Subs 5 in 4, we get

Fin - k√ h =A (dh/dt dh/dt = (Fin - k√h)/A (6)

Where, dh/dt-rate of change of height

Therefore,

$$A = (\pi * R^2 * h^2)/H^2$$

Substituting the value of A in equations, we get

Fin – Fout =1/s [Adh/dt +h(2*π*R²*h*1/H²)*db/dt] (7)

The above Equation describe the mathematical model for single conical tank level process, this equation is implemented in MATLAB Simulink. The basic method of identifying the system is step response method. A step change in inlet flow rate represents a process as first order transfer function with dead time.

$$G(s) = \frac{K_p e^{-\tau_d(s)}}{\tau s+1} \quad (8)$$

Where K is the process gain; τ is the first order time constant; τ_d is the dead time

Table.1: Operating parameters of the process tank

Parameter	Description	Value
Fin	Max. Inflow rate of tank	400LPH
K	Value co-efficient	55cm^2/s
H	Total height of the tank	73 cm
R	Top radius	19.25cm

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III. CONTROLLER TUNING METHOD

In this work, a conventional tuning is performed Ziegler-Nichols based PID controller setting and the performance is compared with CC and TL based PID controller. Specific tuning parameters are used for PIDcontroller. Some of the tuning methods are Ziegler Nichols method, and Tyreus-Luyben method, Cohn coon method.

A.Ziegler Nichols Method

This method was proposed by john G.ziegler and Nathaniel B.nichols. This popular method is frequency response analysis of the process; it is also known as ultimate gain method. Loop of this Ziegler Nichols closed loop.controlleris placed in this loop. By adjusting the gain of control system, ultimate gain (k_u) can be measured and oscillation period also measured in terms of (p_u) ultimate period. After measuring the ultimate gain and oscillation period values are noted. By using this $k_{u,}p_u$ value -$t_{r,}t_{s,}$peak overshoot can be determined easily.

Table. 2. Ziegler-Nichols Tuning formula

Types of Controllers	**Parameters**		
	K_C	T_I	T_d
PID	$K_U/1.7$	$P_U/2$	$P_U/8$

B.Cohen –Coon Method

In this method the process reaction curve is obtained first by applying an open loop test and then the process dynamics is approximated by a first order plus dead time model. This method is used when big delays are found in real time process. One of the disadvantage of Cohen - Coon method is that the resulting closed loop system is often more oscillatory than the desired signal.

Table. 3. Cohen-Coon tuning formula

Types of Controllers	**Parameters**		
	K_C	T_I	Td
PID	$\frac{1}{K_m}\frac{\tau_m}{d}(\frac{4}{3}+\frac{d}{4\tau_m})$	$d\frac{32+6d/\tau_m}{13+8d/\tau_m}$	$d\frac{4}{11+2d/\tau_m}$

C.Tyreus Luyben's Method

It is similar to the Ziegler-Nichols method. The Tyreus and Luyben's tuning method Luyben and Luyben (1997) is based on oscillations as in theZiegler-Nichols' method, but with modified formulas for the controller parameters to obtain better stability

Table. 4. Tyreus-Luyben's Tuning formula:

Types of Controllers	**Parameters**		
	K_C	Ti	Td
PID	$K_u/2.2$	$2.2p_u$	$P_u/6.3$

IV. COMPARATIVE CONTROLLER ANALYSIS RESULTS

Application and analysis of closed loop system is performed by implementing values available in table 5. PID controller setting values are calculated using the tuning formulas and values are shown in table 5.

Table 5. Obtained PID Values

Tuning Method	**Kc**	**Ki**	**Kd**
Z-N	48.23	16.31	35.054
T-L	37.27	2.91	34.36
C-C	49.56	9.16	37.866

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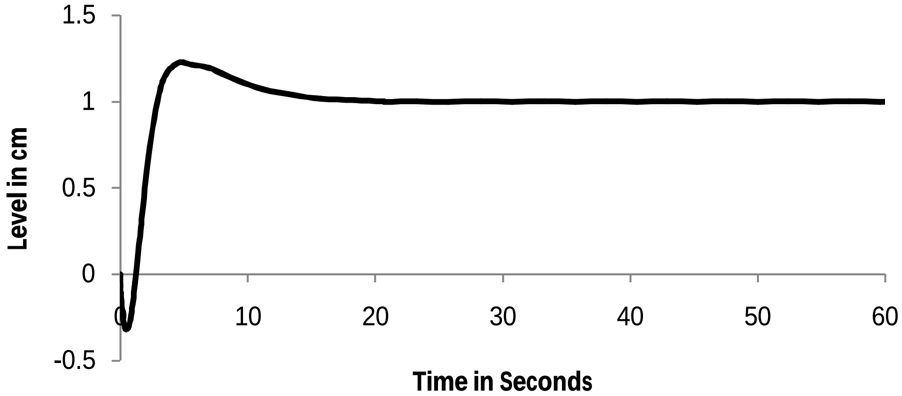

Figure 2.Simulated Closed Loop Response for CC-method

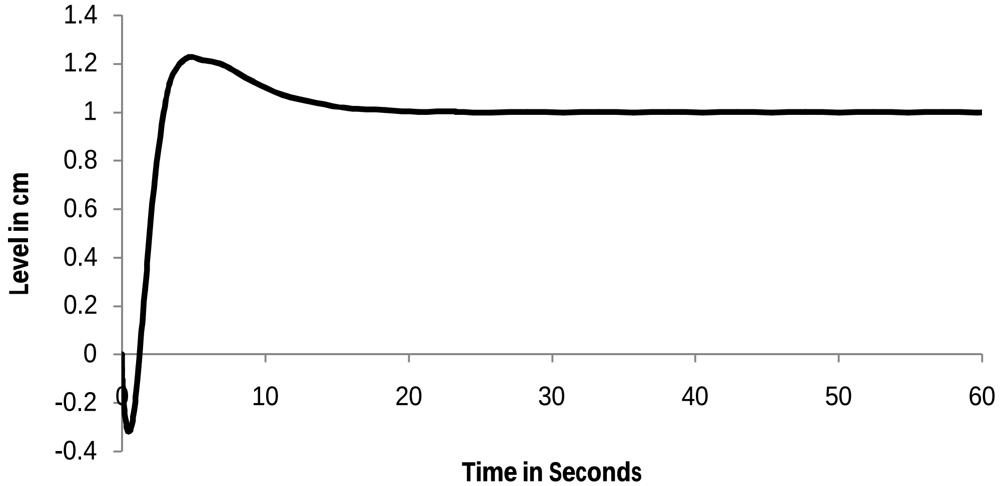

Figure 3. Simulated Closed Loop Response for T-L method

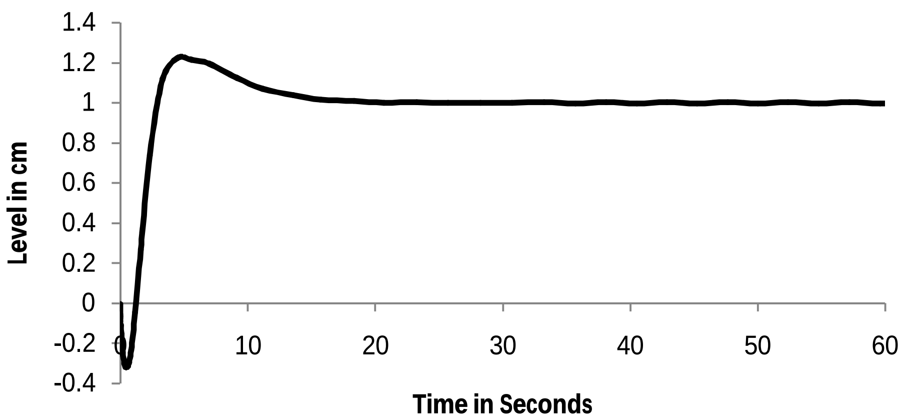

Figure 4.Simulated Closed Loop Response for Z-N Method

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Table 6: Comparison of Time Domain Specification:

Tuning Method	Settling Time (sec)	Rise Time Tr (sec)	Peak overshoot (sec)
Z-N	17.1	0.7	28.6
T-L	43	3.1	18.7
C-C	22	1.6	21.8

By comparing these three methods closed loop response and time domain specifications of different controller settings are shown in figure 2, 3, 4 and table 6. Ziegler-Nichols based tuned PID controller settings method is identified as the best method based on time domain specifications. Because in this method the response get settled as soon as. That is these methods get less rising time and peak overshoot while compared to other two methods.

V. CONCLUSION

This paper has demonstrated a number of PID controller tuning methods being used to tune a Level controller for a nonlinear tank process. The obtained results confirmed that the Ziegler-Nichols method has less oscillation compared with T-L, C-C method and yield better response. The simulation responses for the model reveals the efficiency of the Ziegler-Nichols method in provision of time domain specifications by achieving minimum settling time and no overshoot. Hence from the above results it is concluded that Ziegler-Nichols method to be an improved choice for the Liquid level control of process tank than other PID controllers.

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