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DESIGN OF PID CONTROLLER FOR LEVEL LOOP

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Abstract

Liquid level control is most widely used in diverse processes industries. The key issue in level control system is liquid level control mechanism. In this paper control of liquid level using PID controller is presented. We have developed a system which adjusts the liquid level without human intervention, according to set point. The parameters of PID controller were adjusted automatically. The model presented here meets the precise demand of liquid level system; the accuracy of model is 87.84 %. It is more accurate for controlling the liquid level.

Keywords:PID controller, Tuning of PID, Water level control,Level loop control

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1. Introduction

Controlling the liquid level is a significant parameter in most process industries. The PID algorithm is most frequently used to control various types of the processes. Concerning the safety in production and quality of products, efficiently and timed control of liquid level is necessary. Objective of the proposed system is to control the liquid level of water tank at preferred set point. The liquid level control of tank is major problem in process industries. Normally process industries pumps and stores the liquid in tank; which is then used for further processing. Hence, it becomes necessary to control the liquid level of tank.

Proportional Derivative Integral controller is influencing controller mode. In 1910 the PID Controller was invented and the Ziegler-Nichols (Z-N) tuning method was invented in 1942 [1]. Now days PID controller is most frequently used in chemical and several manufacturing industries to control various processes. PID plays vital role in liquid level control mechanism. PID controls level according to preferred set point. One can change the set point on the fly during level loop. This paper considers design of PID controller for liquid level tank.

The paper is organized as follows.The related work is presented in section 2. The mathematical model for level loop is mentioned in section 3. Section 4 presents with the designing of PID controller and its mathematical model. The experimental results are shown in section 5.

2. Literature Survey

There are various methods used to tune the PID controller to find appropriate values of the parameters.

Our system objective is to design PID controller to maintain the level in tank according to the set point value. The model considered to develop the system is as shown in figure 1. Mostafa A. Fellani [6] et. al. has used PID, P, PI controller to manage/maintain the liquid level at one specific level. They used MATLAB for the simulation, and they compared the dynamic characteristics like Rise time, settling time, steady state error and overshoot of each controller with PID. Miral Changela, Ankit Kumar [7] in their paper presented water level control for two tank model. They mentioned that the liquid level in tank and flow between the tanks is more important in the process modelling. They compared the performance of PID controller with fuzzy controller for their systems. PID controller and fractional order PID controller is used by S. Janarthanan [8] et. al. in their work. They presented different tunning methods to find the parameters of PID. Anca Maxim [9] et. al. proposed model based on multivariable process. Internal Model Controller (IMC) controller is used for Multiple Input Multiple Output (MIMO) system. Hur Abbas [12] et. al. proposed operational model for coupled tanks. A non linear model of SISO system is developed and simulated using MATLAB.

3. Mathematical Model of System

Figure 1 show the liquid level system which contains following parameters.

Process Parameters:

A = Cross sectional area of tank (cm^2)

h = Water level (cm)

Q_{in}= Inlet flow rate

Q_{out} = Outlet flow rate

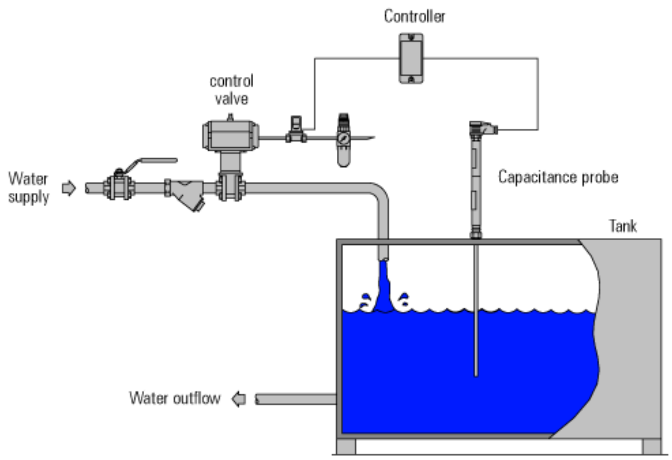


Figure 1. *Liquid level loop*

Modelling Process:

$$\begin{bmatrix} \text{Time Rate of} \\ \text{Change} \\ \text{of Mass into the system} \end{bmatrix} = \begin{bmatrix} \text{Rate of} \\ \text{Mass in flow} \end{bmatrix} - \begin{bmatrix} \text{Rate of} \\ \text{Mass Out flow} \end{bmatrix}$$

$$\rho A \frac{dh}{dt} = \rho Q_{in} - \rho Q_{out}$$

$$A\frac{dh}{dt} = Q_{in} - Q_{out} \quad \dots\dots\dots(1)$$

Since

$Q_{out} = \frac{h}{R}$

$$R\frac{dh}{dt} = RQ_{in} - h$$

Put $T = AR$

$T\frac{dh}{dt} = RQ_{in} - h$

Taking Laplace transform

$TSH(S) + H(S) = RQ_{in}(S)$

$$\frac{H(s)}{Q_{in}(s)} = \frac{R}{1 + TS} \dots\dots\dots(2)$$

Equation (2) gives model equations.

4. Design of PID controller

Process Parameters

A = 7.5 m^2

R = 1

T = AR = 7.5

$$G(s) = \frac{1}{1 + 7.5S}$$

Ziegler Nichols Method is used for controller setting which is based on adjusting closed loop until steady state oscillations occur [3]. By Using Z-N Method

$$G(s) = \frac{K_p}{7.5S + 1 + K_p}$$

And

$$W_{cp} = 7.5$$

Following are the parameters of PID controller

$$K_p = 0.6, \ T_i = 0.41, T_d = 0.10$$

5. Results and Analysis

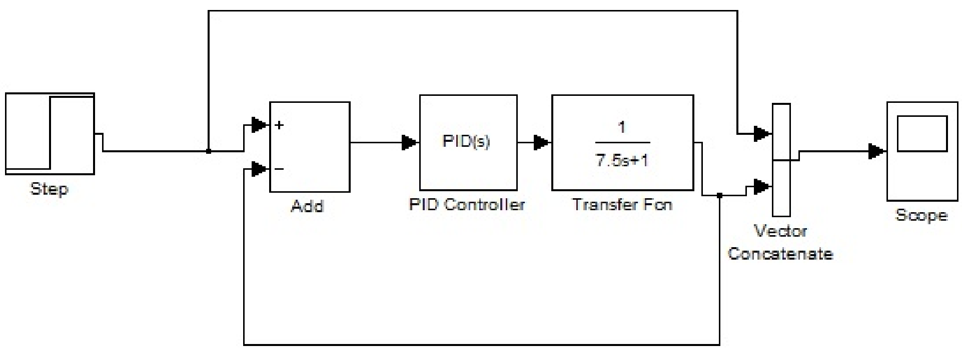


Figure 2. *Simulink model of system*

The Simulink model of single tank water level control system using PID controller for obtaining the step response is mentioned in figure 2. Here the Z-N method is used find the PID parameters. Transfer function in this system represents the mathematical model of single tank system.

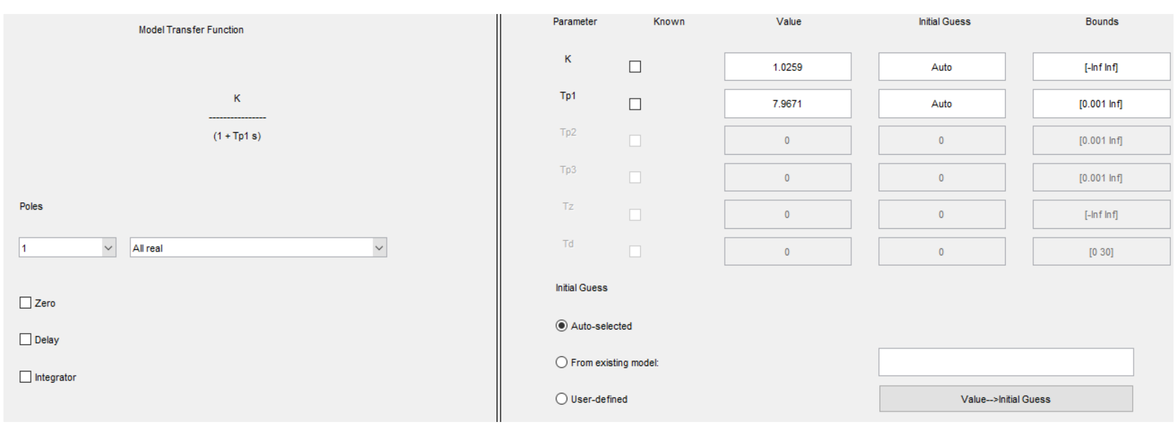
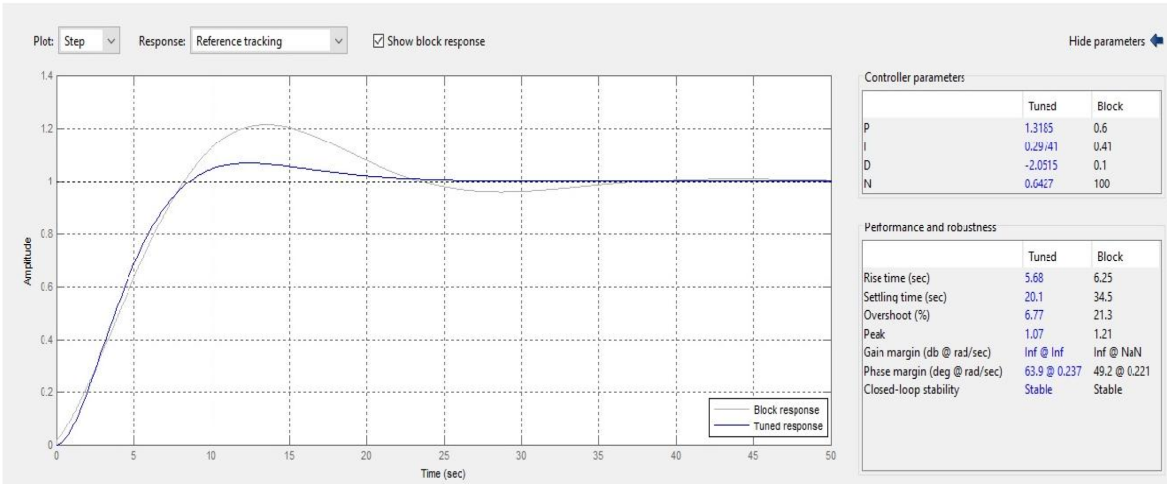


Figure 3. *Model by parameter estimation*

Simulation results of liquid level control system with PID controller are shown in figure 3.



Mathamatical model of level loop is calculated by using MATLAB.

Figure 4. *PID Controller parameters for Sp=250*

Figure 4 shows tunned and block parameters of PID controller for the set point 250. The performance parameters like rise time, settling time, overshoot, gain margin and closed loop stability etc were also mentioned in figure 4.

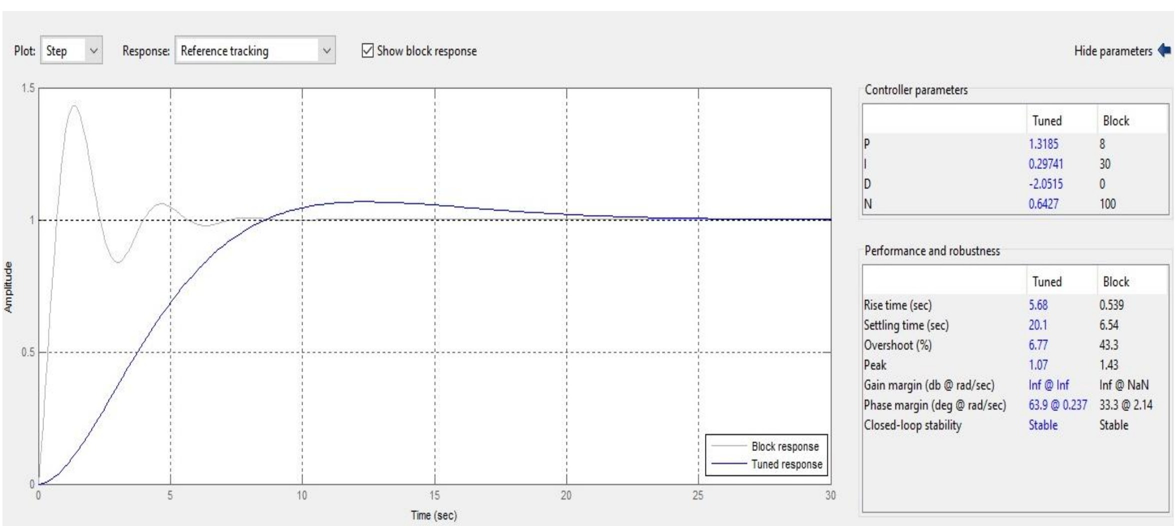


Figure 6. *PID Controller parameters for Sp=300*

For single tank system set point is 300 & flow rate is 600 LPH. Response time 8.4 Sec. The figure 6, Shows controller parameters for set point 300 of actual level system.

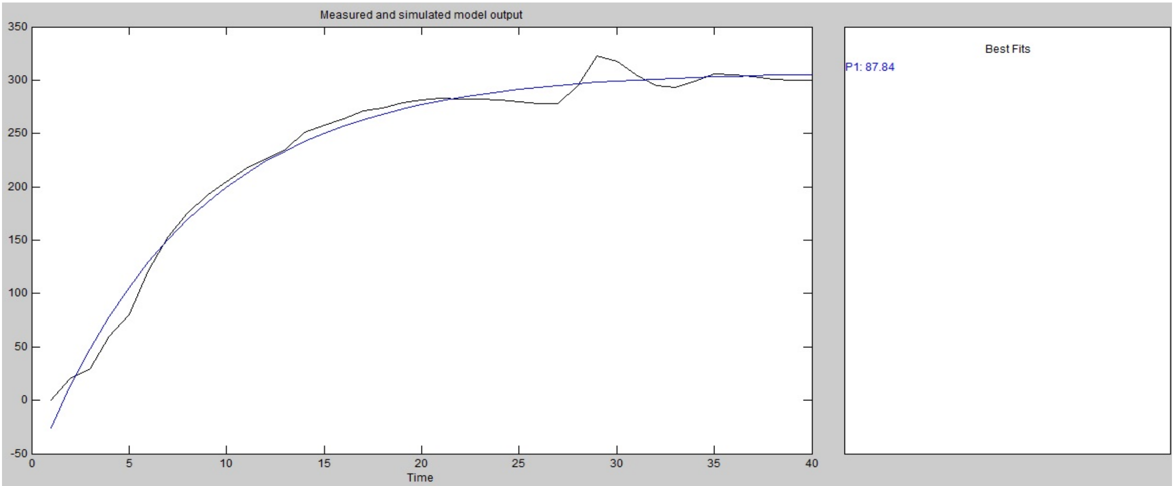


Figure 7. *Measured & Simulated output*

Figure 7 shows response of best fit for designed system. This is obtained by using MATLAB identification tool box. The obtained best fit results are obtained from practical values.

6. Conclusion

The Theoretical model for liquid level control system is obtained by mass balance equation. PID controller designed for the same system and for tunning Zeigler Nicholas method is used. Simulated model parameters obtained by MATLAB. Results are obtained for various set points. The parameters by simulation and by calculation are nearly same. Hence for varying set point PID controller is most efficient which provides good response time. The model gave us 87.84 % best fit.

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