ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

Design of Tunned PID Controller for 2-Tank System

Sabah Abd Elmonem[1], Muawia Mohamed Ahmed Mahmoud[2]

P.G. Student, Department of Control Engineering, AL Neelain University, Faculty of Engineering, KH, Sudan[1]

Associate Professor, Department of Control Engineering, AL Neelain University, Faculty of Engineering, KH, Sudan[2]

ABSTRACT: This paper discusses the mathematical modelling of the two tank system and it performance. The performance was checked using the step response. A PID controller was added to the system to PID controller improve its performance. The PID coefficients were selected based on trial and error method. Good results were obtained.

KEYWORDS: PID Controllers, Coupled tank, liquid level control.

I. INTRODUCTION

In many industrial process applications the liquid level control is of much importance especially in oil and gas industries, waste water treatment plant and food processing industries. Two tank systems relate to liquid level control problems generally existing in industrial surge tanks [1].

Proportional Integral Derivative (PID) controllers are widely used in industrial practice since last six decade. The PID controllers helps to get our output (velocity , temperature , position) where we want it , in a short time, with minimal overshoot, and with little error. It also the most adopted controllers in the industry due to the good cost and given benefits to the industry [2, 3].

The PID controllers function is to maintain the output at a level that there is no difference (error) between the process variable ant the set point in as fast response as possible. Some of the controllers with their mathematical equation are as follows:

Proportional Controller: In a controller with proportional control action, there is a continuous linear relation between the output of the controller m (manipulated variable) and actuating error signal e.

Mathematically $m(t) = K_p\, e(t)$ (1)

Where K_p is known as proportional gain or proportional sensitivity.

Integral Controller: In a controller with integral control action, the output of the controller is changed at a rate which is proportional to the actuating error signal e (t) [2].

Mathematically $d/dt\, m(t) = K_i e(t)$ (2)

Where K_i is a constant.

Derivative Controller: In a controller with derivative control action the output of the controller depends on the rate of change of actuating error signal e [2].

Mathematically $m(t) = K_d\, d/dt\ e(t)$ (3)

Where K_d is known as derivative gain constant.

A PID controller is a controller that includes the proportional element, “P element”, the integral element, "I element” and the derivative element, “D element” [4].

Defining $u(t)$ as the controller output, the final form of the PID algorithm is [4]:

$$u(t) = mv(t) = K_p\, e(t) + K_i e(t) + K_d\, d/dt\ e(t) \quad (4)$$

Where:

K_p : Proportional gain, a tuning parameter

K_i : Integral gain, a tuning parameter

K_d : Derivative gain, a tuning parameter

e: Error = SP− PV

t: Time or instantaneous time (the present)

ISSN: 2319-8753
International Journal of Innovative Research in Science, Engineering and Technology
(An ISO 3297: 2007 Certified Organization)
Vol. 3, Issue 11, November 2014

mv: Manipulated variable
The figure 1 shows the simple structure of a PID controller [4].

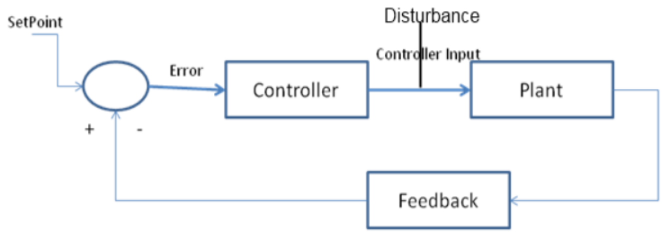

Fig.1PID Controller Structure

II. 2-TANK PID DESIGN METHOD

Before starting the process of designing the controller until the system works correctly, we need understand a lot of mathematical equations that govern the system. In this system nonlinear dynamic model are observed .Four steps are taken to derive each of the corresponding linearized perturbation models from the nonlinear model .These steps will be generally discussed in this topic .figure 2 shows the schematic diagram of coupled tank system that been used [5].

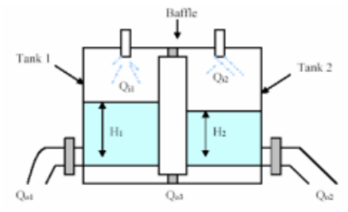

Fig. 2Schematic Diagram of Coupled Tank System

After the conclusion of a lot of mathematical equations, understood and compensation parameters that describe the system of equations in the transfer function has been inferred that the tank control system and the compensation in the following equations:

$$(T_1 s + 1)\, h_1(s) = k_1 q_1\,(s) + k_{12}\, h_2(s) \qquad (4)$$

$$(T_2 s + 1)\, h_2(s) = k_2 q_2\,(s) + k_{21}\, h_1(s) \qquad (5)$$

For the second order configuration that shows in h_2 is the process variable (PV) and q_1 is the manipulated variable (MV) [1, 5]. Case will be considered when $q_2$zero is [1, 5]. Then, equation and will be expressed into a form that relates between the (MV), q_1 and the (PV), h_2 and the final transfer function can be obtained as [5],

$$\frac{h_2(s)}{q_1(s)} = \frac{k_1 k_2}{(T_1 s+1)(T_2 s+1) - k_{12} k_{21}} \qquad (6)$$

$$= \frac{k_1 k_2}{T_1 T_2 s^2 + (T_1 + T_2)s + (1 - k_{12} k_{21})}$$

Table1: Parameters Values

T_1=6	T_2=6	K1=0.2	K2=0.2	K12=0.7	K21=0.7

By using the value that has been obtained from T1, T2, K1, K2, K12 and K21 and put it in equation the value of transfer function become [5]:

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

$$TF = \frac{(0.2)(0.2)}{(6)(6)s^2 + (6+6)s + [1-(0.7)(0.7)]}$$

Then, the transfer function will become,

$$TF = \frac{0.04}{36s^2 + 12s + 0.51}$$

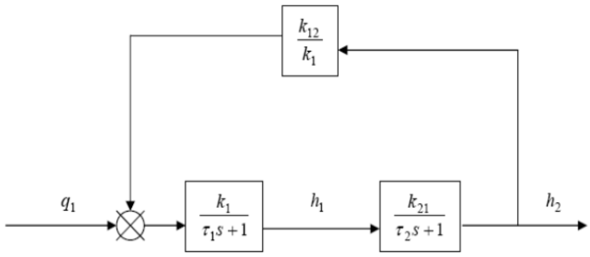

Fig. 3Block Diagram of Second Order Process for Coupled Tank System

III. PARAMETERS TUNING

According to the trial and error method used above and referring to this effect of each parameter in response characteristics such settling time, rise time, and steady state error. The parameters value chosen as: K_d=2, K_p=12, K_i=1 are found to achieve the best performance. This is shown in table2, 3, and 4.

Table2: characteristics of coupled tank system without PID

Settling time	82.1 sec
Rise time	45.1 sec
Steady state	0.0784

Table3: characteristics of coupled tank system with unity PID

Settling time	185 sec
Rise time	22.8 sec
Steady state	1

Table4: Characteristics of Coupled Tank System with PID Tunning

No. of trial	K_d	K_p	K_i	Settling time	Rise time	Steady state final value	Over shoot %
PID Trial 1	7	12	2	90.4 sec	14.9 sec	1	30%
PID Trial 2	10	20	5	122 sec	8.83 sec	1	50%
PID Trial 3	2	12	1	80.8 sec	23.3 sec	1	10%

IV. RESULTS

The following figures show the simulation results of the control system in coupled tank. Figure (4) which represent the system response before adding the controller shows some problems in the system performance. As shown there is a series problem in its steady state final value. A big steady state error of about 92% occurs. This is an unacceptable performance and should be altered.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

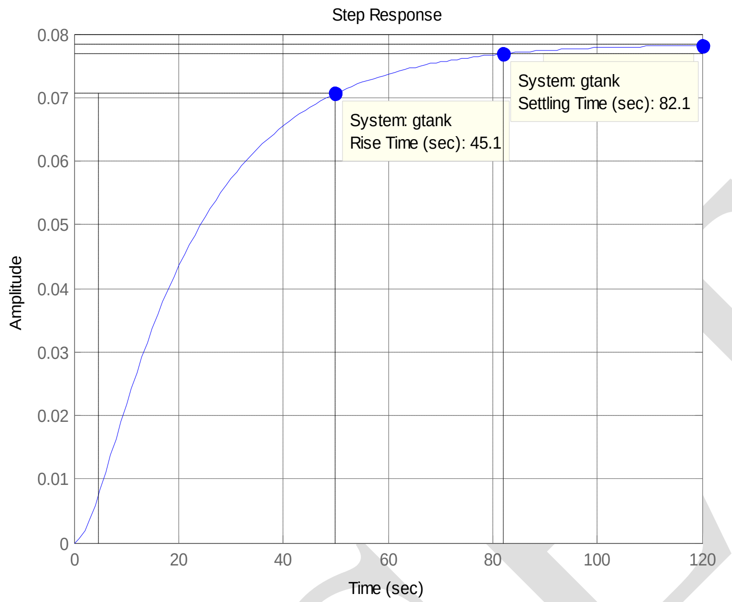

Fig. 4 Characteristic of Coupled Tank without Controller

When adding a PID controller with unity coefficient for K_p, K_d, K_i, the performance of the system tends to have a better performance as shown in figure (5), especially in removing the steady state error.

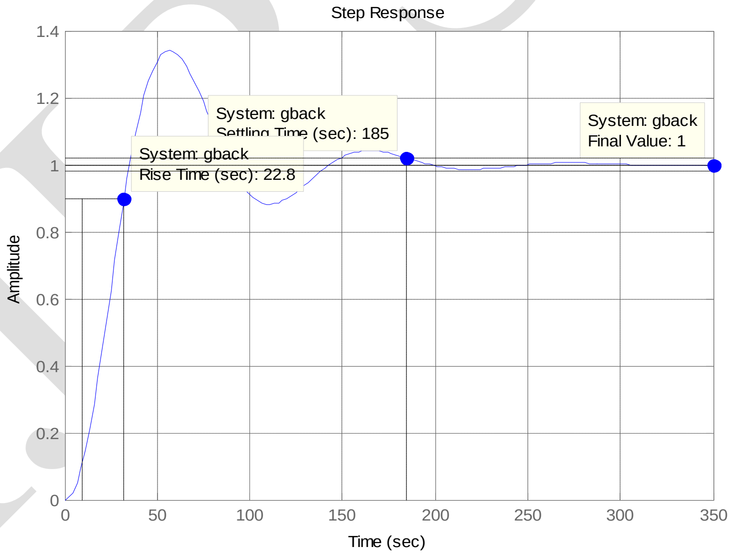

Fig. 5 Characteristic of Coupled Tank with unity PID Controller

To obtain better performance the coefficient of the controller parameters should be changed. Figure (6) shows the system response when K_p, Ki, K_d equal to 12, 2, 7 respectively.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

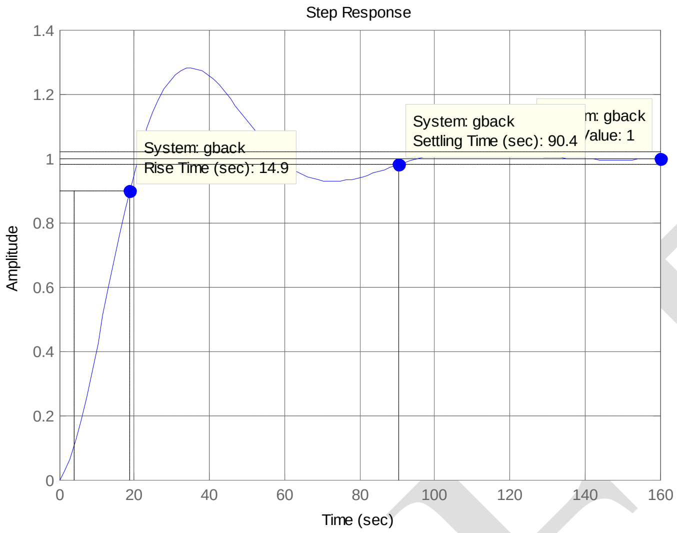

Fig. 6 Characteristic of Coupled Tank with PID Controller

Figure 7 shows the performance of PID controller when the proportional gain is set equal to 20, integral gain is set equal to 5 and derivative gain is set equal 10.

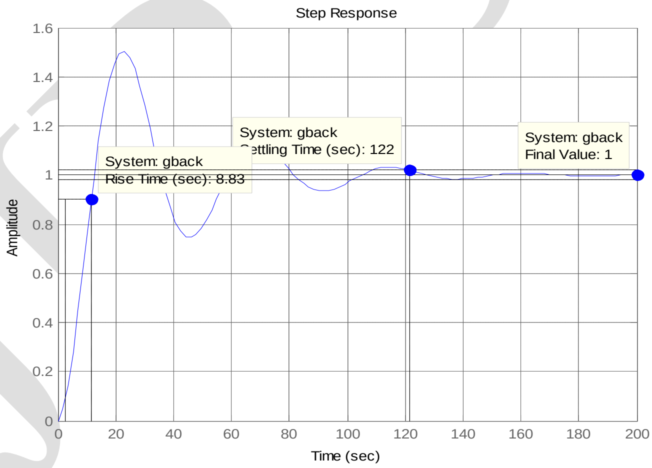

Fig. 7 Characteristic of Coupled Tank with PID Controller

Figure 8 shows the performance of PID controller when the proportional gain is set equal to 12, integral gain is set equal to 1 and derivative gain is set equal 2. To achieve the desired performance the designer of the control system can change the controller parameters until the desired state is obtained.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

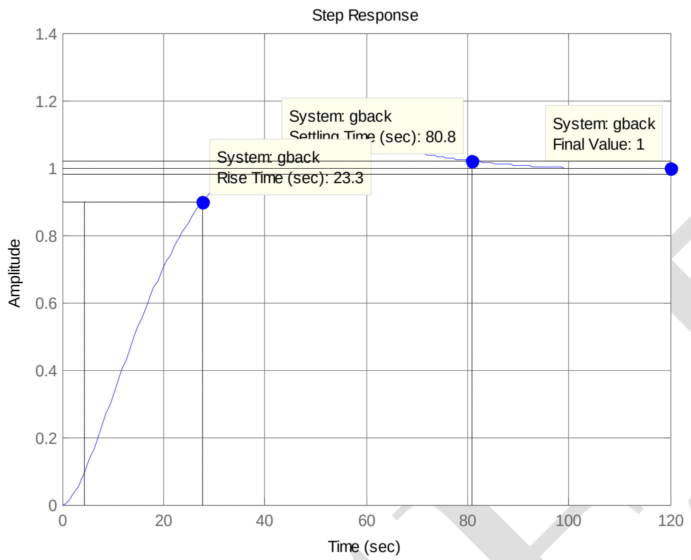

Fig. 8 Characteristic of Coupled Tank with PID Controller

V. CONCLUSION

The two tank system was mathematically modelled and its transfer function was found. The transfer function was tested using the step response to evaluate its performance characteristics namely settling time, rise time, steady state, and overshoot. Generally, these characteristics were fair and somehow unfair such as steady state error. The PID controller was known to be the suitable solution to overcome the problems of these characteristics. The coefficients of the PID should be chosen properly to obtain the required performance. In this paper the trial and error method was used of find the best performance by changing the controller parameters. The coefficients use have shown better performance. So this method can be followed to obtain better performance.

REFERENCES

[1] P.Srinivas[1], K.Vijaya Lakshmi[2], and V.Naveen Kumar[3], “A Comparison of PID Controller Tuning Methods for Three Tank Level Process”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol.3Issue 1, January2014.

[2] [1]Pawan Kumar Kushwaha, and [2]Viond Kumar Giri, “PID Controllers for Water Level Control of Two Tank System.”, VSRD International Journal of Electrical, Electronics & Communication Engineering, Vol. III Issue VIII August 2013.

[3] Terry Bartelt, “Industrial Control Electronics, Devices, Systems and Applications.”2006.

[4] Maria Joao Mortag ua Rodigues, “PID Control of Water in A Tank”, Bachelor’s Thesis in Electronics, June 2000.

[5] Mohd Izzat “Implementation of PID Controller for Controlling the Liquid Level of the Coupled Tank System” UNIVERSITI MALAYSIA PAHANG, 2008.

[6] Katsuhiko Ogata," Modern Control Engineering ", Prentice-Hall, Inc., 1997.