Parameter Estimation For Liquid Level System

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***Abstract* – PID controller are widely used in process industries. Most of industrial processes are controlled by PID regulators due to its simple structure and robustness to the modeling errors. PID controllers are widely used to control industrial processes that are mostly open loop stable or unstable. Proper Selection of feedback structure and controller tuning that helps to improve the performance of the**

Loop. Poor tuning of PID controller can lead to mechanical wear associated with excessive control Activity, poor control performance and even poor quality products. In this paper we used Liquid level system and find model using Evolutionary techniques. Here, We present results with theoretically and practically.

Keywords – *PID controller, Real time Liquid level system, Evolutionary techniques.*

I. Introduction

PID controllers are still widely used in industrial applications despite continued advancement in control technology. Most of the industrial loops are controlled by PID regulators due to their simple structure which is easy to be understood by the engineers who design it. The algorithm provides adequate performance in the vast majority of applications. According to a survey conducted by Japan electric measuring instruments manufacturers association in 1989, 90 percent of the control loops in industries are of PID type and small portion of the control loops works well. Also survey by ender indicates 30 percent of the controllers are operated in manual mode and 20 percent of the loops use factory tuning. It means that PID controller is widely used but poorly tuned. Poor tuned can lead to mechanical wear associated with excessive control activity, poor control performance and even poor quality products.

The PID controller tuning is method of computing the three control parameters Proportional gain, Derivative time and Integral time, such that the controller meets desired performance specification (Fig 1).

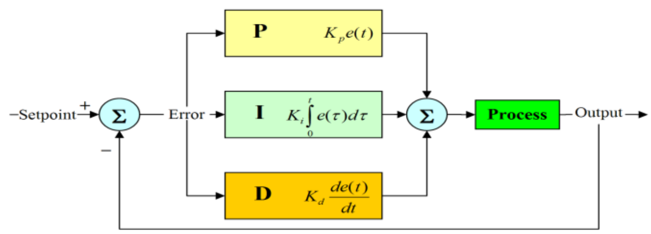

Figure 1. A Simple PID controller

In the second section, description of Liquid level system with its instruments. In the third section, Model identification using Evolutionary techniques and find results both theoretically and practically. Practically result find out with two methods first set outlet valve 100% closed and then after set outlet valve 50% closed. We also provide the comparison of between these two results. In the fourth section, Comparison in Results of Both Theoretically and Practically Value. In the fifth section, Conclusion.

II. Description of the Liquid level System

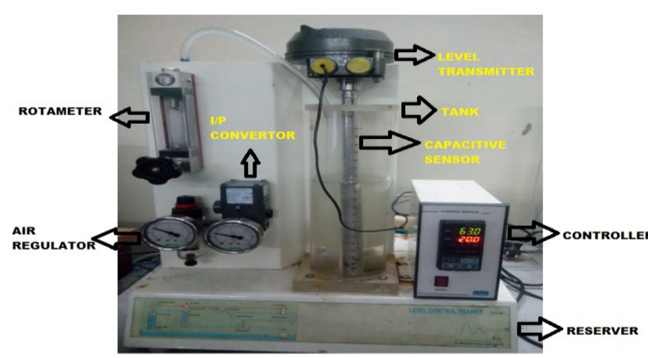

Figure 2. Liquid Level System

This is the Real Liquid Level System in our Lab. Its detailed Process Diagram given below.

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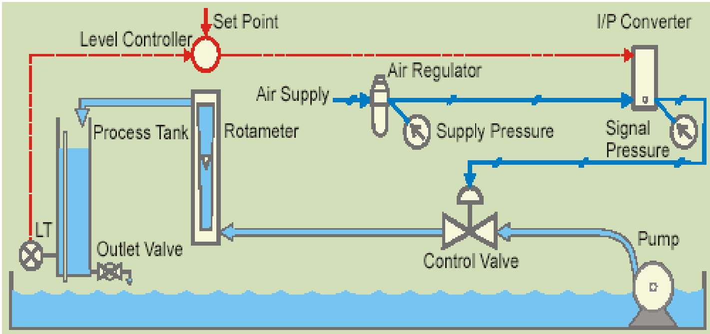


Figure 3. Process diagram of Liquid Level System

Level control trainer is designed for teaching the basic level control principles. The process setup consists of supply water tank fitted with pump for water circulation. The level transmitter is fitted on transparent process tank senses level in the tank and transmits the signals to interfacing unit/control module. The output of interfacing unit/control module is connected to I/P converter. A pneumatic control valve adjusts the water flow in to the tank to control the level. The process parameter (Level) is controlled through computer or µp controller by manipulating control valve.

In this trainer, PID control action is adjusted through software by computer as well as by digital indicating controller. The computer is connected to controller through communication port in supervisory mode.

III. Model Identification Using Evolutionary Techniques.

Different researchers say's that the Open loop system is Integrating or Non-self regulating. but they are not proof these results with the help of Theoretically and Practically. Here, We used two Different methods and getting the results.

Dynamics of Single Tank System:

Single Tank System have One Input and One Output. Here, Input taken from the Control valve and Output given to the Outlet Valve. So, the equation of single tank System given below,

Inflow – Outflow = Accumulation in the Tank

$$\boxed{q_i - q_o = A\, dh / dt}$$

Where, $A = \pi r^2$ (Cross sectional Area)

q_i = Inflow Through the Control Valve

q_0 = Outflow to the Outlet Valve

h = Height Of the Tank

1) Simulation and Results of open loop Single tank system Theoretically:

Here, we give Open loop simulation of single tank system with theoretically. For find out the theoretically value of A (cross sectional area of Tank). We measure the Diameter and Height of the Tank. and based on these two value we find out the open loop simulation of single tank system theoretically.

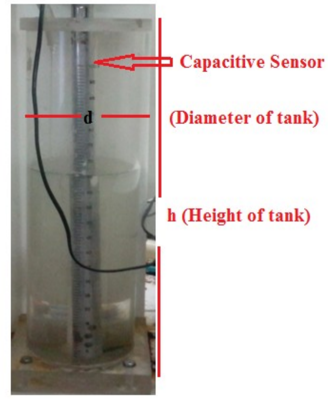


Figure 4. Process Tank

Diameter of Tank d = 9 cm

Height of Tank h = 0-100%

Theorically equation,

$$A = \pi r^2 \quad \text{------------- (1)}$$

r = (d/2)

so, r = (9/2)

r = 4.5 c.m -------------- (2)

Put eq^n (2) Value put in eq^n (1)

$$A = 3.14 * (4.5 \text{ c.m})^2$$

$$\boxed{A = 63.585 \text{ c.m}^2}$$

But in tank Capacitive sensor is also available

So , sensor diameter

d = 2 c.m

r = (d/2)

so, r = (2/2) c.m

r = 1 c.m ------------- (3)

Put eq^n (3) Value put in eq^n (1)

$$A = 3.14 * (1 \text{ c.m})^2$$

$$\boxed{A = 3.14 \text{ c.m}^2}$$

so , total A of tank

$$\boxed{A = 63.585 \text{ c.m}^2 - 3.14 \text{ c.m}^2 = 60.445 \text{ c.m}^2}$$

----------- (A)

2) Simulation and Results of open loop Single tank System practically:

Here, we give Open loop simulation of single tank system with Practically solution. For find out the practically value of A (cross sectional area of Tank). We used two different methods. First, adjusted Outlet valve fully closed and measure the value of A. then, second method we adjusted Outlet valve 50 percentage approx. and measure the value of A. So, we taken better value of A. and these two methods are given below.

I take reading with adjusted control valve 30% open and 70% close.

2.1) Simulation of Single tank system with fully closed outlet valve

Adjusted outlet valve fully closed and take reading practically,

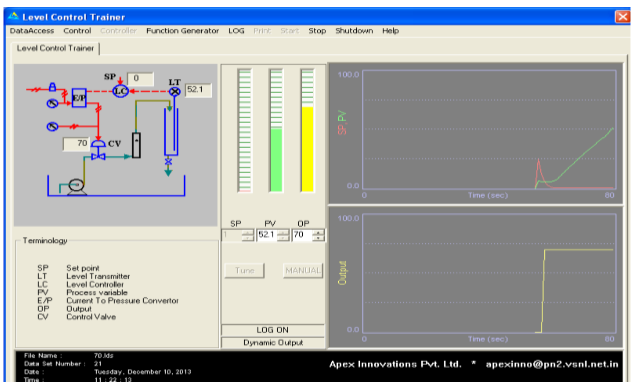
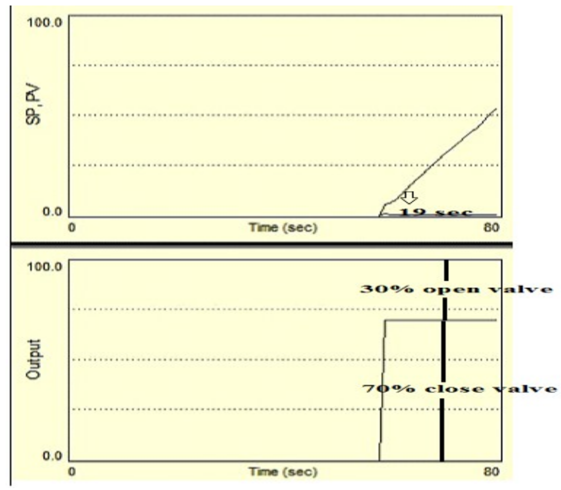


Figure 5. Level Control Trainer output with waveform (fully closed valve)

Time	Process Value	Output
11:21:19	6.3	70.0
11:21:21	6.6	70.0
11:21:24	8.4	70.0
11:21:27	10.9	70.0
11:21:30	13.6	70.0
11:21:32	**16.1**	**70.0**
11:21:35	18.7	70.0
11:21:38	21.0	70.0
11:21:40	23.4	70.0
11:21:43	26.0	70.0
11:21:46	28.4	70.0
11:21:49	30.8	70.0
11:21:51	**32.9**	**70.0**
11:21:54	35.1	70.0
11:21:57	37.5	70.0
11:21:59	39.8	70.0
11:22:20	41.9	70.0
11:22:50	43.7	70.0
11:22:80	46.3	70.0
11:22:10	49.5	70.0
11:22:13	52.1	70.0
11:22:16	54.4	70.0

Table 1. Reading of fully closed valve



Graph 1. Output waveforms of open loop System with fully closed valve

Now, Outlet Valve Fully Closed,

Time : 11: 21:51 - 32.9 %

11: 21:32 - 16.1 %

Total Time: 19 sec

$$\frac{dh}{dt} = \frac{32.9\,\% - 16.1\%}{19\ \text{sec}} = \frac{16.8\,\%}{19\ \text{sec}} \quad \text{-------------} (4)$$

To convert % into c.m

So, 100 % = 30 c. m

16.8 % = ?

$$\text{Then,}\quad \frac{16.8\,\% * 30\ \text{c.m}}{100\,\%} = 5.04\ \text{c.m} \quad \text{-------------} (5)$$

Put eq^n (5) Value put in eq^n (4)

$$\frac{dh}{dt} = \frac{5.04\ \text{c.m}}{19\ \text{sec}}$$

$$\frac{dh}{dt} = 0.2652\ {}^{cm}/_{sec} \quad \text{----------------} (6)$$

Inflow – Outflow = Accumulation in the Tank

But Here, Outlet valve fully closed so, outflow = 0

So, Inflow = Accumulation in the Tank

Inflow = A dh / dt

$A = \frac{\text{inflow (i/p)}}{dh / dt}$ (inflow reading taken threw rotameter) ----------------- (7)

Rotameter reading 58 LPH (Litter Per Hours)

To convert LPH into c.m

$\text{Inflow} = \frac{58 * 1000\ c.m^3}{60 * 60\ sec} = 16.11\ c.m^3/ sec$ ----------------- (8)

Put eq^n (8) and (6) Value put in eq^n (7)

$A = \frac{16.11\ c.m^3/sec}{0.2652\ c.m/sec}$

$A = 60.74\ c.m^2$ --------------------- (B)

2.2) Simulation of Single tank system with 50% adjusted outlet valve

Adjusted outlet valve 50 percent approx.

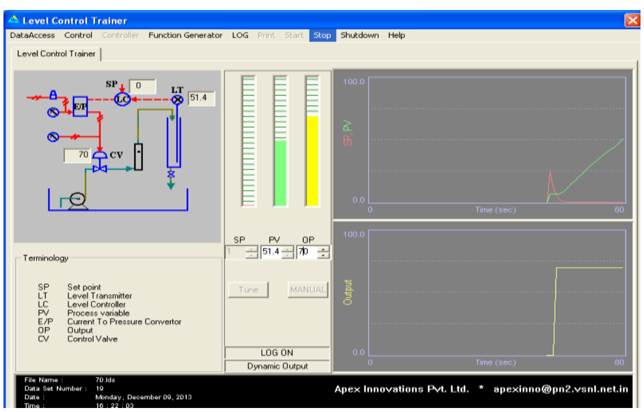
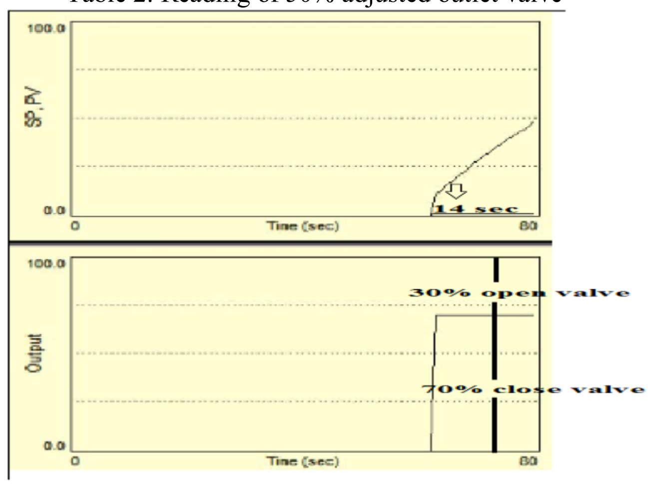


Figure 6. Level Control Trainer output with waveform (50% approx. outlet valve)

Time	Process Value	Output
16:21:14	10.9	70.0
16:21:17	13.6	70.0
16:21:20	16.1	70.0
16:21:22	18.4	70.0
16:21:25	20.8	70.0
16:21:28	23.1	70.0
16:21:30	**25.6**	**70.0**
16:21:33	28.1	70.0
16:21:36	30.3	70.0
16:21:39	32.4	70.0
16:21:41	34.8	70.0
16:21:44	**36.8**	**70.0**
16:21:47	39.1	70.0
16:21:50	41.1	70.0
16:21:52	42.6	70.0
16:21:55	44.1	70.0
16:21:58	46.3	70.0
16:22:0	49.1	70.0
16:22:3	51.4	70.0

Table 2. Reading of 50% adjusted outlet valve



Graph 2. Output waveforms of open loop System with 50% adjusted outlet valve

Now, outlet valve adjusted @ 50% approx,

1) Here, Input reading taken through rotameter.
2) But output flow has no rotameter.
3) So, I used one biker and check output flow in 1 min.

$\text{So, outflow} = \frac{48\ m.l}{60\ sec}$

Now, m.l converted into c.m

$\text{Outflow} = \frac{48\ c.m^3}{60\ sec}$ $(m.l = c.m^3)$

$\text{Outflow} = 0.8\ c.m^3/sec$ ------------------ (9)

Inflow – Outflow = A dh/dt ------------------- (10)

Put eq^n (8) and (9) Value put in eq^n (10)

$16.11\ c.m^3/sec - 0.8\ c.m^3/sec = A\ dh/dt$

$A\ dh/dt = 15.31\ c.m^3/sec$

------------------- (11)

Now, find dh / dt on table reading threw.

Time :- 16 : 21 : 44 - 36.8 %
16 : 21 : 30 - 25.6 %
Total time: - 14 sec.

$$\text{So,}\quad \frac{dh}{dt} = \frac{36.8\% - 25.6\%}{14\ sec} = \frac{11.2\%}{14\ sec} \quad \text{---------- (12)}$$

To convert % into c.m

So, 100 % = 30 c. m
11.2 % = ?

$$\text{Then,}\quad \frac{11.2\ \% * 30\ c.m}{100\%} = 3.36\ c.m$$

So, 3.36 c.m Value put in eq^n (12)

$$\frac{dh}{dt} = \frac{3.36\ c.m}{14\ sec}$$

$$\frac{dh}{dt} = 0.24\ {}^{c.m}/_{sec} \quad \text{-----------------} \quad (13)$$

Put eq^n (13) Value put in eq^n (11)

$$A = \frac{15.31\ c.m^3/sec}{0.24\ c.m/sec}$$

$A = 63.80\ c.m^2$

----------------- (C)

IV. Comparison in Results of Both Theoretically and Practically Value

After, simulation Of Open Loop Single Tank System I get,

A) **Theoretically,** Value of **A = 60.445 c.m²**

And

Practically,

B) Fully Closed the outlet Valve at that time
A = 60.74 c.m²

C) Output valve adjusted @ 50 % approx. at that time
A = 63.80 c.m²

V. Conclusion

After, Showing the Open loop System output Graph, we conclude that the single tank level system is integrating process and having Non-self Regulating nature. Integrating or Non-self regulating System is very tough to control.

Controller tuning of such system is difficult that is why many Researchers are concentrate on Model Based Controller Tuning of Integrating or Non-self regulating system.

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