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# PID Based Temperature Controller

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**Abstract:** In today's scenario temperature controlling plays vital role in most process industries. In this paper we are proposing a controller which can be used to control the temperature of a tank that is automatically tuned. Here temperature controller for water tank by using Delta PID controller is presented. The mathematical model of same is developed. The model is tested by using MATLAB software. There are many kinds of controlling mechanisms, i.e. on-off type controller, proportional controller, digital sensing mechanism, PID controller etc. Among of them, PID controller is the best known controller within affordable range. The results from Mathematical model and PID controller are verified and the results obtained were much encouraging.

**Keywords:** PID controller, proportional controller, Delta PID & Temperature control.

## I. INTRODUCTION

The PID (Proportional, Integral & Derivative) algorithm is mostly used in industry to control the various processes. It has been used since last more than 50 years. Elmer Sperry developed the PID controller in 1911 [1].
Consider the process in which liquid is flowing into the tank at some rate Fin and out of the tank at some rate Fout as shown in figure 1. The sensor is added in the system to provide controlling signal, which will control the loop. This signal is provided as an input to a Controller. The controller compares the required temperature, which is called the Set Point (SP), with actual temperature in the tank and provides an output signal to the heater.

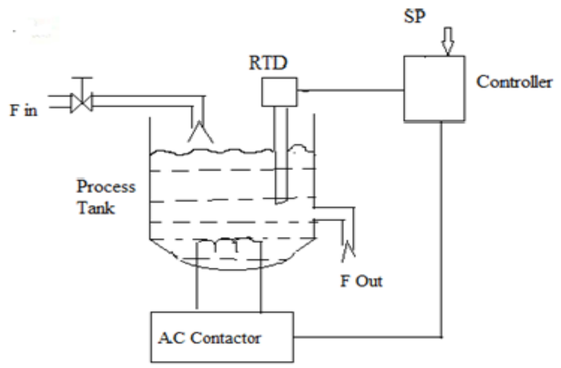


Figure 1: Temperature Control System

The main objective of the control system is to maintain the process output at specified level. The output of the process is called process variable (PV) or controlled variable (CV). The output is measured by a sensor and fed-back to the comparator via signal conditioning unit. The desired value of CV is called the reference value or the set point (SP). The output of the comparator is the error e which is the difference between SP and CV, given to the controller. Depending upon the e and its settings, controller generates output, which is actually the input for the process and is called manipulated variable (MV). The manipulated variable is generally denoted by u. As shown in the block diagram Figure, this system is having single input and single output (SISO).
The paper is organized in I to V sections. Section II, explains the details of PID controller. In section III, the mathematical model of PID controller is presented. Section IV is results.

## II. PID CONTROLLER

The PID controller is combination of Proportional, Integral & Derivative. Proportional controller considers only present error values and gives stability against small disturbance. The proportional produces output which proportional to error. Integral controller considers past error. Integral term produces output depend on magnitude of error, finally Derivative accounts future values and calculate according to slope of error. The derivative function (rate action) compensates for load changes which take place rapidly.
Now days in most of the industry's PID controller is implemented by using programmable logic controller. Some controllers called Auto tune controllers attempt to adjust the PID parameters automatically. [2][3]

## III.MATHAMATICAL MODEL

Modeling is the mathematical representation of a given system. The basis of mathematical models is physical and chemical laws such as laws of conservation of mass, energy and momentum.
Assumptions plays important role to build the model. The model developed down to microscopic detail would be very complex and impractical to solve. So, assumptions are laid to get good enough solution. Degree of freedom should be zero in order to find the solution.

Assumptions.
- Perfect mixing of the component with temp. T.
- The inlet & outlet flow rates are equal.

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- Density (ϱ) & heat capacity (C) are assumed to be constant-thus temperature dependence is neglected.
- Heat loss is negligible.

We consider energy balance because thermal effect predominate the system

Energy balance equation.

$$\begin{bmatrix}\text{Rate of}\\ \text{Accumulation}\\ \text{Of energy}\end{bmatrix} = \begin{bmatrix}\text{Rate of}\\ \text{energy in}\\ \text{(convection)}\end{bmatrix} - \begin{bmatrix}\text{Rate of}\\ \text{energy out}\end{bmatrix} + \begin{bmatrix}\text{rate of heat}\\ \text{addition to system}\\ \text{from surrounding}\end{bmatrix} + \ldots$$

$$\ldots + \begin{bmatrix}\text{rate of work}\\ \text{performed on a system}\\ \text{by surrounding}\end{bmatrix}$$

$$\frac{dUint}{dt} = -\Delta\left(W\hat{H}\right) + Q \ldots\ldots\ldots\ldots\ldots (1)$$

For pure flow or moderate pressure the internal energy is approx equal to enthalpy (heat content in the steam)

$$(dUint) = dH = CdT \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where,

$$\left.\begin{matrix}\text{Uint Internal energy}\\ \text{H} - \text{Enthalpy}\\ \text{C} - \text{Constant}\end{matrix}\right\} \quad \text{Depends on temperature}$$

Total internal energy of liquid in tank can be expressed as a product of internal energy per unit mass in the tank

$$Uint = \hat{U}int.\ \varrho.\ C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

An expression for rate of internal energy accumulation can be derived from equation (2)

$$\frac{dUint}{dt} = .\varrho.C.V\frac{dT}{dt} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

We derive the expression for enthalpy term that appears an right sight of the eq.(1) Suppose the liquid in the tank is constant temperature T has enthalpy H the integration equation (2), we get

$$\int_{\hat{H}ref}^{\hat{H}} d\hat{H} = \int_{Tref.}^{\hat{T}} C.dT$$

$$\hat{H} - \hat{H}ref = C(T - Tref) \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Assume,

$$\hat{H}ref = 0$$

$$\hat{H} = C(T - Tref) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Similarly for the inlet flow

$$\hat{H}i = C(Ti - Tref) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Put equation (4) & (5) in equation (1) Which gives desired dynamic model of stirred tank heating system.

$$V.\varrho.C.\frac{dT}{dt} = wc(Ti - T) + Q \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (8)$$

Tref is cancelled because heat capacity C assumed as constant & thus independent of temp.

Degree of freedom for this model gives three parameter V.ϱ.C. & four variables Ti, T, W, Q & one equation i.e. no. (8)
For control purpose:

- Manipulated Variable Q
- Disturbance Variable Ti, W [6][7]

## IV. RESULTS

PID Mode:

- Set Point 50°C
- Controlling Time 10 Sec.
- Flow Rate 40 lph


Figure 2: Temperature Control Loop

Table 01: PID Mode I/P & O/P

| I/P In Sec | O/ P in °c | I/P In Sec | O/ P in °c |
|---|---|---|---|
| 10 | 40.1 | 110 | 47.2 |
| 20 | 40.2 | 120 | 47.8 |
| 30 | 42 | 130 | 48.3 |
| 40 | 42.7 | 140 | 48.6 |
| 50 | 43.6 | 150 | 49.1 |
| 60 | 44.2 | 160 | 49.5 |
| 70 | 44.9 | 170 | 49.9 |
| 80 | 45.6 | 180 | 50.0 |
| 90 | 46.1 | 190 | 50.0 |

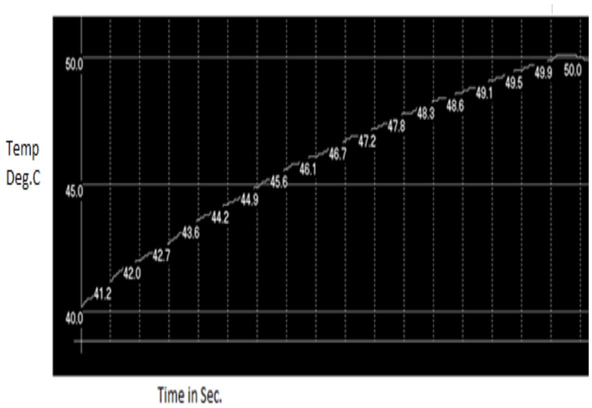


Figure 3: PID Mode

- Flow rate 40lph
- Controlling Time 30 sec.
- Set Point 55°c

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Table 02: P Mode I/P & O/P

| I/P In Sec | O/ P in °c | I/P In Sec | O/ P in °c |
|---|---|---|---|
| 30 | 52 | 210 | 55 |
| 60 | 53.1 | 240 | 55 |
| 90 | 53.1 | 270 | 55 |
| 120 | 54.7 | 300 | 55 |
| 150 | 54.8 | 360 | 55 |
| 180 | 54.9 | | |

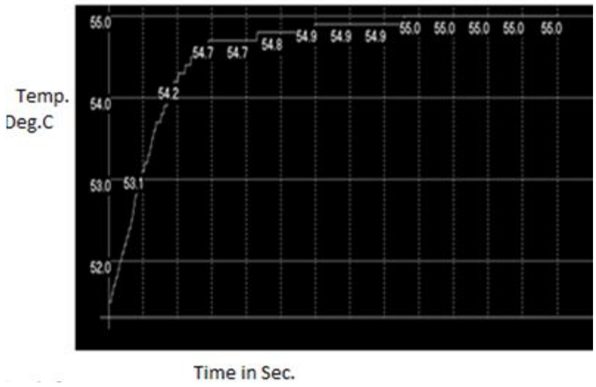


Figure 4: Proportional mode

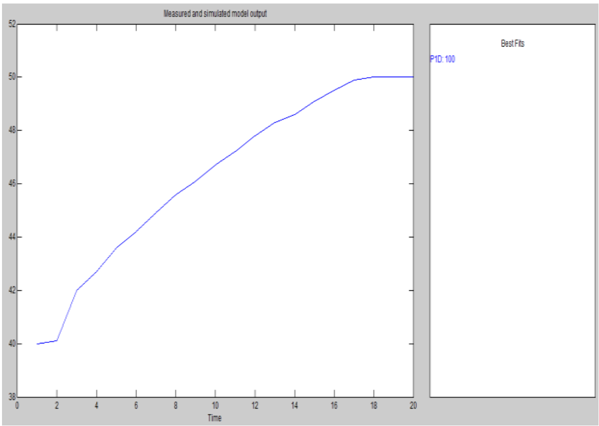


Figure 5: Results using MATLAB

## V. CONCLUSION

Temperature control is most essential parameter in industry. Control of a process is achieved by means of a closed loop circuit. One of the primary purposes of using feedback in control system is to reduce the sensitivity of the system to parameter variations.

This system gives information about controlling temperature in a tank. Here we used analog PID controller to control the temperature. The gains are to be tuned automatically. Results obtained from this system are compared with MATLAB.

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