

# Temperature Control of Feed-Forward Process using Smart Controller

Janki R. Bhalodi<sup>1</sup> Dipesh S. Vyas<sup>2</sup> Hardik J. Bhalodia<sup>3</sup>

<sup>2</sup>Assistant Professor <sup>3</sup>M.Tech Student

<sup>1</sup>Department of Instrumentation and Control <sup>3</sup>Department of Embedded System

<sup>1,2</sup>AITs – Rajkot <sup>3</sup>RK University - Rajkot

**Abstract**— Temperature is a one of process parameter which highly affects system stability. If there is any minor change in desired temperature value critical condition will be occurred. This paper presents a Heating system which control temperature of circular heating tank with PID controller. Heating system is based on laboratory experiment. System consists of control panel and online controlling facility. Whole system is operated and controlled by software configuration. Operation can provide both option either manually or automatic. First of all design process model of Heating system and after design Heating system modeling, system and PID controller is simulate in LabVIEW (Laboratory Virtual Instrument Engineering Workbench) software. PID controller is tuned with Ziegler-Nichols method and simulated in LabVIEW.

**Key words:** Heating System, Feed-Forward Process, PID Controller, Labview

## I. INTRODUCTION

System consists of water reservoir from which inlet water is continuously passed to heating tank from bottom inlet. Flow of water is controlled by plunger pump. Heating tank having continuous outflow from upper outlet. There is a heater placed in heating tank to heat water and heater is controlled by solid state relay. Temperature sensors is connected to measure tank inlet temperature and tank outlet temperature. Temperature of the heating tank can be controlled by either direct heating of heater or by open and closed control loop.



Fig. 1: Heating System Arrangement

## II. PROCESS TRANSFER FUNCTION

The process model used in the simulator is based on energy balance equation <sup>[2]</sup>

$$\frac{d(Cp V T_1 \rho)}{dt} = Ke u + Cp W(Tin - T1) \dots \dots \dots (1)$$

By taking the Laplace transform of equation (1), get the transfer function of the system is first order plus dead time with control signal to the temperature T,

$$\frac{T(s)}{U(s)} = H(s) = \frac{Ku e^{-Ts}}{Ts+1} \dots \dots \dots (2)$$

The parameters of H(s) are:

- 1) Gain  $K_u = \frac{Ke}{Cp W}$
- 2) Time constant  $T = \frac{\rho V}{W}$
- 3) Time delay  $\tau = \frac{Ke}{W}$

Consider real system configuration data, get the transfer function from the control signal of heater to the temperature T,

$$\frac{T(s)}{U(s)} = \frac{0.6037 e^{-6s}}{11.79 s + 1} \dots \dots \dots (3)$$

Constant	Value
Tank Volume (V)	1.1875E-3 m <sup>3</sup>
Heater Energy (K <sub>e</sub> )	3 K W
Water Heat Coefficient (C <sub>p</sub> )	4.179 KJ/Kg °K
Water Density (ρ)	1000 Kg/m <sup>3</sup>
Mass flow of water (W)	0.875 Kg/min

Table 1: Value of Heating System Configuration

## III. PID CONTROLLER

A PID controller needs to be tuned (PID gains set to appropriate values for your specific system) to function properly.

### A. Ziegler-Nichols Tuning Method:

The proportional, integral and derivative terms must be individually adjusted or "tuned" to a particular system using Ziegler-Nichols step tuning method. It provides accuracy and stability for the process. Tuning parameter is derived from system parameters, delay L, time constant T and gain K. <sup>[4]</sup>

Where PID controller parameter values find out from the equation,

$$K_p = \frac{1.2 T}{K L}, T_i = 2L, T_d = 0.5 L$$

## IV. SIMULATION

In temperature controlling system, it is better to perform practical using any kind of system software rather than directly perform on actual system. It also helps to prevent from any kind of accident and gives near about results for better performance. There are many kind of system algorithms used to perform using software.

Simulation done with the help of LabVIEW. LabVIEW is one of (short form of Laboratory Virtual Instrumentation Engineering Workbench) the best platform and development environment for a visual programming language from National Instruments. LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms.

LabVIEW <sup>[5]</sup> programs/subroutines are called virtual instruments (VIs). Each VI has three components:

- Block Diagram
- Front Panel

– Connector Panel

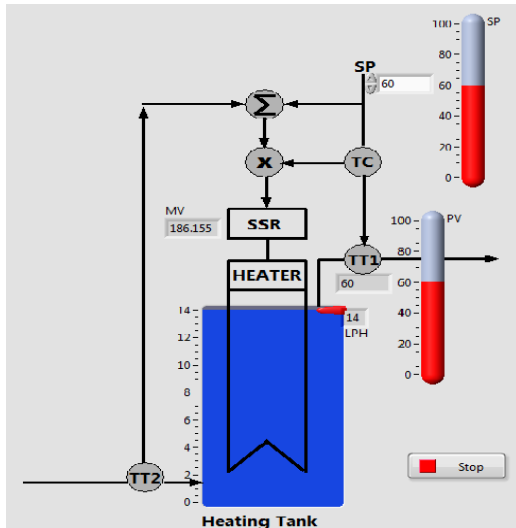


Fig. 2: Simulated Process Diagram of Heating system

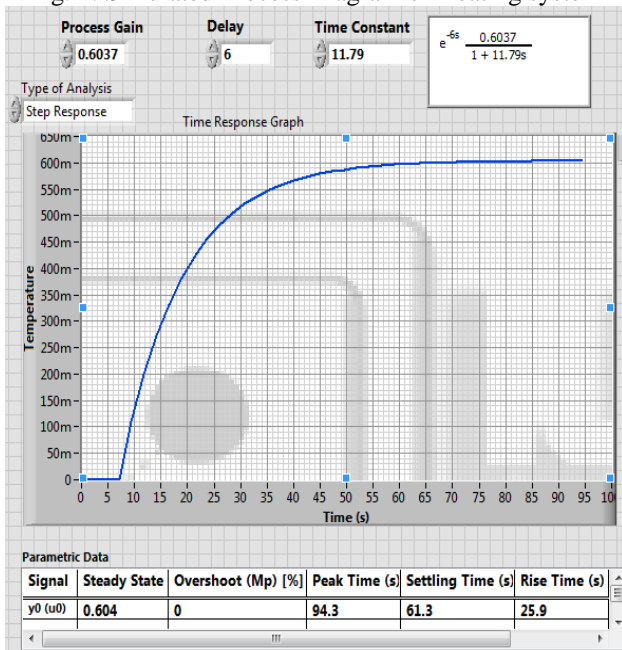


Fig. 3: Front Panel of Time Response of Heating system

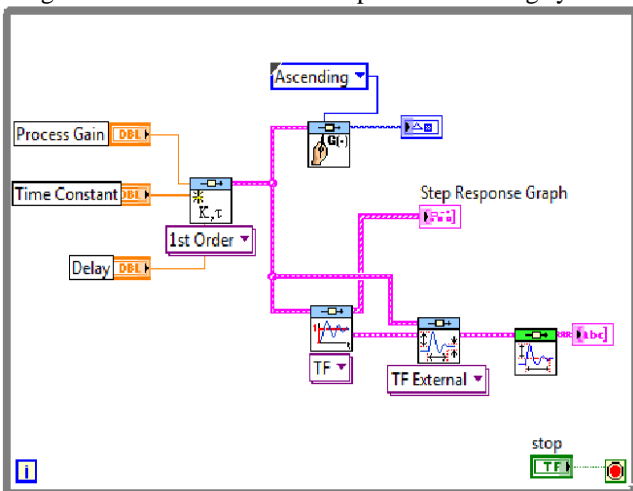


Fig. 4: Block Diagram of Time Response of Heating system

A. PID Tuning Simulation:

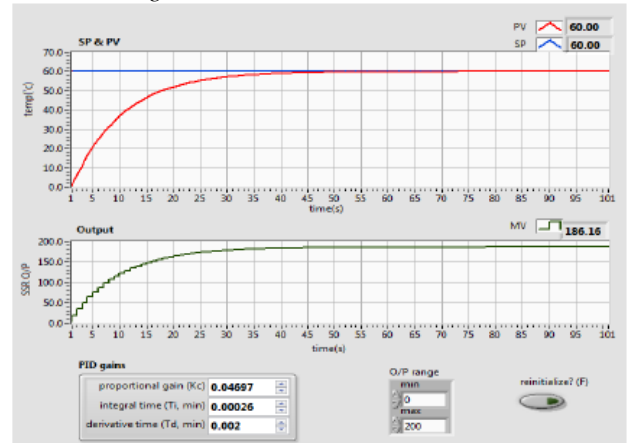


Fig. 5: Front Panel of Temperature Control Loop

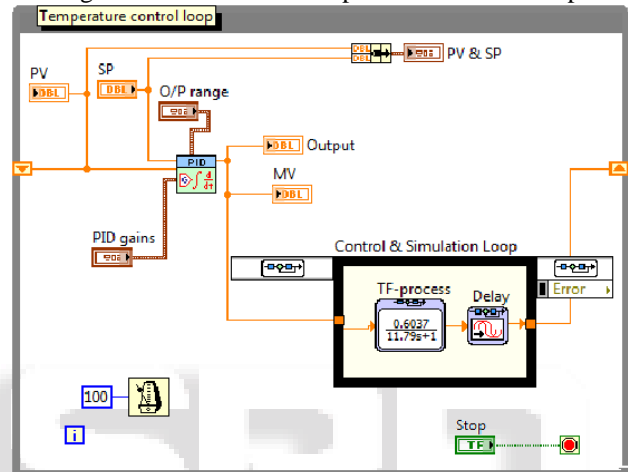


Fig. 6: Block Diagram Of Temperature Control Loop

Table given below shows time response parameters of the Heating system of open loop configuration and after temperature control by PID tuning. It is clearly observed that rise time is too much in open loop rather than PID controller. Although the difference in settling time and peak time is small.

	Rise Time(s)	Settling Time(s)	Pick Time(s)	Stead State
Open loop	52.9	61.3	94.3	0.604
With PID Controller	20.8	57.6	81.3	0

Table 2: Simulated Process Parameter Comparison

V. CONCLUSIONS

The main aim of this paper is to implement the effective control algorithm to control the temperature of heating system. In open loop configuration, system has very high rise time and settling time and steady state also present. To overcome these problem, control with tuned PID parameter. But it is observed that tuned PID parameter gives smooth response but have very high settling time.

REFERENCES:

[1] Tao Liu, Ke Yao, and FurongGao, "Identification and Autotuning of Temperature-Control System with Application to Injection Molding", IEEE transactions on control systems technology, vol. 17, no. 6, November 2009

- [2] A.R. Laware, V.S. Bandal, D.B. Talange, “Real Time Temperature Control System Using PID Controller and Supervisory Control and Data Acquisition System (SCADA)”, International Journal of Application or Innovation in Engineering & Management (IJAEM), Volume 2, Issue 2, February 2013
- [3] PID and Fuzzy Logic Toolkit User Manual, National Instruments Corporation
- [4] K. Astrom & Hagglund, “PID Controllers: Theory, Design and Tuning
- [5] S. Sumathi & P. Surekha, “LabVIEW based Advanced Instrumentation System”
- [6] Apex Innovation, Universal Process Control Trainer

