

Temperature Process Monitoring and Control using LabVIEW

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Abstract

This paper represents the LabVIEW based simulation design of Proportional-Integral-Derivative (PID) for Temperature control. It project aims at designing and implements a PID controller for temperature process. Temperature control of a liquid in a heating tank is achieved by a PID controller through switching a heater on and off. The PID controller gives response outputs which have minimum steady state error so this used in this process. The process block diagram formulated using LabVIEW icons, indicators and controls. This LabVIEW program saves the user time to identify and understand the operations of the process very easily by viewing the process flow.

Keywords-- PID controller, LabVIEW, Temperature control, heating tank.

I. INTRODUCTION

Temperature control plays a vital role in heat generation unit of industry. The temperature process enables the continuous process in which the change in temperature is adjusted to get desired temperature. This can be implemented by using PID controller and monitoring in front panel of LabVIEW. This paper described about the real time implementation of PID algorithm on temperature process. The real time implementation was simulated and tested using LabVIEW. This control technique has produced good performance and high accuracy. It gave good response for the tuned values of the parameters. [1].

This paper represents PID algorithm-based controller for electromagnetic oven for maintaining the oven temperature. The controller parameters are adjusted and tuned using various tuning methods and strategies. The controller is designed by the analysis of all the responses which obtained through the tuning methods. [2] This paper represents Fuzzy algorithm-based controller for Multiple Input Single Output of temperature process. The fuzzy knowledge base algorithm is implemented based on temperature value indicated by the sensor. This can be monitored using LabVIEW. [3]

This paper described about the temperature of control used to control the

temperature of a chamber surface, such a convoluted external surface of a chamber that is used to process a semiconductor substrate. A film distributor in the vacuum chamber applies a fluid film on to the process chamber surface. This temperature control system particularly used for controlling the temperature of a semiconductor processing apparatus comprising a process chamber having external surface [4].

This paper implies that how to control and monitor the temperature process in the petrochemical industries. It starts from storing high amount of chemicals that leads to crack in distillation column, if it is not maintained properly so it is vital to control the temperature process. Operation split into two parts. One is for sensing the temperature using temperature sensor and other one is to control the same using real time controlling software. In order to control the process, LabVIEW is a controlling software and Virtual Instrumentation are used. The analog output of the temperature is given to the analog to digital converter and it is processed by the central system. [5] Humidity sensing is important in the fields of environmental control, process monitoring and bio medical analysis. Silicon containing micro structured humidity sensor is fabricated at small distance above the surface of glass substrate as the movable electrode of a capacitor. Temperature sensing is done by the thin film platinum resistors. [6]

The main objective is to give a proper simulation model of the temperature control system and thereby making easier the real implementation. The other objective is it is an automation process it can be controlled using our PC and Laptops. The output of the process can be stored and it can be reviewed. This program can be easily interfaced with other real word components for controlling the process effectively. [7]

II. CONTROLLER

PID controllers have three control modes:

1. Proportional Control
2. Integral Control
3. Derivative Control

Each of the three modes reacts differently to the error. The amount of response produced by each control mode is adjustable by changing the controller's tuning settings. A PID controller is an instrument or equipment used in industrial control applications to regulate temperature, flow, pressure, speed and other few process variables. PID (proportional integral derivative) controllers use a control loop feedback mechanism to control process variables and are the most accurate and stable controller.

The PID controller gives an output response which have minimum overshoot and less steady state error as compared to other controllers. But it has more oscillations it affects the system stability.

The relationship between the input $e(t)$ and output $u(t)$ can be formulated for PID controller in the following

$$U(t) = K_p e(t) + K_I \int e(t) dt + K_D de(t)/dt \rightarrow (1)$$

In Laplace domain, the transfer function is expressed as follows:

$$C(S) = K_p + K_I/s + K_D s \rightarrow (2)$$

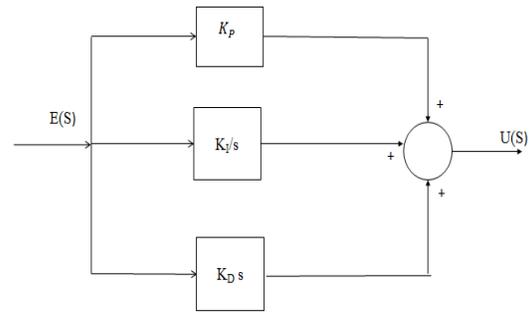


Fig .1PID block diagram

III. SIMULATION AND LABVIEW

LabVIEW (Laboratory Virtual Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments. The LabVIEW graphical language is an intuitive way for engineers to develop their measurement and control applications. It is easy to learn and use, the language also delivers the performance needed for advanced applications.

With LabVIEW, control engineers can use the same platform to develop and evolve and design their control strategies across different approaches and technologies. For PID control, LabVIEW is relatively simple and has control applications. For Advanced control design, LabVIEW tools include plant and controller modelling tools based on control algorithms Input /Output signals. LabVIEW has a continuous dynamic system execution add-on for using these models with traditional control blocks such as transfer functions, integrators, comparators, differentiators, feedback loops and nodes.

In the field of Motion control, LabVIEW is used for controlling industrial Machines and systems requiring machine control. The inherent LabVIEW Input/output capabilities make it a natural tool for acquiring load data to be used for driving simulations or new prototypes and mechanisms of hardware

1. FRONT PANEL

The front panel is the user interface of a VI. We build the front panel by using controls and indicators, which are the interactive input and

output terminals of the VI, respectively. Controls are knobs, push buttons, dials, and other located on the controls palette.

Controls simulate instrument input mechanisms and supply data to the block diagram of the VI created. Indicators are graphs, LED, and other displays. Indicators simulate instrument output mechanisms display data the block diagram acquires or generates.

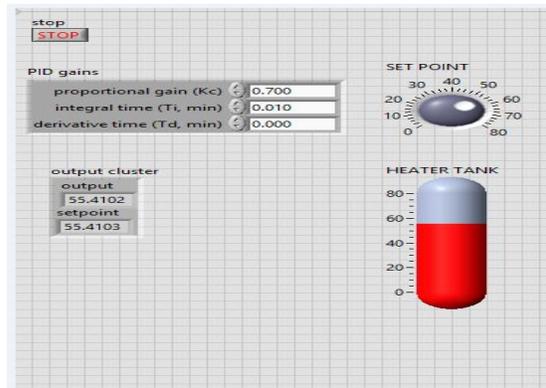


Fig.2 Front panel of simulation

In Fig 2, the knob is used to set the set point for the process. (The set point is the input given defined as the desired or target value for an essential variable, or process value of a system.) The thermometer indicates the temperature of the water inside the heating tank. (The change in temperature value represents the process variable change). The P, I&D values are given to the PID gain block the response of the process is recorded in the process chart. The output cluster is used to display the process variable and the set point given. Stop button is used to terminate the program of temperature process.

2. BLOCK DIAGRAM

The block diagram contains the graphical representations of functions to control the front panel objects. Front panel objects appear as icon terminals on the block. Wires connect controls and indicator to express VIs. This movement of data is known as data flow programming.

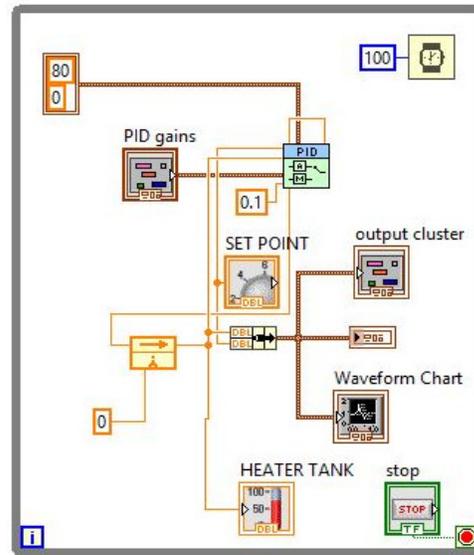


Fig.3 Block diagram of the simulation

In this Fig 3, the setpoint is given to PID controller. The gain values of PID also given to PID controller. The range of the tank is given to PID block. The PID controller is connected to the heater. Therefore bundle block is used to display set point and process variable value in the process chart. Feedback node is used to compare the actual value with setpoint value. Stop button is a boolean input which is used to stop the program.

The timer is used to synchronize the process and computer speed for every 100 ms the values entered into the process. While loop used for acquiring the data simultaneously from the process so the continuous data viewed in a tank. Setpoint is the actual requirement of the input. PID gains are used to stay output in the set point. Timer is used for reduce power allocation, frequency and memory usage. Feedback used to transfer the output to the original process variable. Array contain the lower and upper limit of the temperatures. In this VI, it contains 0°C as the lower temperature range and 80°C as the maximum temperature range. The waveform chart represents the output response of the process by using the PID gain values. Since the program has no complexity, the general architecture of LabVIEW is used.

IV. MATHEMATICAL MODELLING

The experimental determination of the dynamic and static behaviour of the process is called system identification. System identification can be done mainly in two ways one is the mathematical modelling and the other is the

empirical modelling, the mathematical modelling equations relating the input and the output formed. Empirical methods use data gathered from experimental setup to define the mathematical model of a system. In this paper, empirical method used for the temperature process. The transfer function for the process model is obtained from step response. Step data implies that the process is manual mode and initially at steady state. The transfer functions of the process models are required only for the simulation studies of the controller design. In this paper, we are commonly used model to describe the dynamics of the industrial temperature process is general first order plus time delay process (FOPTD) and the FOPTD model structure is given as

$$G(S) = \frac{K}{Ts + 1} e^{-tds} \quad \rightarrow(3)$$

Where, td- Time delay, k-process gain.

Mathematical modelling can be used to understand the process, to optimize process design and hence operating conditions, to design control strategies for the process, to train operating personnel, model based action and helps in achieving uniformity and in the disturbance rejection of all which translate into a better process economics.

V. CONTROLLER TUNING

The Controller can be tuned to get the optimum values for P, I and D. The general approaches for tuning have some criteria like one-quarter decay ratio, minimum settling time, minimum overshoot error and so on. The most popular method for empirical tuning is called Process Reaction Curve, developed by Cohen and Coon. From process reaction curve, the various tuning method such as Cohen and Coon, Ziegler and Nicholas Method are used to find optimum value of parameters like P, I and D.

VI. SCHEMATIC DIAGRAM

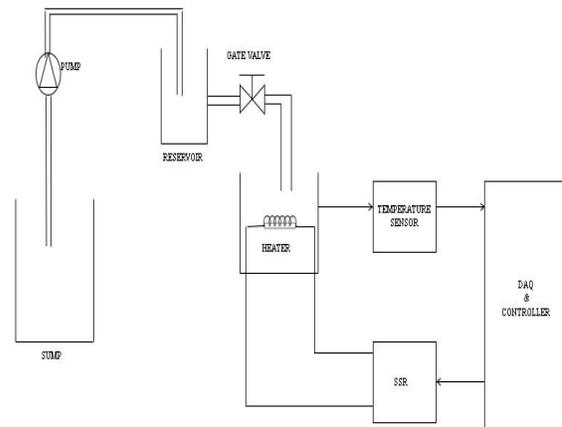


Fig.4 Schematic diagram

This Fig 4 represents the general schematic diagram of the temperature control system. The water at ground level sump is pumped to top level reservoir. The electrical pump is energized with AC supply of 230volt and 50Hertz frequency. The liquid flow to the heating tank is regulated by a rotameter in terms of litres per hour (LPH). The input water supply to the process tank is regulated by a gate valve. The temperature of the process liquid is increased by a heater coil which is regulated and controlled by solid state relay which may act as final control element. The temperature may be acquired using a sensor like RTD or thermistor through a data acquisition module (DAQ). The controller actuates the relay so as to maintain the setpoint and overshoot.

VII. RESULT AND DISCUSSION

Simulation for temperature control system for the liquid in the tank is performed by using PID controller in LabVIEW is given below.

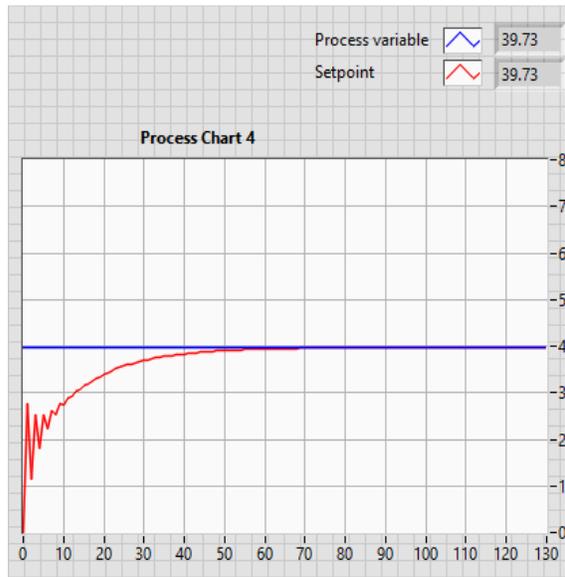


Fig.5 Response of the Heating Tank

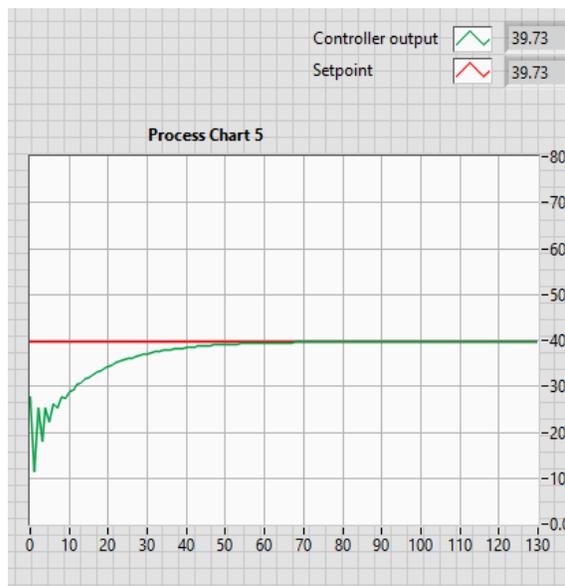


Fig.6 Response of Controller Output

The Fig 5 shows the output response of the heater tank and Fig 6 represents the controller output. Here we have the setpoint is given as 45°C . The actual process take around 60 seconds to reach the setpoint and stay with the value until setpoint change or PID value change happened. Here both the process variable and controller output will be similar in case of simulation. But in the case of real time implementation, the controller range and response curve varies.

VIII. CONCLUSION

The main drawback is to control the temperature process effectively. Since the temperature process is highly non-linear, it is very difficult to maintain the set point of the system without any offset. However it can be simulated easily using SCADA, NI LabVIEW and MATLAB. Due to its wide range of control abilities, here we use LabVIEW due to its wide range of control abilities. Since relay is used as an actuator, the actual response may vary with simulation results. The controller output increases with the process variable so as to reach. However, different values of Proportional-Integral-Derivative controller from different tuning techniques give better and expected response.

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