Labview Based Transient Performance Analysis of Non-Linear Process

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Abstract: Temperature monitoring and control is an essential process in a real time process control industries. The total process consists of two steps such as the sensing of temperature using a temperature sensor and hence controlling of the same using a real time controlling software .In this work, we consider temperature process with air as medium, mathematically it is realised that the process is a highly non-linear behaviour. The mathematical modelling of the process is carried out by transfer function method and it is identified as FOPTD process .Ziegler-Nicholas and cohen-coon tuning methods are used for conventional controller parameter tuning. In this work we hypothise RTD as a sensor for sensing the temperature and the use of labview of National Instruments for controlling the same. The analog output of temperature sensor is fed to the analog to digital converter (ADC) - - which converts it into a digital signal. This signal is fed to the LabVIEW system using NI-DAQ PCI6221 device. The parameter (here, Temperature) set point is fixed based on the process. The generated error signal can be recorded in an array and graphical analysis can be performed using the PID Toolkit VI present inside the software. Through the use of continuously recorded output, process engineers can pinpoint the time and machine in which the temperature goes out of the specified range and make a necessary deeds according to the signal.

Keywords: Labview, NIDAQ, Temperature process, Transient analysis.

I. INTRODUCTION

In the recent years, control system has assumed an increasingly important role in the development and advancement of modern civilization and technology. Practically every aspect of our day to day activities is affected by some type of control system. Automatic control system are found in abundance in all sectors of industry such as quality control of manufactured products, automatic assembly line, machine-tool control, space technology and weapon system, computer control, transportation systems, power systems, robotics and many others. It is essential in such industrial operations as controlling pressure, temperature, humidity and flow in the process industries. Recent applications of modern control theory includes such as non-engineering systems as biological, biomedical, control of inventory, economic and socio economic systems. Here we propose the digital system using ***Labview as a software tools for acquiring and analysing of real time data.***

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II.PROCESS DESCRIBTION

Air temperature system is designed to study the basic temperature control principles like P,PI, PD and PID controllers. Set up also helps in studying the open loop response and tuning of controller by different methods. It consists of the following components Multi speed blower, Heater, Digital indicating controller, solid state relay and RTD. These units are fitted on support housing designed for tabletop mounting. The set up also helps in understanding principles of SCADA control, in which PID controlling is by digital indicating controller. The computer is connected to the controller through communication port in supervisory mode.

III.Mathematical Modeling

Mathematical modelling is a representation of mathematical entities ie., representing the process, devices and concepts by means of number of variables which are defined to represent the inputs, outputs and inter states of the process and set of differential equations.

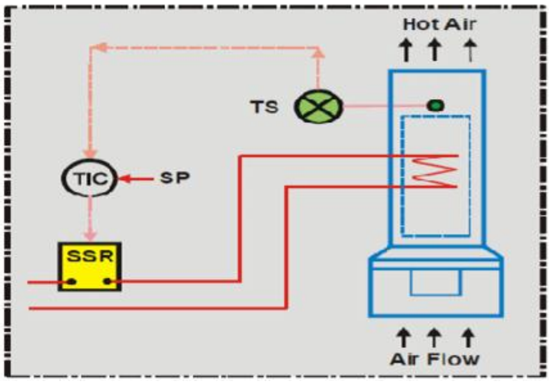


Figure 1 Experimental setup

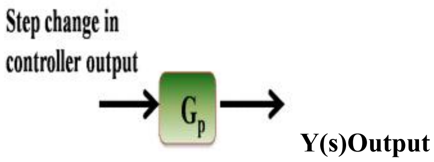


Figure 2: Block diagram of open loop response

A. Modelling Procedure

The transfer function method is used for modelling the non-linear process. First apply a step change of positive amplitude 10 to the controller output and tabulate the response. To the sigmoidal curve draw a tangent which cuts the line draw from starting point and the line draw in the settling point. The amplitude gives the value of B. The time delay can be defined as delay in the output response for a step change in the input. From this, the gain(k) for the FOPTD equation can be obtained.

The FOPTD equation is given by

$$G(s)=\frac{ke^{-tds}}{\tau S+1} \quad (1)$$

Where k=Change in output /Change in input

T_d=time delay in seconds

T=time constant

Hence the overall process transfer function is given by

$$G(s) = \frac{0.19}{38s+1}e^{-26s} \quad (2)$$

IV. Tuning of conventional controller

Tuning of a control loop is the adjustment of its control parameters(K_p,T_i,T_d)to the optimum values for the desired response.Designing and tuning a PID controller appears to be conceptually intuitive,but can be hard in practice,if multiple objectives such as short transient and high stability are to be achieved usually initial design need to be adjusted repeatedly through software simulations

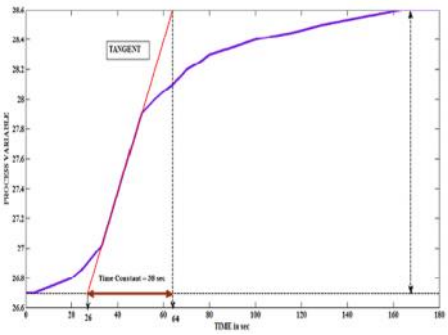


Figure 3: Response for a step change in controller output

Table I: Formula table for Z-N tuning method

CONTROLLER	K_p	T_i	T_d
P	U/RL=7.692	∞	0
PI	0.9U/RL=6.923	3.3L =86.6	0
PID	1.2U/RL =9.2307	2L =52	0.5L =13

until the closed loop system performs or compromises as desired.

In this work we follow the tuning rules of Ziegeler Nichols(open loop)method for the desired operation of the process.

Where,

U is the change in input=10

R is the slope=B/τ =1.9/38=0.04

L is the dead time=τ=26seconds.

V.DATA AQUISITION

Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems (abbreviated with the acronym **DAS** or **DAQ**) typically convert analog waveforms into digital values for processing. The components of data acquisition systems include:

- Sensors that convert physical parameters to electrical signals.
- Signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values.
- Analog-to-digital converters, which convert conditioned sensor signals to digital values

A.NI-DAQ Assistant

DAQ Assistant is a graphical interface for interactively creating, editing, and running NI-DAQmx virtual channels and tasks. An NI-DAQmx virtual channel consists of a physical channel on a DAQ device and the configuration information for this physical channel, such as input range and custom scaling. An NI-DAQmx task is a collection of virtual channels, timing and triggering information, and other properties regarding the acquisition or generation.This system uses a data acquisition system (DAQ) that is connected to a PC in the lab. It gathers input from the process and passes output signals to the control element. A control algorithm is implemented in software on the PC that is connected to the DAQ system. The LabVIEW software package from National Instruments is used to develop the custom data acquisition and control program. The program measures the temperature from the process, compares it to a desired set point, and issues the proper control signal to the final control element. The control signal adjusts the rotation speed of an electric fan.The fan rotation speed determines the rate of air flow over the heating element.

National Instruments PCXI

The I/O system is the Process control eXtensions for Instrumentation (PCXI) system from National Instruments. This is a modular data acquisition system that has the ability to connect to a PC. This system includes an input module, output module, and terminal blocks that are housed in a chassis. The PCXI system provides a basic I/O interface along with signal conditioning. It is designed to connect to a

DAQ card which is located in the PC. The DAQ card performs A/D and D/A conversion, as well as signal timing and multiplexing.

Analog Input

The analog input module is a PCI 6221 is a 16-Channel Analog Input Module. It is ideal for measuring small voltage and current inputs, and includes a Cold Junction Compensation circuit for use with thermocouple sensors. Connected to the front of the PCI6221 is a terminal block. The terminal block provides the wiring terminals that external signals are connected to.

Analog Output

For analog output, a PCI 6221 2-Channel Isolated Analog Output Module is provided. It is able to provide six channels of slowly varying DC voltage or current signals. The output voltage range is software selectable with the maximum swing between ±10 volts.

Software

Perhaps the most important piece of the system is the software. The software is the controller. It analyzes the input from the process and decides on an output action based on a control algorithm. The software is also the instrumentation. It displays data on the PC screen that a human operator can use to understand how the system is behaving. The software also enables an operator to control the process by entering a set point or by manually controlling the final control element.

National Instrumennts Labview 10 Express

LabVIEW is a graphics-based software development package that incorporates data acquisition, measurement, analysis, presentation, and control. Programs are written in the form of Virtual Instruments, or "VI's" that can execute alone or can be used as "sub-VI's" in larger programs. The programming style is much like the C programming language, however, actual code input is done graphically rather than typed with a text editor. This makes it easy for non-programmers to quickly create and debug applications.The software integrates seamlessly with data acquisition and measurement products from National Instruments. When used with the PCXI system, the result is very quick development of powerful measurement and control applications. Perhaps the biggest benefit of the LabVIEW system is that it includes hundreds of VI's that are ready to use in a custom program. In the development of this project I took full advantage of ready-made VI's for control, acquisition, and analysis.

Front Panel

The front panel is what allows the operator to control and monitor the process. It includes software controls and indicators that mimic physical controls such as PID parameters, numerator and denominator values indicates an array function for representing the transfer function. The indicator functions representing the values of transfer function model, step response of the process and the response after controller implementation, transient response analysis of the process.The temperature of the process is displayed in a waveform graph along with the set point value. By showing both set point and measured values on the graph, one can easily see how the system responds to changes in set point. This is very helpful when trying to determine the correct PID constants. The PID values can be set in a numerical control box.

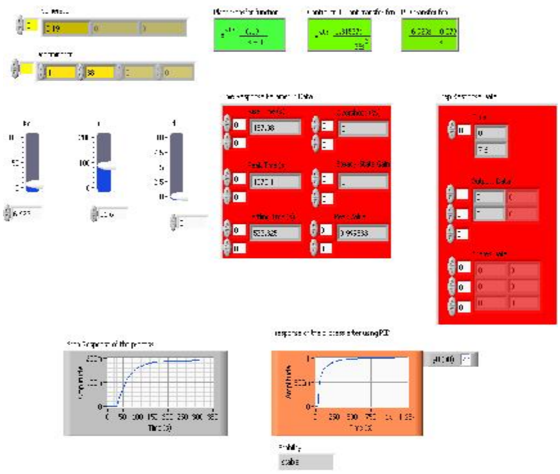


Figure 4: FRONT PANEL DIAGRAM OF THE MODEL

Block Diagram

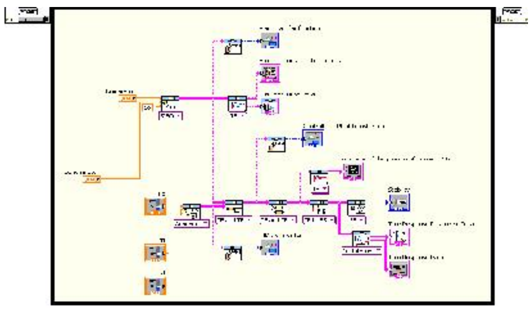
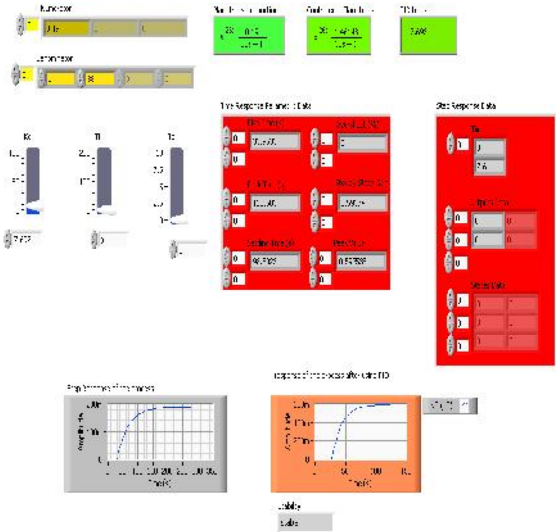


Figure 5:Labview Block Diagram

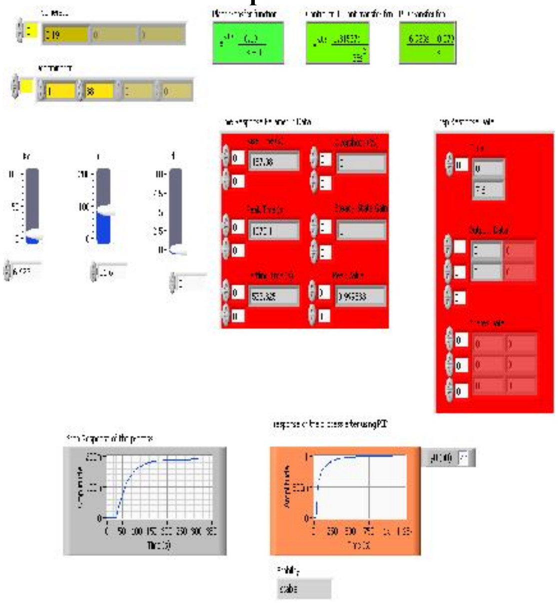
The block diagram is a graphical representation of the underlying software program. It consists of icons that represent typical programming elements such as constants,variables, subroutines, and loops. Figure 3 below is a screenshot of the block diagram for this system.

Result

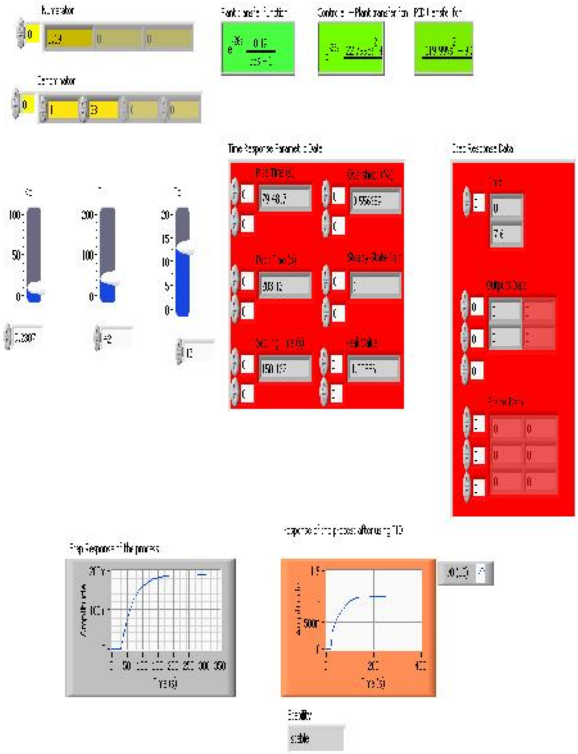
The system worked extremely well given the time constraints on design and construction.The fan is able to cool the heated element to a desired when running at is maximum speed. Using manual control, the operator is able to vary the fan speed from almost zero to full speed very smoothly. When operating under automatic control, the system does a very good job of keeping the temperature within a few degrees of the set point. This was true even without tuning the loop for optimal control. For example,when set as proportional only control with unity gain, the temperature was held constant with an offset of five degrees from the setpoint. Shown below as Figure 6 is a screenshot showing a graph of the measured and setpoint values.



In the above results the controller tuning parameters are fixed as Kp=7.692



Here The parameter is fixed as Kp=6.923 Ti=86.6 and Td=0



The controller parameters are fixed as Kp=9.2307 Ti=42 Td=13

Conclusion

The system described in this paper illustrates the design and development of a feedback control system that employs a proportional, integral, and derivative controller implemented using LabVIEW. The setup is straightforward provided that the transient response analysis of thermal process LabVIEW environment is intuitive and allows much to be done in little time.

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