

PID Based Flow Control Using Lab-VIEW

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Abstract— The primary aim of the paper is to replace the physical PID instrument with virtual PID that has equal controlling capabilities as that of instrument. This designing is done on software called Lab VIEW. A NI USB DAQ card is used to interface with the hardware. The hardware is a Flow Loop Trainer Kit whose flow has to be controlled using a feedback control loop. The flow of process execution is: The designed PID will be generating the necessary controlling electronic signal. This signal will be acquired by DAQ card. The DAQ card transfers it to I to P converter which will convert the electrical signal 4-20 mA into pneumatic signal 3-15 psig to actuate the control valve. As the control valve acts on pneumatic signals only, this conversion is required. The control valve controls the fluid flow. Orifice through DPT will give the feedback, measuring the flow in the pipe. This transmitted signal is acquired by DAQ and sent back to computer. These values are called process values and are further processed into the designed PID. This way a closed loop system is formed.

Keywords— DAQ card (Data Acquisition), Lab-VIEW (Laboratory Virtual Instrument Engineering workbench),PID (Proportional, Integrator, Derivative).

I. INTRODUCTION

Proportional integral derivative (PID) control method (algorithm) has been the most popular control method, which is widely used in control engineering. From an automation perspective, PID is more than enough for 99% of control situations. It is well known that a great many systems have very simple dynamics and in these situations PID is often sufficient to provide the performance needed.

Many industrial control loops that are nonlinear to some degree are linear enough in the control region near the set point for which PID control algorithm works fine. PID controllers can be more intuitive to tune.

For example it is easier to reason out the expected behavior while changing one of the PID gains than pole placement option. There are many advantages of PID's such as their simplicity and possibility of coupling PID algorithm with smith predictor, feed-forward loops, nonlinear gain scheduling and other advanced control techniques

Lab VIEW, which stands for *Laboratory Virtual Instrumentation Engineering Workbench*, is a graphical computing environment for instrumentation, system design, and signal processing. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, Lab VIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various flavours of Linux, and Mac OS X.

The code files have the extension ".vi", which is an abbreviation for "Virtual Instrument". Lab VIEW offers lots of additional Add-Ons and Toolkits.

II. HOW A PID CONTROLLER WORK

The PID controller maintains the output at set point so that there is no difference (error) between the process variable (PV) and the set point (SP). The PID controller is looking at the difference (or "error") between the PV and the SP. It looks at the absolute error and the rate of change of error. Absolute error means is there a big difference in the PV and SP or a little difference? Rate of change of error means is the difference between the PV or SP getting smaller or larger as time goes on.

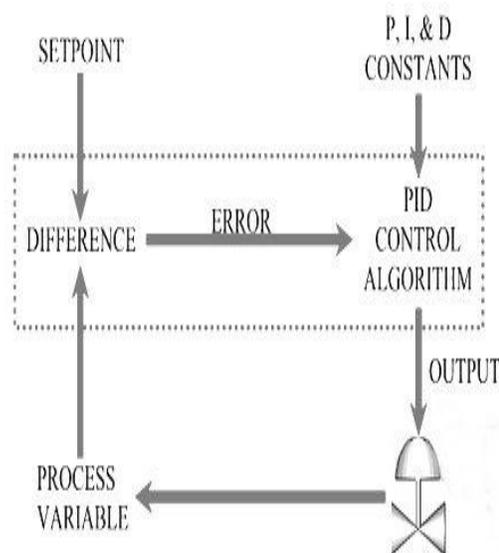


Figure 1: PID Working Diagram

When there is a "process upset", meaning, when the process variable or the set point quickly changes - the PID controller has to quickly change the output to get the process variable back equal to the set point. If you have a walk-in cooler with a PID controller and someone opens the door and walks in, the temperature (process variable) could rise very quickly. Therefore the PID controller has to increase the cooling (output) to compensate for this temperature rise. Once the PID controller has the process variable equal to the set point, a good PID controller will not vary the output. You want the output to be very steady (not changing). If the valve is constantly changing, instead of maintaining a constant value, this could cause more wear on the control element. So there are these two contradictory goals. Fast response (fast change in output) when there is a "process upset", but slow response (steady output) when the PV is close to the set point. Note that the output often goes past (over shoots) the steady-state output to get the process back to the set point. For example, a cooler may normally have its cooling valve open 34% to maintain zero degrees (after the cooler has been closed up and the temperature settled down). If someone opens the cooler, walks in, walks around to find something, then walks back out, and then closes the cooler door the PID controller is freaking out because the temperature may have raised 20 degrees. So it may crank the cooling valve open to 50, 75, or even 100 percent to hurry up and cool the cooler back down before slowly closing the cooling valve back down to 34 percent. The above formula is the classic PID formula. Where 'Kp' is Proportional constant, 'Ki' is Integral constant and 'Kd' is Derivative constant and 'et', is error. The flow of fluid in vessel is controlled by using feedback flow scheme.

PID Equation

$$u(t) = Mv(t) = k_p e(t) + k_i \int_0^t e(t) d\tau + k_d \frac{d}{dt} e(t)$$

Tuning Method For Flow Loop

The process of selecting the controller parameter to meet given performance specification is known as tuning of the controllers. Necessity of controller tuning because of three types of disturbances to the process .the basic approach is to open the process control loops that no control action occur, this is done by disconnecting the controller output from final control element .all the process parameter held at their nominal values.

There are three method of tuning:

1. Ziegler-Nichols Method
2. Frequency Response Method
3. Open loop transient Method

The Tuning method used for Flow control is,

Ziegler-Nichols Closed Loop Method

This method is base on frequency response of the process. Connect a controller to the process, set the parameters so that control action is proportional i.e, $T_i = \infty$ and $T_d = 0$. Increase the gain slowly until the process starts to oscillate. The gain when this is K_u and the period of Oscillation is T_u . Using the table Given Below the values of K_c , T_i and T_d is calculated

Table 1:
Calculation of Constants Using Ziegler-Nichols Method

Controller	K_c	T_i	T_d
P	$0.5K_u$	--	--
PI	$0.4K_u$	$0.8T_u$	--
PID	$0.6K_u$	$0.5T_u$	$0.125T_u$

It is also important to stress that using the ultimate-cycle tuning method may be out of the question in processes where bringing the system into continuous oscillation could be dangerous or might cause damage. Instead, another method of tuning, such as the trial and error method or the open-loop step response method should be used. The open-loop step response method is also know the open-loop Ziegler-Nichols method.

III. ANALYTICAL FLOW MEASUREMENT

This simple system although giving an indication of the flow rate (Q), is actually transmitting a signal proportional to the differential pressure (ΔP). However, the relationship between the volume of flow Q and ΔP is not linear. Thus such a system would not be appropriate in instrumentation or metering that requires a linear relationship or scale. In actuality the differential pressure increases in proportion to the square of the flow rate, which is called as Bernoulli's equation.

We can write this as:

$$\Delta P = Q^2$$

In other words the flow rate (Q) is proportional to the square root of the differential pressure (ΔP).

$$\text{Volumetric Flow Rate} = Q \propto \sqrt{\Delta P}$$

IV. THE FLOW LOOP HARDWARE AND SOFTWARE REQUIREMENTS

Flow loop Elements

- *Flow meter* : Rota meter (mechanical).
- *Final Control Element* : Control Valve (Pneumatic).
- *Transducer*: Orifice Plate (mechanical)
- *Transmitter*: DPT(Differential Pressure Transmitter) (Electronic).



Figure 2: Physical Flow Loop (hardware)

Interfacing Electronic Card

- *NI USB DAQ 6009*: Data Acquisition Card by National Instrumentation (NI).

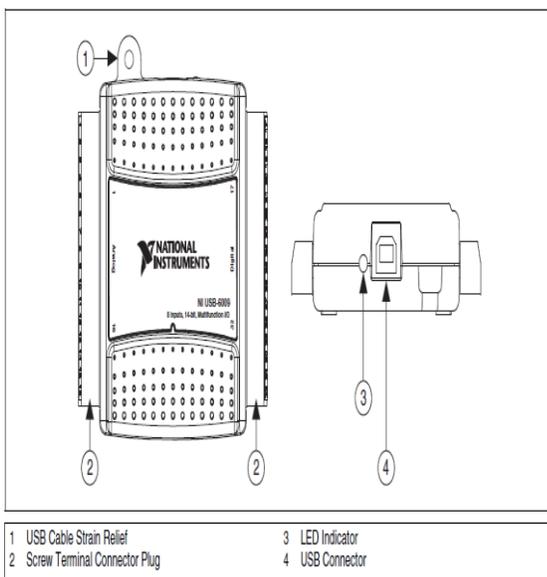


Figure 3: NI USB DAQ 6009

Software

- Lab VIEW installed computer.
- PID and Fuzzy Logic Tool Kit.

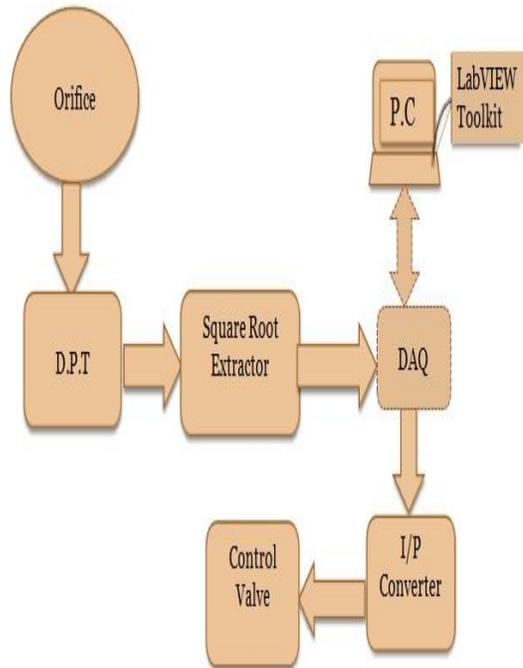


Figure 4: Process flow Block diagram

V. SOFTWARE CONFIGURATION AND IMPLEMENTATION

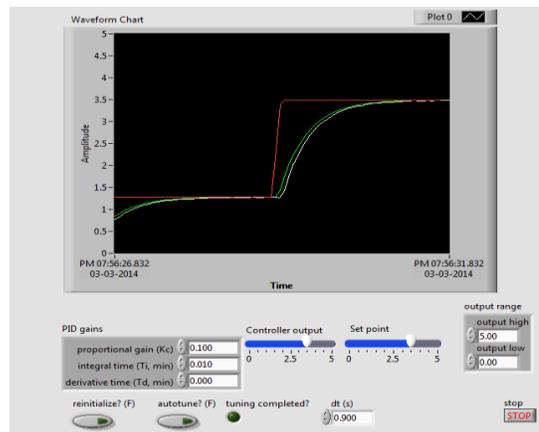


Figure 5: Front Panel vi of the process

Controls:

- *Kc*: the value of the proportional controller gain.
- *Ki*: the value of the integral gain.
- *Kd*: the value of the derivative gain Kd.

- *SP*: desired steady state value. variable in order to consider that steady state occurred.
- *Auto Tuning*: starts auto-tuning operation.
- *Stop*: the abort push button.
- *Output range*: defines the minimum and maximum output range.
- *dt(s)*: controller sampling rate is determined.

Indicators:

- *Waveform chart*: set point Vs process variable plotter.
- *Controller output*: the value of controller output is indicated.

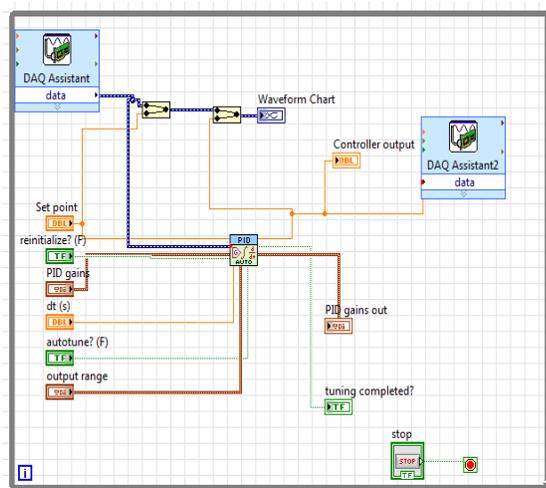


Figure 6:Block Diagram of the process

Block Diagram Elements:

- *PID Auto tuning toolkit*: PID controller algorithm.
- *DAQ Assistant*: Acquiring and Generation of Signal.

VI. BENEFITS OF THE APPLICATION

This project replaces the conventional PID instrument with a virtual controller. It saves time of manufacturing of instrument. Since the PID logic can be designed on LabVIEW in a very short period, as the manufacturing of instrument requires plenty of skills which cannot be implemented in a short span of time. Practically this application needs no maintenance and very easy to upgrade. Whereas instruments require timely maintenance and their up-gradations is very difficult.

VII. CONCLUSION

According to the experimental investigations in NI LabVIEW we can say that the new system developed would be highly flexible and easy in controlling the flow. It will create a new era in the field of Process Automation.

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