A LabVIEW Based PID Level Controller for a Conical Tank Using Interfacing Hardware NI myRIO-1900

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Abstract- *The proposed paper describes, a liquid level in the conical tank is to be controlled at desired set point value. The hardware PID is replacing with soft PID that also has the same controlling capability as that of hardware Instrument. The LabVIEW based PID controller for a level control system using interfacing hardware NI myRIO-1900 to evaluate the benefit of computer base system. Virtual Instrumentation PID controller is implementing using graphical programming language called LabVIEW, developed by National Instruments. The process set up mounted with a tank, which level has to be acquired and control using a feedback loop. The designed PID will be generating the necessary controlling electrical signal. This signal will be acquired by NI myRIO-1900 and implement at the final control element to achieve the desire level. The NI myRIO transfers the electrical signal in to I/P converter which will convert the electrical signal 4-20mA into pneumatic signal 3-15psig to activate the control element.*

Keywords- Control & simulation, Level control, myRIO-1900, PID, process variable

I. INTRODUCTION

The level control is important in the process industries to maintain the desire set point. The proportional - Integral-Derivative (PID) scheme was introduced in the 1940s, and commonly used in process control, where "P" denotes proportional control action, "I" denotes integral control and "D" denotes derivative control action. . Setting the parameters of PID is called as tuning of PID controller. There are various standard tuning methods available such as Ziegler Nichols [1], Cohen-coon [2], and many other traditional techniques. It gives tuning parameter, which bring the process value as much as close to the desired set point. Proportional action: It generates manipulated output based upon current error with related to set point. P mode generate offset. Integral action: The integral actions magnify the effect of long-term steady-state errors, apply ever- increasing effort until they decrease to zero [2].

Derivative action: The derivative action is deal with the rate-of-change of the error with respect to time. Derivative action will speed up the controller action so that the process variable will quickly reach the set point. Lab View is a graphical user programming language with an additional advantage of graphical user interface (GUI). We use a NI myRIO-1900 for interfacing with the hardware. This is interfacing product of the same company National Instruments [3] [4]. It is extremely easy to use and flexible to give improved system Performance. The system performance could be able to obtain by the graphical representation of set point, process value. The transient response such as settling time, offset, overshoot, response time could be observed from the graphs and PID algorithm can consequently vary the proportional gain, reset time and derivative time with the purpose of get desire performance [5] [6].

Organization of paper: Part 2 includes details on process hardware setup, system transfer function and system block diagram. Part 3 gives details about a LabVIEW based PID Function icon, control & simulation loop, summation icon, Hardware implementation, programming and signal conditioning in Lab View. Part 4 contain details about tuning of PID to obtain best Controller output. Part 5 includes the obtain results. Part 6 give out the conclusion made from implementation of work.

II. PROCESS SETUP

The process is a cascade control Hardware setup shown in figure 1. The main apparatus of the cascade control trainer is describes in this way:

Storage tank: Storage tank is used for supplying water. It is located under the Level tank setup assembly. It has the pump for circulating water into the main tank, which tank level has to be controlled.

Level tank: Transparent level tank be support on the hold plate of the level tank setup assembly. Graduated level is providing on the transparent tank to point out tank level in %. The level tank has a discharge valve at underside, which open in to the storage tank. Discharge flow of the tank could be able to vary through the help of discharge valve provide at the outlet.

Level sensor: Level sensor (Capacitance type) transmitter is mount on level tank to indicate level in term of 4-20mA. The level of water is acquired and transmits to interfacing device (myRIO-1900) for communicating in to computer.

Control valve: Pneumatic control valve is used for varying the input flow of water into the level tank.

I/P Converter: The current to pressure converter (I/P converter) receive signal from computer through interfacing device, which converts supply pressure in to desired output pressure respect to the signal obtained for pneumatic valve manipulation.

Other devices: A pressure gauge, air regulator, pumps for water circulation, Rota meter and water piping are the other devices in the hardware set up.

Transfer function of the process in terms of voltage $= \frac{13.88}{18s+1} e^{-1.4s}$.

Fig. 2 process setup

III. PROCESS BLOCK DIAGRAM

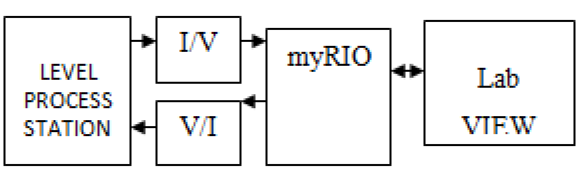

Fig. 3 process block diagram

The process block diagram of the system shown in Figure 3.The Tank level is measured by level transmitter, outputs of which is 4-20mA signal. Transmitter signal is sent to LabVIEW based PID Controller through NI myRIO. LabVIEW based PID Controller, which produce the required control signal. The required control signal is a voltage signal. It is converting into current using V-I convertor circuit. The output of V-I circuit is given to I/P convertor, which actuate the inlet flow pneumatic control valve [7]

IV. PROCESS IMPLEMENTATION IN LABVIEW

To control level of tank the PID controller is used. The existence of hardware based PID is replaced by LabVIEW.
voltage.

Summation Function:

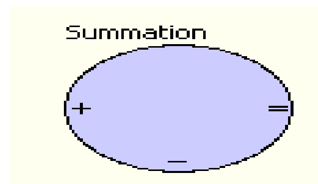

Fig. 6 Summation

Add or subtract the input signals. This function accepts mixed vector and scalar input. The error signal is feed to the PID controller

Control & Simulation Loop:

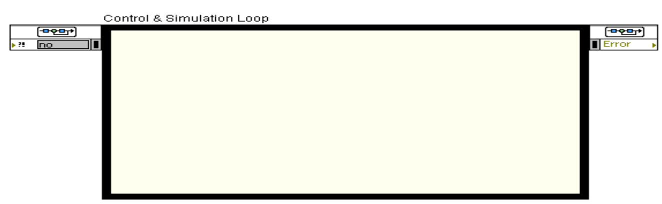

Fig. 4 control & simulation loop

Execute the simulation until the Control & Simulation Loop reach the simulation steady time. We must put all simulation functions within a Control & Simulation Loop or as a simulation subsystem. We could place simulation subsystems inside a control & simulation loop or run simulation sub diagram as a stand-alone.

PID VI (virtual):

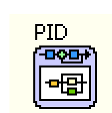

Fig. 5 Virtual PID

Its form a PID model in the form of transfer function .The transfer function is feed in to the form voltage. It gets the error signal from the summation block in terms of voltage and produces the output signal in terms Of voltage.

V. HARDWARE IMPLEMENTATION

Fig. 7 myRIO-1900

Acquire and generate signals using myRIO-1900

5.1 Configure myRIO –1900 to acquire input Signal and Input Port

To obtain signal from level transmitter using myRIO-1900 as shown in Figure 8 (Analog Input port A/AI-03). Configure the myRIO-1900 to acquire the transmitter signal by selecting analog input port. The Transmitter produces voltages respect to the level change in the tank, that voltage acquired by analog input port (A/AI-03).

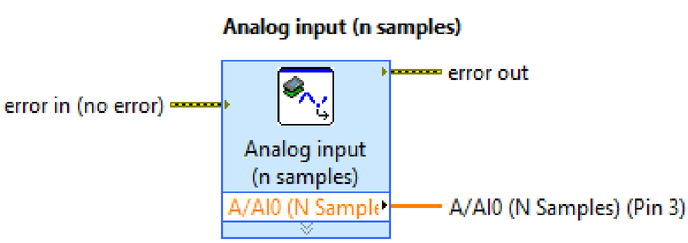

Fig. 8 Input port configuration

5.2 Configure myRIO –1900 to Generate output Signal and output Port

To generate signal from myRIO-1900 as shown in Figure 9(Analog Input port A/AO-02).The control voltage is generated in range of (1-5V),which connected to 250 ohm resistor in series with control signal voltage to convert (4-20 mA Current) for manipulating the I/P Converter .

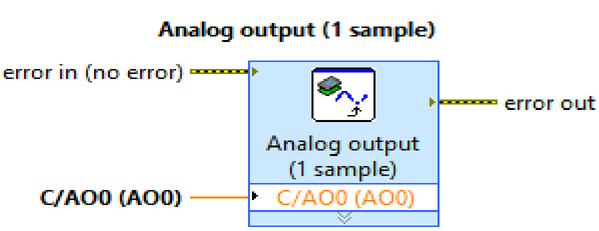

Fig .9 Output port configurations

VI. SIGNAL CONDITIONING (V/I CONVERTER)

The LabView could be generating analog output voltage signal. So the control generated by LabVIEW PID VI is given to interfacing device myRIO-1900, which is configured to generate output voltage signal of 1 – 5 volts to analog output port A/AO-02 .This voltage signal is give to V-I convertor, shown in figure 6 to obtain 4-20 mA current output . The output of V-I Convertor circuit is give to I/P Convertor, which convert 4 – 20mA current signal to 3 – 15 psig Air pressure. This will manipulate the final Control Valve.

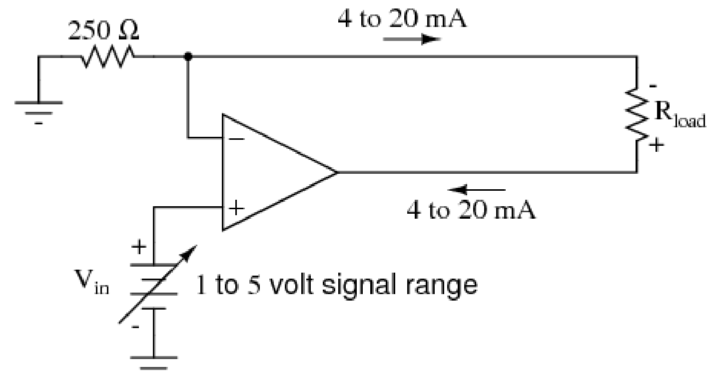

Fig 10: V – I converter

VII. PROGRAMMING PID VI IN LABVIEW

For programming Block diagram VI in LabView as shows in the Figure 7. A While Loop is chosen and transmitter signal acquired by myRIO-1900, which is given to PID VI input as a process variable in terms of voltage. Numeric Indicator Tank tool, which is indicate real time level in the tank. Set point is given to PID VI through Numeric Control of Vertical pointer slide. PID Input / Output range is put to 1-5 Volts. D(t) is put to 1. PID gains are calculated by trial and error method and given as input to PID VI. The outputs of PID controller are giving to myRIO-1900 and generate control output at output port. The PID Controller output is also displayed on numeric indicator tool concurrently. Three real time parameter values such as controller output, process variable and set point are display on waveform chart. Front Panel VI is shows in Figure 8 [8].

VIII. TUNNING OF PID

The outlet valve of the tank fixed to some default position i.e. partially opens, so the tank does not overflow and the storage tank pump is started. The overhead tank, whose level is to be controlled and the process variable is display on the front panel of the VI that indicate the real time water level in the tank. The PID values are taken based on model [9]. The proportional gain K_C is set to -1.688. The negative value of K_C is selected because the final control valve is in the type of Air-to-close i.e. normally open. Here PID controller output should increase to close the valve, where reverse action of controller is implemented. This reverse action of controller is done by negation of proportional term and keeps integral and derivative terms as it is.

METHODS	PROPORTIONAL	INTEGRAL	DERIVATIVE
ZEIGLER NICHOLAS FORMULAE	$K_c = 0.6\,K_U$	$t_i = P_U/2$	$t_d = P_U/8$
ZEIGLER NICHOLAS VAUES	1.688	1.585	0.396

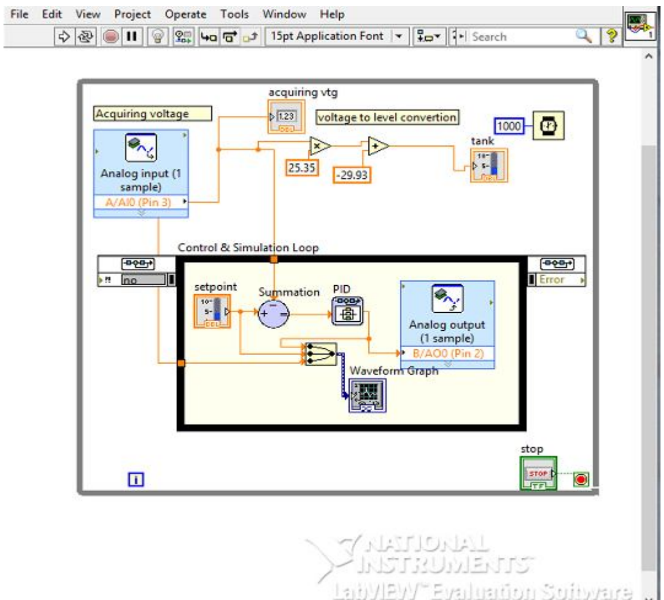

Fig. 11 Block Diagram

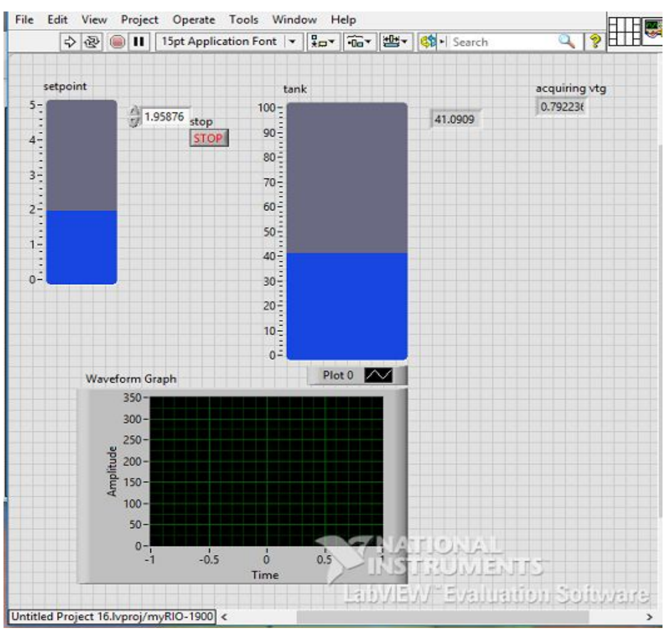

Fig. 12 Front Panel VI

IX. RESULTS

After successful implementation of PID controller and tuning, the following charts show the set point, process variable and controller output plot with respect to time. Figure 13 show the previous value of set point was 3 which is step up to 4. If set point increases the controller output fall as it is a reverse acting mode. So the control valve make more opening and the level begins to increase. Figure 14 show the step down of set point from 4 to 3. Thus the set point is decreased the controller output rise immediately and the control valve is get closed and flow is decreased. The process variables come close to set point within less than 30 seconds. The process variable maintain at set point in about 2 minutes.

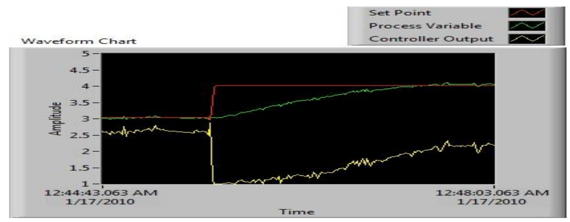

Fig 13: Set point = 4

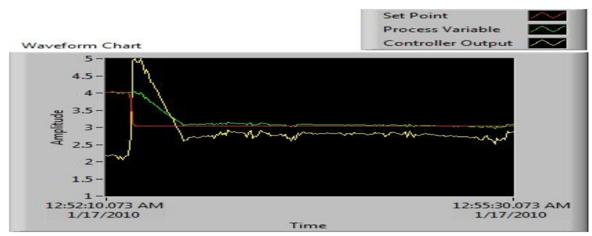

Fig 14: Set point = 3

X. CONCLUSIONS

With the help of LabVIEW Functions, indicators and a virtual PID are implemented and tested [9], which replace the conventional hardware PID instrument with a virtual PID controller. This LabVIEW based PID controller is quite flexible and easy to implement. This application requires no maintenance and very easy to improve [10] .The graphical user interface (GUI) of LabVIEW improve the utilization of the software.

REFERENCES

[1] J. G. Ziegler and N. B. Nichols, "Optimum settings for automatic controllers,"Trans. ASME, vol. 64, pp. 759–768, 1942.

[2] Astrom K,J, T. Hagllund; "PID controllers Theory, Design and Tuning ",2nd edition,Instrument Society of America,1994

[3] R. A. . S. Mohan, "Complete industrial solution for automation in temperature and humidity monitoring using labview," VIT University, Vellore, India, p. 5.

[4] P. P. P. Harsh Kaji, Shruti Annigeri, "Designing pid controller using labview for controlling fluid level of vessel," International Journal of Engineering Research and Applications (IJERA), vol. 3, pp. 1329–1333, March-April 2013.trol Electronics.

[5] M. K. A. Z. MOHAMMAD A.K. ALIA, "A closed-loop temperature control system by utilizing a labview custome-design pid controller," Al-Balqa Applied University Amman, Jordon, p. 4.