Preclusion of High and Low Pressure in Boiler by using LabVIEW

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Abstract— Pressure is an important physical parameter to be controlled in process boiler, heat exchanger, nuclear reactor and steam carrying pipeline. In the article the issue has been face in boiler operation due to pressure is handled. In boiler, the problem is due to maximum and minimum range of pressure. Due to the issues there is a chance to causes the hazop. To avoid such the problem the high and low pressure in boiler has to control. In the paper such the problem has sorted out by implementing ON-OFF control. Here the proposed control action for pressure control is implemented with the help of LabVIEW (Laboratory Virtual Instrument Engineering Workbench) software and NI ELVIS hardware. In the idea the boiler's low range and high is monitored and controlled valve desirably. And also the high range and low range of pressure in the boiler is signified to plant operator by alarm signal.

Key words: Pressure Control, LabVIEW, NI ELVIS, ON-OFF Control and Hazop

I. INTRODUCTION

Pressure is one of the most important parameter that has to be controlled in the process industries. It is defined as the force per unit area. The force is applied perpendicular to the surface of an object per unit area over which the force is distributed. Gauge pressure is the pressure relative to the atmospheric or ambient pressure. The presence of pressure in the closed surface changes dynamically which must be taken care of its functional behavior. The changes inside the closed system correspond to the amount of pressure at the inlet valve and the outlet valve. The rate of inflow and the outflow is always monitored in plant like boiler [2] [6], where the level of water in tank varies with change in output steam. The steam in tank indicated using pressure gauge, the pressure also comes into picture with heat exchanger. The key function that acts as an important one that affects the efficiency is pressure controlling, it is a necessary factor that should be taken care in every pressure plant industries. The base motivation is to operate the pressure in a measured manner and to arrange the safety action if the process misbehaves. In case of misbehavior of pressure in pressure vessel then the necessary safety action is carried out. The safety action is implemented with on-off control action which is correlated with the operation of LabVIEW.

The pressure process is performed using a model pressure control trainer kit and controlled through simulation program using LabVIEW [3]. During the functioning of pressure process, the value of pressure in the given process must be maintained within the stipulated range, when it reaches its saturation point and goes beyond the preset level, and then there arises the problem. This problem may arise when the outflow pressure is less than the input or when the inlet/outlet valve misbehaves. This problem may sometimes lead to explosion of the plant in the process station.

The below experimental setup is designed to control the pressure in the plant by using on-off control action with the help of LabVIEW [1]. When the range of pressure exceeds the pre-set value then the control action makes the output controlled valve to ON or 100% open, which is operated in the automated manner using LabVIEW coding and NIELVIS[9], as ELVIS has the facility of both acquiring and generating the signals the process dynamic output of process variable is monitored by acquiring the signal from pressure sensor attached along with the pressure vessel and if set point value exceeds then the corresponding output value is provided for the controlled output valve through I/p converter.

II. PROCESS DESCRIPTION

The experimental approach for pressure process is done with pressure control trainer kit. The pressure process kit is interfaced with controller. The control action is carried out in this experiment is on-off control action. The On-Off control action is implemented in controlled output valve which is operated by controller inputs. At first, the pressure vessel is supplied with pressurized air by using high pressure compressor air (HPC) at the input valve. The input valve is manually controlled which made to open partially. The pressure [7] created inside the vessel is indicated by pressure gauge fixed on the head of the cylinder. The capacitive type pressure sensor attached along with the cylinder generates current corresponding to the pressure present in the vessel. Since current from pressure sensor is of minimum value, the output current is converted into voltage (I/V) with specific resistance. The output voltage signal is then acquired the controller. The dynamic change of voltage is considered as process variable, each voltage value denotes its corresponding pressure value. The controller generates voltage to get the desired output by adjusting the control valve to perform on-off control action (open/ close).

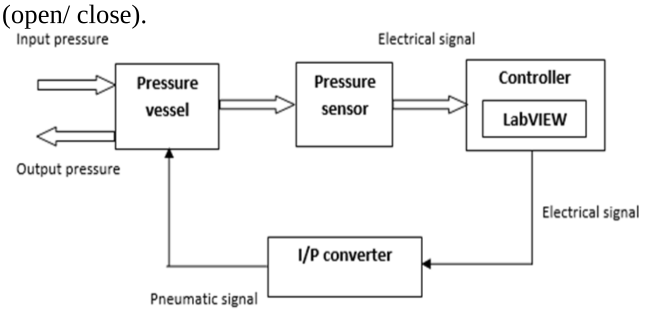

Fig. 1: Block diagram of complete pressure process.

The output voltage generated by the controller which is converted into current (V/I) to operate I/P converter. The I/P converter generates corresponding pressure to open or close the output valve. When the output valve should be opened/ closed is decided graphical programming of controller. The set point is considered as the maximum pressure level, when the process variable exceeds the set point then the controlled output valve performs on-off control action automatically which prevent the process from damage. On-off control action undertakes the safety issue when it exceeds the set point.

III. SOFTWARE IMPLEMENTATION

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming [8] environment which has become prevalent throughout research labs, academia and industry. It is a powerful versatile analysis and instrumentation software system for measurement and automation. Its programming language called G Programming, which is performed using a graphical block diagram that compiles into machine code and eliminate a lot of syntactical details. LabVIEW offers more flexibility than standard laboratory instruments because it is software based.

A. G- Programming

LabVIEW ties the creation of user interfaces (called front panels) into the development cycle. LabVIEW programs or subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, front panel and icon/connector panel. The front panel is built using control palette and indicators built by function palette. Controls are inputs – they allow a user to supply information to the VI. Indicators in block diagram are the outputs – they indicate or display, the results based on the inputs given to the front panel of VI. The back panel, which is a block diagram, contains the graphical source code. All of the objects placed on the front panel will appear on the back panel as terminals. The back panel also contains structures and functions which perform operations on controls by users and output data to indicators. The structures and functions are found on the Functions palette and can be placed on the back panel. Collectively controls, property nodes, indicators, structures and functions will be referred to as nodes. Nodes are connected with each other using wires – e.g. two controls and an indicator can be wired to the addition function so that the indicator displays the addition of the two controls.

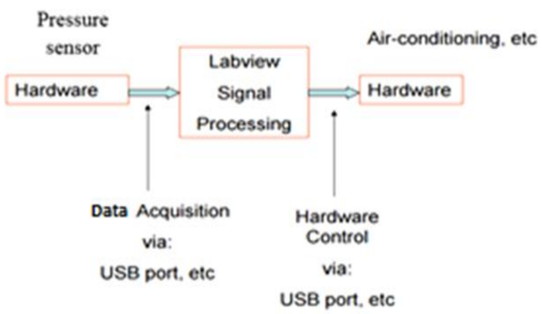

Fig. 2: A Schematic diagram of an instrument system based on LabVIEW.

Thus a virtual instrument can either be run as a program, with the front panel serving as an interacting module with the users, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs of the nodes through the Icon/ Connector pane. This implies each VI can be easily examined before being embedded as a subroutine into a main program.

The above figure is the (a) atic diagram of simple data acquisition from pressure sensor used in air conditioner, where the amount of gas is sensed. The operation to be carried out is represented in graphical manner.

The graphical approach also allows non-programmers to build programs by dragging and dropping virtual representations of lab equipment with which they are already aware of it. The LabVIEW environment of programming, with the included examples and documentation, makes it simple to create basic applications. This is a benefit on one hand, but there is also a certain danger of underestimating the expertise programmer needed for high-quality G programming. For difficult algorithms or large-scale code, it is important that the programmer possess an extensive knowledge of special LabVIEW syntax and the topology of its memory management. The most advanced LabVIEW development programming systems offer the possibilities of building stand-alone applications. Furthermore, it is possible to create distributed application, which communicate by a client/server scheme, and are therefore easier to implement due to the inherently parallel execution in nature of G.

B. VI Description

LabVIEW program has built in template VI's that include the front panel and block diagram, control palette, and function palette. The following procedures are to be followed for constructing the VI.

1) The front panel is designed corresponding to requirements of system (fig: front panel). The panel consist of set point control, process variable and output variable indicator, arrangement of comparison between set point Vs process variable (chart 1) and output variable (chart 2) in waveform chart.
2) The pressure sensor output is acquired through DAQ assistant, in which the acquired voltage is continuously compared with the set point. When the process variable exceed the set point (i.e.) the PV is greater than SP then the output valve is set to open to decrease the pressure.
3) In default the output valve is supplied with pressure to remain it in closed manner. When the PV exceeds then the DAQ assistant generate corresponding voltage through NI ELVIS which is converted to current to operate I/P converter.
4) The program is performed continuously within the while loop, where the set point and process variable, and output variable are monitored.
5) The safety monitoring VI is presented indicating the alarm system when the pressure exceeds the set point limit.

IV. HARDWARE IMPLEMENTATION

The hardware execution of proposed process setup is shown in the figure 3 which gives the detailed description. As discussed, the pressure sensor used here act as transmitter which is fitted on the vessel. The input air pressure provided by the compressor is manually adjusted to regulate the inflow.

The pressure sensor output is connected to NI ELVIS breadboard where current to voltage conversion occurs. The voltage is acquired through analog input channel AI 0+ and AI 0- to ground.

Fig. 3(a)

Fig. 3(b)

Fig. 3(a) & 3(b): Hardware Implementation of Pressure Process through NI ELVIS

The output voltage generated from NI ELVIS through AO 0 to the breadboard where voltage to current conversion occurs to operate I/P converter. The pressure is supplied to the controlled output valve corresponding to the current given to converter. The process purely controlled with on-off control action which is regulated by LabVIEW software.

The experimental approach for pressure process is done with pressure control trainer kit. The pressure process kit is interfaced with Labview through NI ELVIS hardware [5], where Labview acts as a controller. The control action is carried out in this experiment is on-off control action. The On-Off control action is implemented in controlled output valve which is operated by LabVIEW inputs.

At first, the pressure vessel is supplied with air by using high pressure compressor air (HPC) at the input valve. The input valve is manually controlled which made to open partially. The pressure [7] created inside the vessel is indicated by pressure gauge fixed on the head of the cylinder.

The capacitive type pressure sensor attached along with the cylinder generates current corresponding to the pressure present in the vessel. Since current is not much compatible with NI ELVIS, the output current is converted into voltage (I/V) with specific resistance.

The output voltage signal is then acquired through NI ELVIS to Labview. The dynamic change of voltage is considered as process variable, each voltage value denotes its corresponding pressure value. The LabVIEW software acts like controller, which further generates voltage to operate output valve (open/close). The output voltage generated through NI ELVIS which is converted into current (V/I) to operate I/P converter.

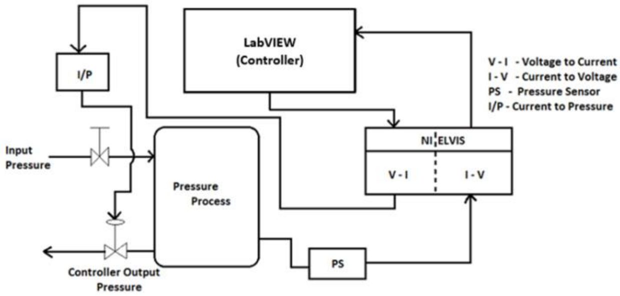

Fig. 4: Schematic diagram of pressure process in ELVIS interface.

The I/P generates corresponding pressure to open or close the output valve. When the output valve should be opened/ closed is decided by LabVIEW graphical programming. The set point is considered as the maximum pressure level, when the process variable exceeds the set point then the controlled output valve performs on-off control action automatically, which prevent the process from damage. On-off control action undertakes the safety issue when it exceeds the set point.

V. ON-OFF CONTROL OF PRESSURE PROCESS

In this process the pressure is being controlled using on-off control action. The control valve in on-off control has only two position either it is fully closed or fully open. This control element does not operate at any intermediate position, i.e. partly open or partly closed. The control system made for controlling such elements is known as on- off control theory **[4]**. In this control system, when process variable changes and crosses certain preset level, the output valve of the system turns to fully opened and gives 0% output. Generally in on- off control system, the output causes change in process variable. Hence due to effect of output, the process variable again starts changing in reverse direction. During this change, the process variable regains the predetermined level, then output valve of the system is immediately closed and output is immediately turns to 100%. When it crosses below the preset level, the output valve of the system is fully closed to give 100% output. This cycle of closing and opening of output valve continues till the system is in operation. Mechanical functioning final control pneumatic actuator [4] is shown in fig 6 along with the graphical explanation of on-off control action mechanism.

Input Pressure (psi)	Output Voltage (v)
5	0.5
10	0.9
15	1.3
20	1.5
25	1.7
30	2
35	2.1
40	2.3
45	2.4
50	2.5
55	2.6
60	2.6

Table 5 (a)

Input Voltage (v)	Output Pressure (psi)
8.6	55 (close)
0	2 (open)

Table 5 (b)

Table 5: 5(a) Tabulation for I/P pressure and pressure sensor output. 5(b) Tabulation I/P voltage generated to regulate On-Off control action of output valve.

The readings are noted according to the input pressure applied manually by the user. The output voltage of tabulation in table 5(A) is from pressure sensor through I/V converter, and the input voltage of tabulation in table 5(B) which is generated by the LabVIEW through NI ELVIS hardware is given to i/P converter to regulate on-off control action in the controlled output valve.

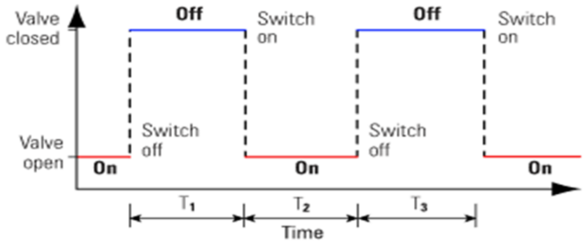

Fig 6: On-Off control graphical representation of pneumatic actuator

VI. Result

The objective work of pressure process is being controlled and monitored & safety issue in industrial process is examined in a small scale with pressure control trainer kit. The overall process is purely controlled and monitored with LabVIEW software along with NI ELVIS hardware in an effective manner.

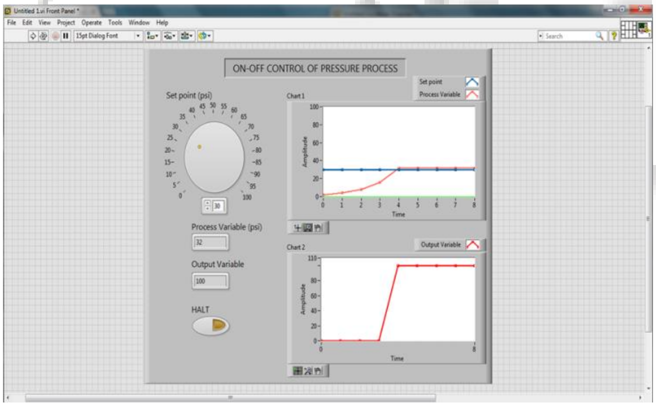

Fig 7: Front panel design for On-Off control action of pressure process

From figure 7 the design of front panel [10] in LabVIEW software for controlling and monitoring the pressure process with on-off control action. The set point is user defined which is considered as the maximum pressure that the vessel has to be maintained within that limit. The dynamic changes in pressure occur in the pressure vessel is sensed by pressure sensor, where the output voltage is considered as process variable. When the process variable exceeds the set point then the on-off control action takes place on the output controlled valve.

From figure 8 the design of front panel in LabVIEW software for the safety monitoring purpose. The process is continuously monitored, when the pressure level is indicated in three levels. When the Boolean LED3 glows, which indicate that the pressure is below 5 psi. If the pressure retains in the normal level then the Boolean LED 2 glows, which indicate that the pressure is within the limit. If the pressure exceeds the preset level then the Boolean LED 1 glow which indicates the pressure is greater than 30psi.

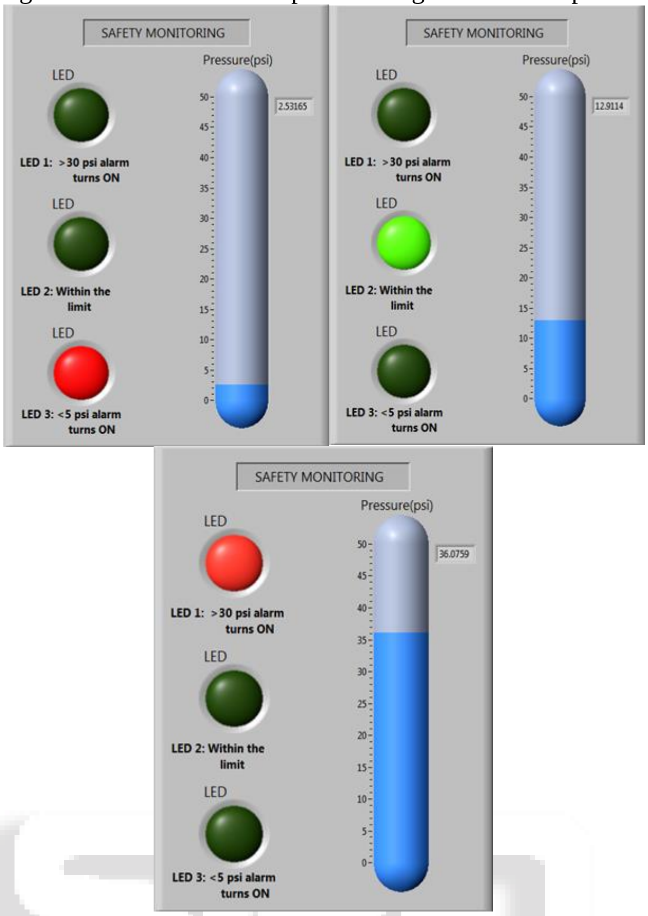

Fig. 8: Front panel design for safety monitoring of pressure process.

VII. Conclusion

The intension of this experiment is carried out in an efficient manner. The beginning step of this control action can be enhanced in different manner. The proposed configuration will be implemented as feedforward, feedback and moral predictive control configuration in fore-coming research. The proposed article has planned to enhance through the LabVIEW software which can be taken up in operating the process through Web server, setting up by sharing the data of the system through E-mail or mobile notification to the controller in the control room.

References

[1] Janani Rajaraman and K.Saraswathi, "A Labview Based Monitoring and Controlling of Various Process Variables", International Journal of Advanced Research in Electrical Electronics and Instrumentation Engineering Volume 3, Issue 10, October 2014

[2] Sanjoy Kumar Chakraborty, Nilotpal Mannaand Surodh Dey, "Importance of three -elements boiler drum level control and its installation in power plant", International Journal of Instrumentation and Control Systems (IJICS) Volume 4, No 2, April 2014

[3] Koprda, S.; Turcani, M.; Balogh, Z., "Modelling, simulation and monitoring with the use of LabVIEW", Application of Information and Communication

Technologies (AICT), 2012 6th International Conference on, vol., no., pp.1,5, 17-19, Oct 2012.
[4] M. F. Rahmat, N. H Sunar Sy Najib Sy Salim, Mastura Shafinaz Zainal Abidin, A. A Mohd Fauzi and Z. H. Ismail, "Review on Modeling and Controller design in pneumatic actuator control system", International Journal on Smart Sensing and intelligent Systems volume 4, no 4, December 2011
[5] Prof. Hiren J. Patel, Prof. Robinson P. Paul, Prof. Ghansyam B. Rathod, Prof. Rajvirsinh Rana, and Palak Patel, "Temperature monitoring and control system using NI ELVIS and LabVIEW", International Journal on Recent and Innovation Trends in Computing and Communication Volume 2, Issue 7, 2011
[6] B.Hemalat, Dr. A.Vimala Juliet, N.Natarajan, "Boiler Level Control Using Labview", International Journal of Computer Applications (0975 - 8887) Volume 1, No. 17, 2010
[7] J Jorstad, "Pressure assisted processes for high integrity aluminium castings",International Journal of MetalcastingFTJOctober 2009
[8] Getting Started with LabVIEW, June 2013 Available from http://www.ni.com/pdf/manuals/373427j.pdf
[9] NI ELVIS User guide, http://www.csus.edu/indiv/d/degraffenreidw/electronics/ELVIS.pdf
[10] Santori, M., "An instrument that isn't really (Laboratory Virtual Instrument Engineering Workbench)", Spectrum, IEEE, vol 27, no 8, pp 36, 39, Aug 1990
[11] Jevoitha Jerome, "Virtual Instrumentation Using LabVIEW".
[12] D. Patranabis, "Instrumentation and Control".