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Monitoring and Controlling of Boiler Drum Parameters using NI-myDAQ and LabVIEW

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ABSTRACT: Boiler systems in power plants require monitoring on continuous basis and inspection at regular intervals. There can be errors in measuring boiler parameters and different stages of boiler system are to be monitored manually. So a reliable monitoring system is necessary to ensure safe and continuous operation of boiler. The proposed work outlines the design and development of boiler automation system using NI-myDAQ, LabVIEW, temperature sensors and pressure sensors. The NI-myDAQ and LabVIEW are interfaced via RS 232 communication. LabVIEW is used to monitor temperature and pressure inside the boiler using their respective sensors and the corresponding output is given to the NI-myDAQ which controls the temperature and pressure level. If the temperature and/or pressure inside the boiler exceed the predefined range, the corresponding valve release pressure and raises an alarm to alert the user. The proposed boiler automation ensures safe, reliable and continuous operation of boiler system and hence of the power generation plant.

KEYWORDS: Boiler automation,NI-myDAQ, LabVIEW, RTD.

I.INTRODUCTION

Boiler systems in power plants require monitoring on continuous basis and inspection at regular intervals. There are numerous possibilities errors in measuring boiler parameters and various stages are monitored manually and hence the system is prone to malfunctioning [1]. A steam turbine extracts thermal energy from pressurized steam coming from the boiler and generates rotary motion to drive an electrical generator. Industrial steam turbines represent one of the largest populations of prime movers used in many industries for a wide variety of applications. This underscores the significance of temperature and pressure control of boiler systems.
Further, the power plant automation involves automatic control of all the processes to achieve improved efficiency of the system. Further, such automation reduces human resource needs and enhances cost efficiency. The demand for automated machines in power plants keeps increasing for better efficiency and improved performance.

Anish Mathew has proposed an internal model for control of the pressure process using ARM Microcontroller [2]. The PID and Internal Model Control (IMC) algorithm are embedded into the target ARM microcontroller and its performance is studied with real time experimental setup.

Saurav Kumar has presented a multiple parameter monitoring and controlling for a boiler using PIC controller [3]. High pressure boilers provided with optimized heat transfer areas, for its rated duty, are used in this model. Boiler parameters like pressure, drum water level and water flow are monitored and controlled by PIC controller.

Shital S. Chopade et al. have proposed a system which monitors boiler temperature, pressure and volume of steam using various sensors which provide input to PLC [4]. The output of PLC controls the boiler temperature and pressure

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and generates desired volume of steam. Automated check valves are deployed to release pressure and an alarm is raised in case of an emergency.
The proposed work outlines the design and development of a simple boiler automation system using NI-myDAQ, LabVIEW and a PID controller to sense and to ensure that the temperature and pressure inside the boiler remains stable within the predefined range.

The paper is organized as follows: Section II presents the proposed methodology for temperature and pressure control with respective flowcharts. While Section III describes the boiler control automation in LabVIEW, Section IV discusses the experimental results. Section V presents conclusions of the work.

II. PROPOSED METHODOLOGY

The work integrates a NI-myDAQ board for data collection from field sensors deployed within the boiler, data evaluation and generation of an appropriate output signal for the boiler operation in accordance with a pre-specified procedure. The proposed system has 3 sections:
Boiler section: Closed boiler drum, sensors & a heater are assembled together to constitute the boiler section.
Controlling section: The NI myDAQ and Arduino Uno controller are employed for data collection from temperature sensor and the analysis of data so collected. Appropriate output signals are generated for automatic actuation and termination of peripherals used in the system.
Power supply section: This section meets the power requirements of the unit and comprises of the circuits for providing DC power for the RTD-temperature sensor and steam valve.

The process parameters of the plant are monitored and applied as the input parameters, through Data Acquisition System, to the LabVIEW VI. The block diagram, shown in Figure 1, describes monitoring and controlling of temperature and pressure of boiler using NI-myDAQand LabVIEW.The boiler control automation consists of NI-MyDAQ for data acquisition, LabVIEW to monitor and control the operation of boiler, Resistive Temperature Detector Pt-100 (RTD Pt-100) temperature sensing, pressure gauge for pressure monitoring and a steam valve to allow the steam to go out of the boiler.

Flowchart for Temperature Control:
The flowchart of the temperature control program is shown in Figure 2. This consists of setting the threshold point in the front panel of LabVIEW, followed by setting the maximum value and minimum value for PID controller. As the heater device is powered up, the temperature of water increases. The temperature sensor senses temperature of water in

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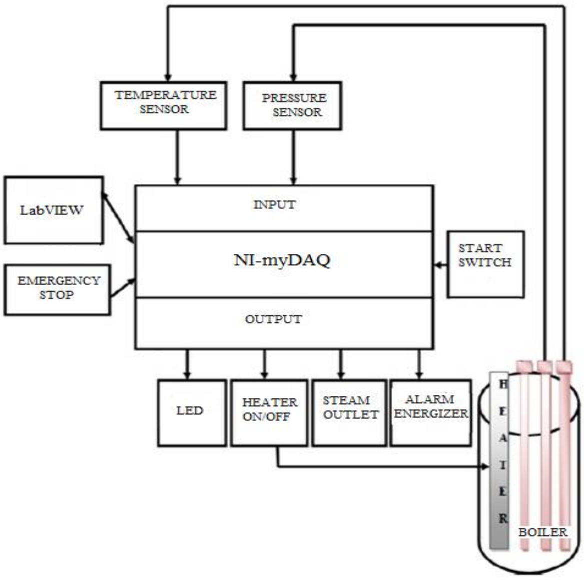

Figure1: Block diagram of boiler control automation.

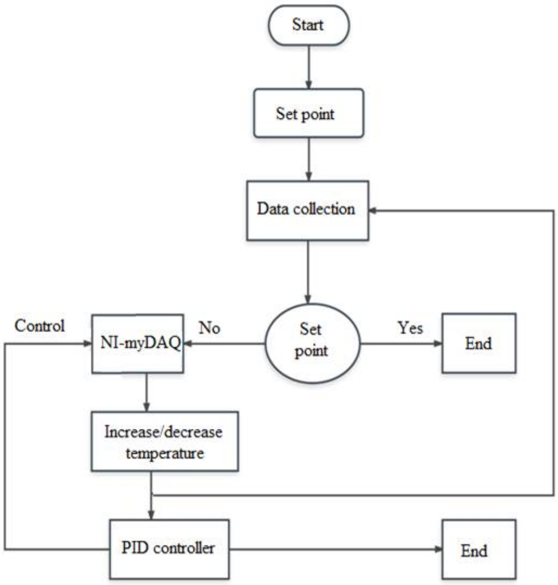

Figure 2: Flowchart for Temperature Control.

the boiler in real time and send it to the NI-myDAQ data acquisition board. The board collects the real time data and sends it to LabVIEW. The system processes and analyzes the data using PID controller. When the temperature reaches the set point, the system completes the task. If the set point is not reached, the data acquisition board adjusts the PID controller and gives a feedback value to the system. The system waits till the temperature reaches the set point and completes the task.

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Flowchart of Boiler Operation:

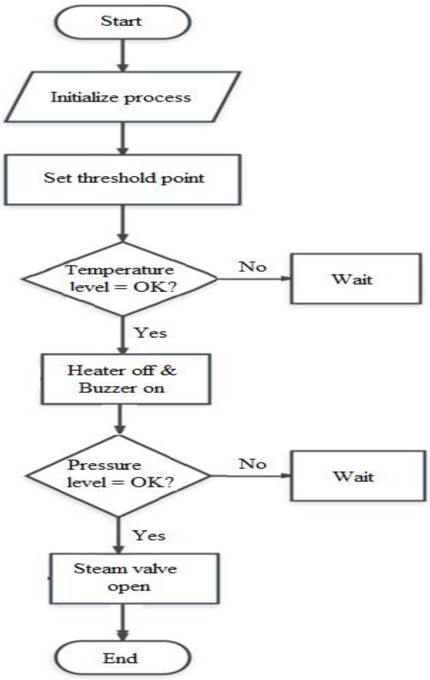

Figure 3: Flowchart for boiler operation.

The flowchart for boiler operation is as shown in Figure 3. This involves setting the threshold values of temperature and pressure in LabVIEW. After temperature control, pressure is sequentially sensed until the set point is reached and then opening the steam valve and raising an alarm.

Experimental setup:
A prototype of boiler control system is developed to demonstrate the proof of concept of boiler monitor and control. A pressure cooker acting as a boiler provides a means for combustion of heat to be transferred into water. The steam temperature has to be kept under control to negate the excess utilization of water in the boiler. The parameters such as pressure and temperature levels of the boiler are measured and the data is input to the NI-myDAQ processor. The NI-myDAQ processor monitors the real time values of the parameters and if the value exceeds the threshold value it automatically controls them by using the driver circuit connected to the boiler. The boiler parameters are monitored and the graphical representations of values are transmitted over RS232 serial communication and displayed in LabVIEW.

III. CONTROLLING IN LABVIEW

The interface design for front panel in LabVIEW, an important part of virtual instrumentation, is as shown in Figure 4. The main functional areas of the interface include parameter input area, data display controls area and results display area [5]. The threshold values for the temperature and pressure are set on front panel. The parameter variations of temperature and pressure level are compared with the threshold values using the comparator. If the parameters rise above the specified threshold, it is represented as an abnormal condition in the front panel. Otherwise, it is indicated as normal. In this setup, the temperature is set as 120 □ as the set point or the threshold value. The values are continuously monitored and if the temperature or pressure exceeds the set value, it controls the steam valve and alerts the operator. A Run/Stop switch is provided on the front panel for manual operation of the boiler.

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The functional block diagram of the proposed boiler control system, in LabVIEW, is shown in Figure 5. The target temperature and pressure is collected by the system and the real time temperature and pressure is passed on to the PID controller with the control values and is monitored continuously.

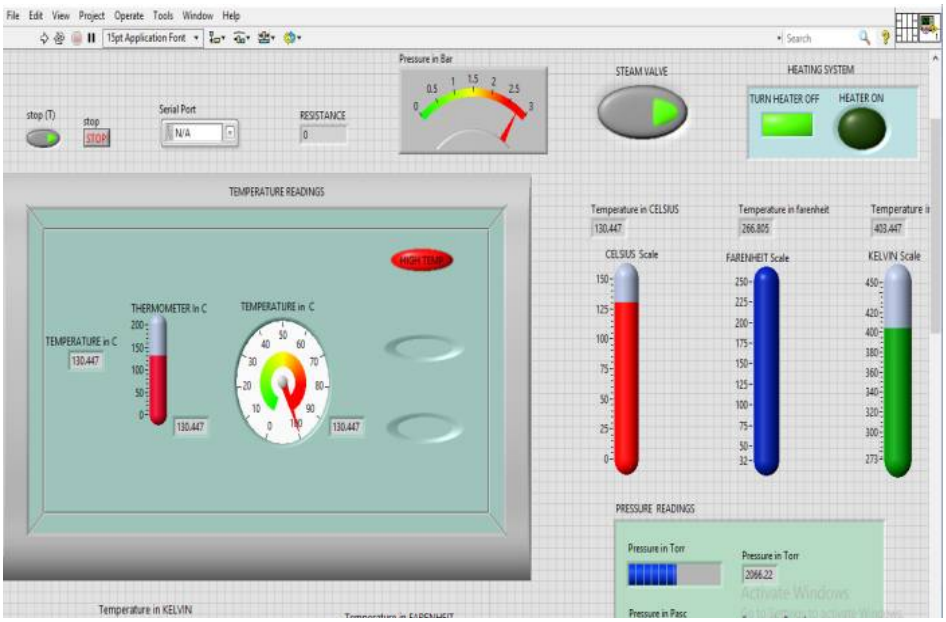

Figure 4: Front panel of proposed system.

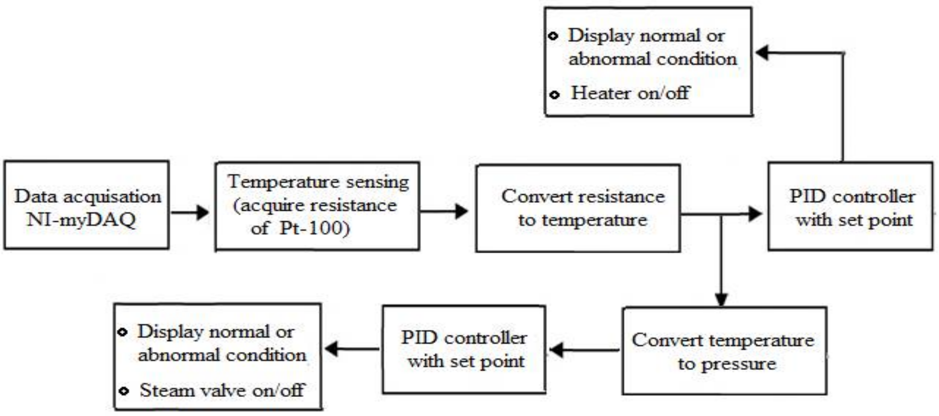

Figure 5: Functional block diagram of the proposed boiler control.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The temperature and pressure control in boiler based on PID control is presented on waveform charts as shown in Figure 6(a) and Figure 6(b), respectively. The threshold point is set and the PID controller is tuned to switch the temperature to 120 ℃ at the upper end and 80 ℃ at the lower end and the pressure to 2 bar at the upper end and 0 bar at the lower end. The target temperature is set at 95 ℃, as indicated by red curve in Figure 6(a), the initial PID gain

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parameters are input and the run button is activated. Then the system starts running and the temperature increases steadily. When the temperature reaches 95 □, the PID VI with auto tuning function is able to keep the process temperature within ±½ ℃ of the set point.

The result shows that when the real time process temperature, represented with white curve in the graph, increases to the set point of 95 ℃, the system becomes stable and the temperature stops increasing further. Thus it is observed that the PID controller program is making timely adjustments and hence, the temperature control is achieved.

For pressure control, the target pressure is set as set point at 1 bar, as indicated by red curve shown in Figure 6(b). The result shows that when the real time process pressure, represented by the white curve in the graph, increases and reaches the set point, the PID controller sends a high signal to activate the solenoid valve to open, thus releasing pressure from the boiler. The boiler system becomes stable and the pressure stops increasing further.

The list of datasheet value of temperature in ℃ and the experimental value of temperature in ℃ for different values of resistance of RTD Pt-100 temperature sensor is tabulated in Table 1.

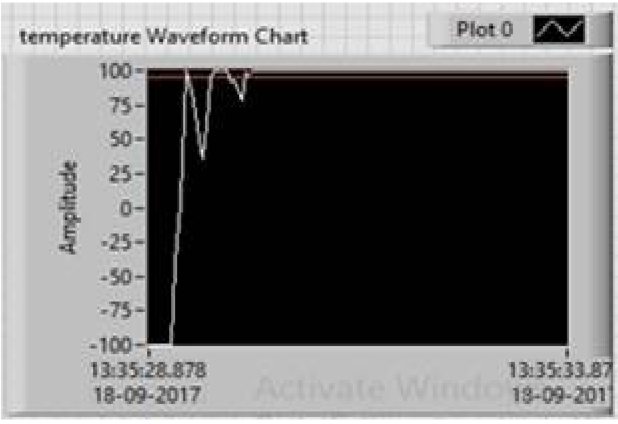

Figure 6(a): Temperature control based on PID at temperature = 95 ℃.

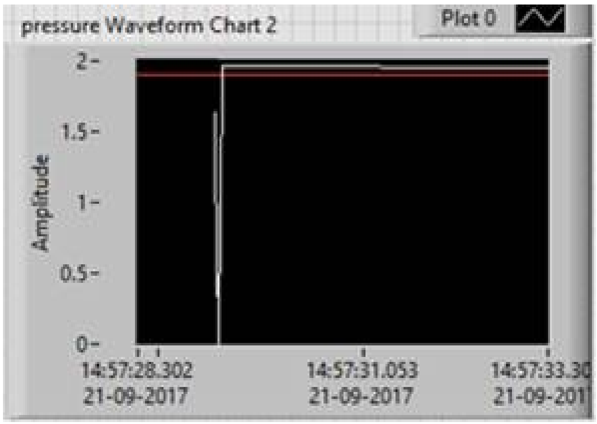

Figure 6(b): Pressure control based on PID at pressure = 1.8 bar.

Table 1: Comparison of datasheet and experimental value

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Sl. No.	Resistance (Ω)	Datasheet Temperature(□)	Experimental Temperature (□)
1.	110.90	28	28
2.	113.61	35	35.1
3.	125.17	65	65.2
4.	130.14	78	78.1
5.	141.53	108	108.3

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V.CONCLUSIONS

Automation of boiler operation with regard to the monitoring and control of its temperature and pressure using LabVIEW and NI-myDAQ is demonstrated with a prototype of a boiler that mimics the operation of a large boiler in a power plant system. Within the constraints of the design and the limits of the physical configuration, the system performs successfully and meets the design specifications.

Fault detection is achieved by comparing the temperature and pressure values of boiler plant with the reference set of values. Any variations exceeding the pre-specified range indicate the faults in the process which can thus be detected and corrected. All the data of the process and the data of LabVIEW front panel screen are maintained as a record and stored for future reference.

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