

Internet Based Boiler Drum Level Control System Using LabVIEW

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Abstract-- An Internet based boiler drum level control system is developed, which enables the students for deeper understanding of the boiler theory, the real experiences on design and implementation of control system. In this work, remote accessed virtual laboratory for 3 types of control of boiler is established using the internal model control (IMC) method. The student can access the remote laboratory and perform experiments without any limitation of time and location by using internet. They can also observe the system performance by changing the set point of the experiment and evaluate the results. Internet based laboratory is cost-effective.

Keywords: Boiler Drum Level Control; Remote Access; Internet; LabVIEW

I. INTRODUCTION

The constant technological progress of the Internet and the World Wide Web (www) has fundamentally altered the practice of distance teaching and learning. Different terminologies have been used for online learning. Terms that are commonly used include (i)E-learning (ii)Internet learning (iii) Distance learning (iv)Networked learning (v)Tele-learning (vi)Virtual learning (vii)Computer-assisted learning (viii)Web-based learning. All of these terms show that the learner is at a distance from the tutor or instructor. Information and communication systems, serve as specific media to implement the learning process. E-learning enabled transfer of skills and knowledge essentially by the computer and network. [1]. E-Learning can also provide benefits for the organizations and individuals such as improved performance, increased access, convenience and flexibility to learners.

Computer-based training reduces overall training time over traditional classroom training. Staying in one location such as home, office, airport, coffee shop without travelling to other locations, reduces the cost of transportation to physical classrooms. In technical education to understand different subjects, experimental tests are conducted in laboratories for the student. In reality, it is very expensive to build such technical laboratories. In spite of that there is time limitation to use this kind of laboratories and in many cases, more than one student has to use an experimental set at same time. Remote virtual laboratories are prepared using some simulation and animation programs on computers. In order to use virtual laboratories, a distance access can be provided by using communication technologies such as internet, General Packet Radio Service (GPRS) and Wireless Application Protocol (WAP). Particularly internet technology is now widely used in

education, business and social lives. Automatic control laboratory is needed for the students to have a deeper understanding of boiler control system design and implementation, but it will be of high cost and need more hours of course time. In order to lower the cost and save the course time, an internet based boiler level control system has been developed, which will enable the students to conduct the control experiment at any time using a remote computer that is connected to the internet [2,3].

Boiler drum water level control is critical to secure operation of the boiler and the steam turbine. Too low a level may overheat and damage boiler tubes. Too high a level may interfere with separating moisture from steam, which reduces efficiency of boiler and moisture carries into the process or turbine. The boiler drum-level control system maintains the constant level by means of regulating boiler feed water when the steam load changes or process disturbances occur.

Usually, 3 element Proportional Integral Derivative (PID) control system is introduced to regulate the drum level with the fixed PID parameters. The control is not ideal because the gains and time constants of the system response change significantly with the change in steam load and disturbances. Therefore, some other controller is required to improve the performance of drum level control system.

The Internal Model Control (IMC) structure provides a suitable framework for satisfying our objectives. IMC was introduced by Garcia and Morari. Using the IMC design procedure, controller complexity depends exclusively on two factors: the complexity of the model and the performance requirements stated by the designer. Furthermore, the proposed procedure provides valuable insight regarding controller tuning effects on both performance and robustness [4].

In process control industry, model-based control strategy is used to track set point and reject load disturbances. This work has illustrated how to design an IMC controller for the boiler level control system using the circuit design tool kit in LabVIEW. The objective of this work is to design an internet based remote boiler drum level control system. So, the solution proposed in this paper runs the LabVIEW 10.1 software on the server side and on the client side only a browser is needed.

Organization of the paper is as follow, Section II describes the types and design of boiler. In Section III development

of virtual laboratory is explained. In Section IV result and comparison between the boiler performances is discussed. The paper concludes in Section V.

II. BOILER DRUM LEVEL CONTROL

Boiler drum level control is critical for the protection of plant and equipment safety. It applies to maintain the equal high and low levels of water within the boiler drum. The purpose of the drum level controller is to bring the drum level up to the boiler start-up and maintain the level at constant steam load [5]. Different types of boiler drum level control are as follows:

A. Single element drum level control

The simplest form of drum level control is the single element control. It is least effective. It requires a drum level measurement and a feed water control valve. The drum level transmitter transmits the process variable (PV) signal. This PV signal is compared to a set point and the difference is a deviation value. This signal is passed by the controller which generates corrective action in the form of a proportional output. The output is then acted to the boiler feed water valve, which then adjusts the level of feed water flow into the boiler drum.

B. Double element drum level control

The two-element drum level controller can be applied to a single element boiler drum where the feed water is at a constant pressure. It requires drum level measurement, load demand measurement and feed water valve control. The load demand change is typically inferred from the steam flow rate measurement. The Two-Element Drum Level Control uses two variables i.e. drum level and steam flow to manipulate the feed water control valve. Steam flow load changes act as a feed forward controller to the feed water control valve providing an initial correction for the load changes. The steam flow range and feed water flow range are matched so that a one pound change in steam flow results in a one pound change in feed water flow. The summation combines the steam flow signal with the feedback action of the drum level controller which makes trim adjustments in feed water flow, as required, to compensate for unmeasured blow down losses and steam flow measurement errors.

C. Three element drum level control

The three-element drum level control is mainly suited where a boiler plant consists of multiple boilers and multiple feed water pumps or where the feed water has variations in pressure or flow. It has three variables: Level, Steam flow rate and Feed water flow rate which are used to manipulate the feed water control valve. This system basically cascades the output of the two element system to the feed water flow controller. Three element boiler drum level control is shown in Figure 1.

This system provides control during transient condition because the two controllers provide independent tuning to minimize phasing interaction present in the two element approach. The addition of the faster feed water secondary loop assures an immediate correction for feed water disturbances [6,7]. The drum level controllers accurately compensates for effects of smaller unmeasured flows such as blow down and mismatch between the two flow measurements. As in the two-element system, nearly all the compensation for change in load is handled by the feed forward portion while the drum level feedback loop provides only trimming action. This system can handle large and rapid load changes as well as feed water disturbances regardless of boiler capacity. This approach is required on multiple boilers having a common feed water supply.

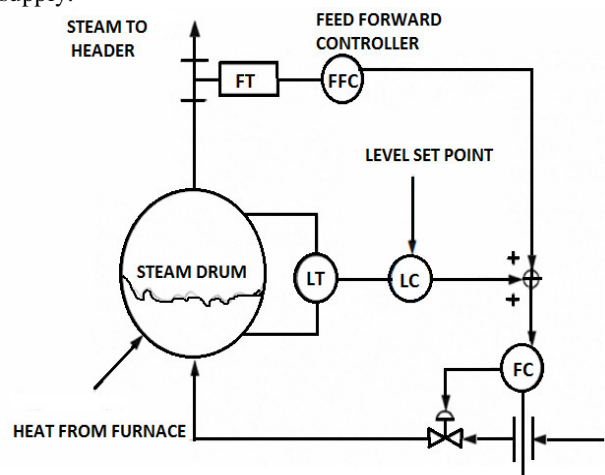


Fig.1 Three element boiler drum level control.

The IMC based PID controller algorithm is robust and simple to handle the uncertainty in model. This method seems to be a useful trade-off for the performance of the closed loop system. It achieves robustness to model inaccuracies with a single tuning parameter. The IMC design procedure can be used to solve quite a few critical problems especially at the industrial level (using the concept of designing a model of the actual plant process). It also gives good solutions to processes having a significant time delay which actually happens when working in a real time environment. For tuning the controller the filter tuning parameter λ value is varied. According to that various effects of discrepancies enter in the system thus, best performance is achieved. Hence, a good filter structure is one for which the optimum λ value gives the best PID performance.

Figure 2 shows the block diagram of IMC based PID controller of 3 element boiler level control in which steam flow element acts as a feed forward controller, level element acts as a primary loop and flow element acts as a secondary loop in the cascade controller [8,9]. Level element and steam flow element mainly correct for unmeasured disturbances in the system. Feed water flow element responds rapidly to variations in feed water

demand either from the steam flow rate feed forward signal and feed water pressure or flow fluctuations.

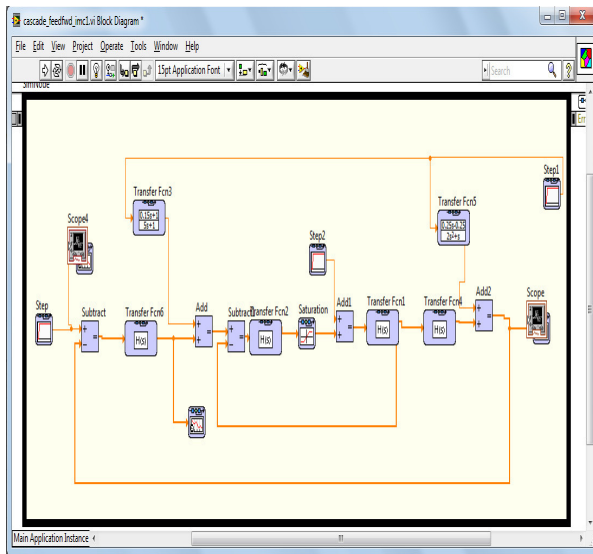


Fig 2. Block diagram of 3 element boiler level control

Figure 3 shows the step responses of IMC based controller in which unit step set point is given. Its rise time is very small and peak overshoot is very low. As a result, the overall performance of the controller is very fast.

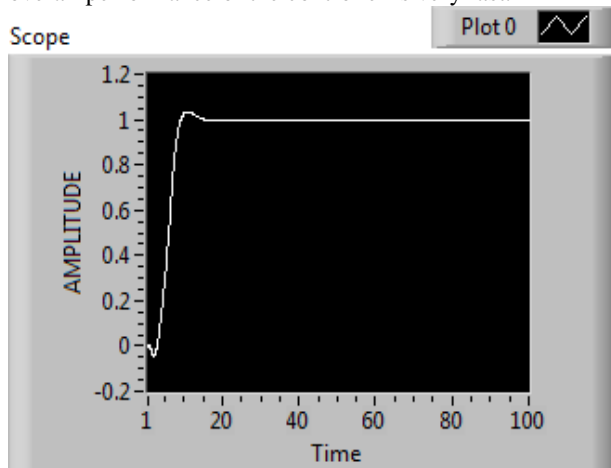


Fig 3. Response of boiler drum level for unit step input.

III. DEVELOPMENT OF VIRTUAL LABORATORY

A block diagram of developed educational tool based on internet is shown in Figure 4. In order to develop the program on a server computer, LabVIEW and LabVIEW WEB Server (LWS) are used in this work. Simulation of boiler drum level control model is created in LabVIEW by circuit design and simulation toolkit. To access the boiler drum level control system through an internet LWS program is used [10]. When all mentioned programs are appropriately operated on a server, a user friendly powerful educational program can be obtained. On the computer of

clients or student, only internet connection and internet explorer program are enough to access the educational tool. So, they do not need any additional programs and expenses.

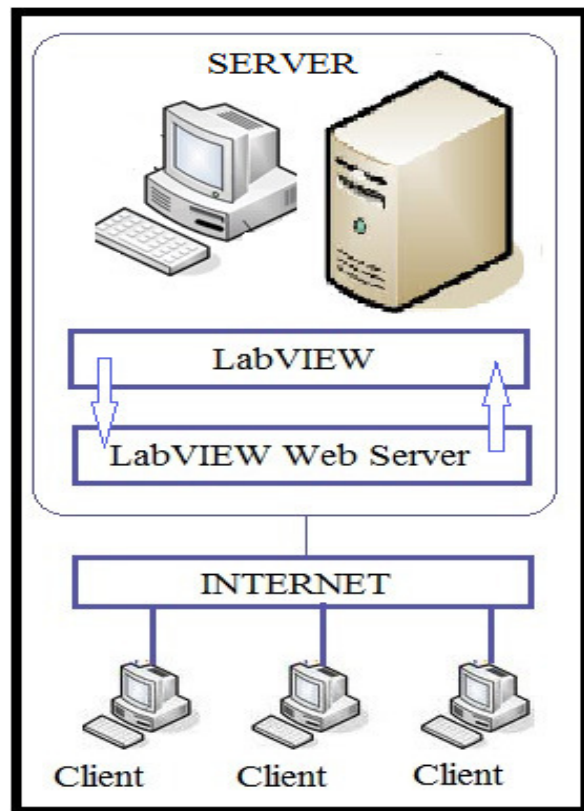


Fig 4. Block diagram of developed educational tool based on internet.

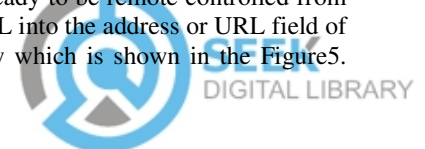
A. Web Server Configuration

To publish virtual instruments (VIs) on the Web, the Web Server must be enabled. The Web Publishing Tool is a LabVIEW built-in tool to publish the front panel of a VI as a HTML document to the web. There are three steps from choosing a VI till saving the HTML file to disk. Steps are as follows:

Step1: "Select VI and Viewing Options": This option publish the VI, which must be in memory of the LabVIEW. The "Viewing Mode" can be changed between "Embedded", "Snapshot" and "Monitor". Embedded allows clients to view and control the front panel. Snapshot allows only to display a static image of the front panel. Monitor allows to display a snapshot with a configurable updating interval.

Step2: "Select HTML Output" In this step we can type the title (document title), a text before (header) the front panel and text after (footer) the front panel which is going to be displayed on the web page.

Step3: "Save the New Web Page" In this step the created HTML file of the VI is going to be saved to a directory with the selected filename and a URL will be created. After saving it, the VI now is ready to be remote controlled from a client by typing this URL into the address or URL field of his Web browser window which is shown in the Figure5.



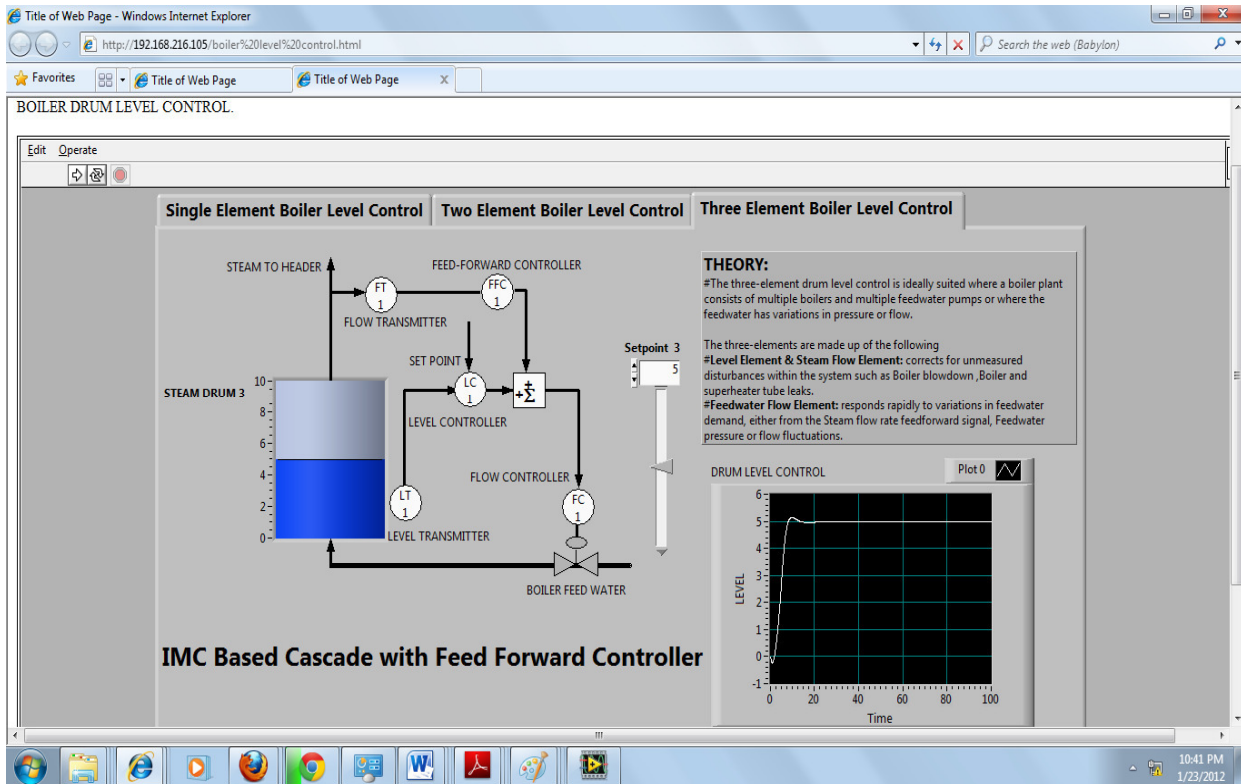


Fig 5. Web page of the developed boiler drum level control laboratory

IV. RESULT AND COMPARISON

This paper presents a general method to create web based remote laboratory. The user interface is shown in Figure 5 through which the user can select the boiler from 3 different boilers and set the set point of the drum water level and compare the differences in their performance. 3 element boiler level response is very fast as compare to other two boilers. In order to save the course time and reduce the system cost, internet based boiler systems have been constructed. This enable the students to conduct the experiment at any time using a computer that is connected to the internet remotely. There are many advantages of using the developed boiler drum level control system laboratory such as (i) Conducting and repeating tests anytime from anywhere. (ii) Avoiding students from electrical and mechanical risks. (iii) Avoid any damage as a result of wrong connections of instruments and machine by students.

V. CONCLUSION

In this work the internet based control system is developed which will make the time required for experiment flexible for the students. It saves much funds for laboratory. The internet control laboratory enables the students to understand the control theory more deeply and have the experience for control system design and implementation.

In future, we are initiating further whole laboratory can be constructed with the help of LabVIEW software.

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