Control of Boiler Operation using PLC – SCADA

K. Gowri Shankar

***Abstract*—This paper outlines the various stages of operation involved in the conversion of a manually operated boiler towards a fully automated boiler. Over the years the demand for high quality, greater efficiency and automated machines has increased in this globalised world. The initial phase of the paper focuses on passing the inputs to the boiler at a required temperature, so as to constantly maintain a particular temperature in the boiler. The Air preheater and Economizer helps in this process. And the paper mainly focuses on level, pressure and flow control at the various stages of the boiler plant. Thus the temperature in the boiler is constantly monitored and brought to a constant temperature as required by the power plant. The automation is further enhanced by constant monitoring using SCADA screen which is connected to the PLC by means of communication cable. By means of tag values set to various variable in SCADA the entire process is controlled as required. At the automated power plant, the boiler is controlled by Variable Frequency Drive (VFD) to put in action the required processes to be carried out at the boiler. Thus the entire cycle is carried out as a paper and at various stages each phase is detailed out. This paper has proved to be very efficient practically as the need for automation grows day by day.**

***Index Terms*—Automation, PLC – SCADA, Boiler.**

I. INTRODUCTION

Over the years the demand for high quality, greater efficiency and automated machines has increased in the industrial sector of power plants. Power plants require continuous monitoring and inspection at frequent intervals. There are possibilities of errors at measuring and various stages involved with human workers and also the lack of few features of microcontrollers. Thus this paper takes a sincere attempt to explain the advantages the companies will face by implementing automation into them.

The boiler control which is the most important part of any power plant, and its automation is the precise effort of this paper.

K. Gowri Shankar is with the Department of Electronics and Communication Engineering, Rajiv Gandhi College of Engineering and Technology, Pondicherry University, India (e-mail: gowri200@yahoo.com)

In order to automate a power plant and minimize human intervention, there is a need to develop a **SCADA (Supervisory Control and Data Acquisition)** system that monitors the plant and helps reduce the errors caused by humans. While the SCADA is used to monitor the system, **PLC (Programmable Logic Controller)** is also used for the internal storage of instruction for the implementing function such as logic, sequencing, timing, counting and arithmetic to control through digital or analog input/ out put modules various types of machines processes. Systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation.

II. DRAWBACK OF CONVENTIONAL SYSTEM

Conventional equipment systems are prone to errors due to the involvement of humans in the data collection and processing using complicated mathematical expressions. Thus what we require is a system that collects raw data, processes it and presents it in values which can be verified and compared with the standard values.

In the coding process of this implementation with micro-controller, it requires a fast and efficient processing which on the other part depends on the length and sub-routines of the coding process. Thus it provides a real challenge with systems involving

III. METHODS

All the values can be filled up by the introduction of the automation technique into the power plants. The automation technique involving the automatic control of all the processes which includes the monitoring and inspection needs provides for a very efficient system. The automation process helps the company having the power plant to reduce the amount of errors that occur , reduction in the human resources, increased efficiency, and most importantly very cost effective.

IV. CRITICAL CONTROL PARAMETERS IN BOILER

A. Level Control

Steam Drum level, De-aerator level and hot well level

B. Pressure Control

Force draft pressure, Induced draft pressure, Steam drum pressure, Deaerator pressure, Turbine inlet steam pressure, balanced draft pressure

C. Flow Control

Air flow, Steam flow, Water flow

D. Temperature Control

Deaerator temperature, Steam drum temperature, Underbed boiler temperature, Turbine inlet steam temperature, Flue gas temperature.

V. AUTOMATION

Delegation of Human Control to technical Equipment aimed to wards achieving.

Advantages

Higher productivity, Superior quality of end product, Efficient usage of raw materials and energy, Improved safety in working condition.

A. History of Control and Automation

PLC
ELECTRICAL CONTROL WITH LOGIC GATES
WITH LOGIC GATES
MANUAL CONTROL

Manual Control

In this, the Control and Automation are done by Manual Operations.
Drawbacks:

- Human Errors subsequently affect quality of end product.
- Hard Wired Logic Control
- In this, Contractor and relays together with timers and counters were used in achieving desired level of automation.
- Bulky and complex wiring, Involves lot of rework to implement changes in control logic, the work can be started only when the takes is fully defined and this leads to longer project time.

Electronics Control with Logic Gates

In this, Contactor and Relays together with timers and counters were replaced with logic gates and electronic timers in the control circuits.

Advantages

- Reduced space requirements, energy saving, less maintenance and hence greater reliability.
- The Major Drawbacks
- Implementation of changes in the control logic as well as reducing the project lead- time was not possible.

Programmable Logic Controller

In this, instead of achieving desired control and automation through physical wiring of control devices, it is achieving through program say software.

Advantages

Reduced Space, Energy saving, Modular Replacement, Easy trouble shooting, Error diagnostics programmer, Economical, Greater life and reliability, The Compatibilities of PLC'S, Logic Control, PID control, Operator control, Signaling and listing, Coordination and communication.

B. How PLC works

Basics of a PLC function are continual scanning of a program. The scanning process involves three basic steps.

Step 1: Testing input status

First the PLC checks each of its input with intention to see which one has status on or off. In other words it checks whether a switch or a sensor etc., is activated or not. The information that the processor thus obtains through this step is stored in memory in order to be used in the following steps.

Step 2: Programming execution

Here a PLC executes a program instruction by instruction based on the program and based on the status of the input has obtained in the preceding step, and appropriate action is taken. The action might be activation of certain outputs and the results can be put off and stored in memory to be retrieved later in the following steps.

Step 3: Checking and Correction of output status

Finally, a PLC checks up output signals and adjust it has needed. Changes are performed based on the input status that had been read during the first step and based on the result of the program execution in step two – following execution of step three PLC returns a beginning of the cycle and continually repeats these steps .
Scanning time = Time for performing step 1+ Time for performing step 2+ Time for performing step 3.

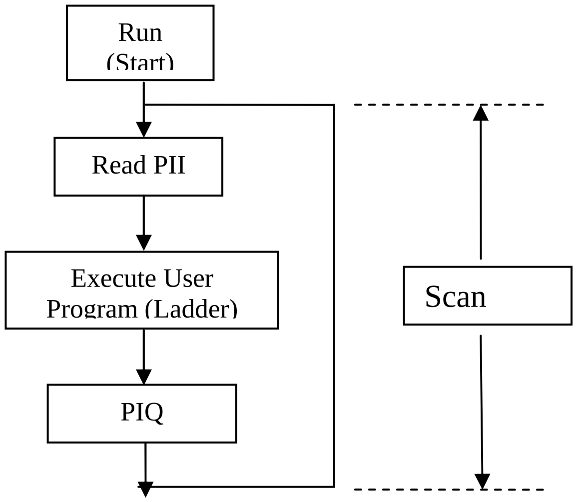
VI. ALLEN BRADLEY PLC

Programmable Logic Controller or PLC is an intelligent system of modules, which was introduced in the control, & instrumentation industry for replacing relay based logic [4]. Over a period of time, better I/O handling capabilities and more programming elements have been added along with improvement in communication.

PLC Working

At the beginning of each cycle the CPU brings in all the field input signals from the input signals from the module and store into internal memory as process of input signal. This internal memory of CPU is called as process input image (PII).

User program (Application) will be available in CPU program memory. Once PII is read, CPU pointer moves in ladder program from left to right and from top to bottom. CPU takes status of input from PII and processes all the rungs in the user program. The result of user program scan is stored in the internal memory of CPU. This internal memory is called process output image or PIQ. At the end of the program run i.e., at the end of scanning cycle, the CPU transfers the signal states in the process image output to the output module and further to the field control.



I/O driver (SCADA) picks up PII and PIQ and transfers the image to database and this image is called driver image. This driver image available in SCADA database is used for graphical view of process monitoring from operator station (OS) in the central control room.

A. *Features of Allen Bradley PLC*

Using Allen Bradley 1000PLC Micrologix 1000PLC has 20 digital outputs. The relationship with bit address to input and output devices is shown in the figure below.

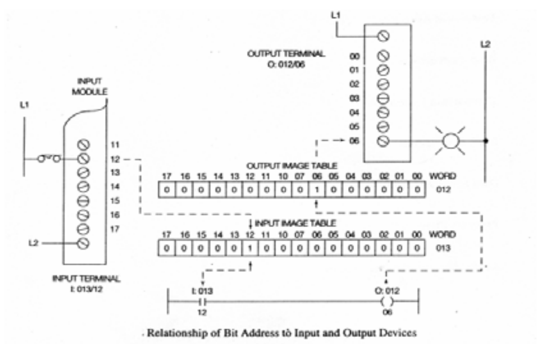


Fig. 1, I/O Pin Configuration of AB PLC

The left side of the screen shows that eh project tree while the right side of the screen is the programming area. Either area can be increased in size, minimized, or closed by left clicking the mouse on the appropriate symbol.

B. *Interfacing*

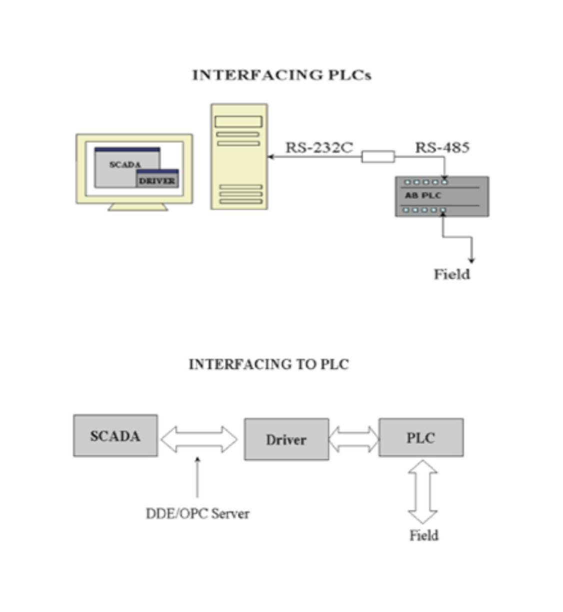


Fig. 2, Interfacing of PLC and SCADA

C. *Connecting to the PLC*

- Open a SCADA application
- Create a tag of type I/O discrete, select the type as discrete
- Select read only if you don't want to force values to PLC. Selecting read and write allows to the SCADA to read and force values to the PLC.
- Type an access name.
- The access name can visualized as a gateway for a group of resources.
- Most of PLC drivers communicate with SCADA package using DDE, DDE requires three parameters namely name of the DDE server, topic name and item name. In case of reading a number of items from a particular PLC driver application name topic name are common, so this application name that is name of the DDE server and Topic name combine to form an access name. Access name is required to be defined only once then other items of driver can be accessed by using the Access name and item name. These details will be provided by the driver vendor or developer.
- Click ok, the access name will be listed finally click done, then type the item name, click save to save the I/O tags. Go to run time to communicate with PLC.

VII. SCADA

SCADA stands for Supervisory Control and Data Acquisition. As the name indicates, it is not a full control system, but rather focuses on the supervisory level [2].

What is SCADA? It is used to monitor and control plant or equipment. The control may be automatic or initiated by operator commands. The data acquisition is accomplished firstly by the RTU's scanning the field inputs connected to the RTU (it may be also called a PLC – programmable logic controller.). This is usually at a fast rate. The central host will scan the PTU's (usually at a slower rate). The data is processed to detect alarm conditions, and if an alarm is present, it will be displayed on special alarm lists.

A. Basics

A SCADA system consists of a number of components [7]. The RTU's. Remote telemetry or terminal units. The central SCADA master system.

Field Instrumentation

The SCADA RTU is a (hopefully) small ruggedized computer, which provides intelligence in the field, and allows the central SCADA master to communicate with the field instruments. It is a stand-alone data acquisition and control unit. Its function is to control process equipment at the remote site, acquire data from the equipment, and transfer the data back to the central SCADA system.

FIX32 software enables you to configure a system environment that provides: [3]

Supervisory control, batch processing, data acquisition, continuous control, and statistical process control for industrial applications.

VIII. BOILER OPERATION

Water plays a major part in the generation of steam. Inlet water to the steam drum should be in purified form, for that, PH value of the water should be maintained, and stored in de-aerator tank. Feed water pump is switched ON by using feed water pump switch. The water from the de-aerator tank is allowed to pass through two parallel pipes. In one pump the flow rate is maintained at 130% and in another it is 5%. Thus the failure of any one pipe does not affect the boiler operation. The water is passed through economizer, thus the heat in the outgoing gases is recovered, by transferring its heat to the water. Then the heated water is made to flow through steam and water drum. In this, water should be maintained at least at 50%. For sensing water level we use PID controller in AB PLC. When the level is lesser than or greater than 50%, PID controller senses the level change and sends the appropriate control signal to the feed water valve 1 or valve 2. Thus, in spite of any changes in disturbance variable, the water level can be maintained at 50% by proper turning of PID controller.

Water in the water drum is maintained at more than 75%. This water is circulated back to steam and water drum, due to difference in temperature, high amount of steam is generated.

The generated steam temperature may be greater or lesser than the desired temperature. So depending on the situation the generated steam is then passed through primary heater followed by secondary heater. The secondary temperature is monitored.

Here we consider three main cases:

1. If the secondary heated temperature is greater than the desired temperature then by using PID controller, approximate control signal is sent to the control valve 3 of the super heater tank, to reduce the temperature, by spraying chilled water from de-aerator tank.
2. If the output of the secondary heated temperature is lesser than the desired, using a PID controller approximate control signal is sent to bunker valve to control fuel flow.
3. If the output of the secondary heated temperature equals the desired temperature, no control action is needed, the stem is taken out.

PID CONTROLLER

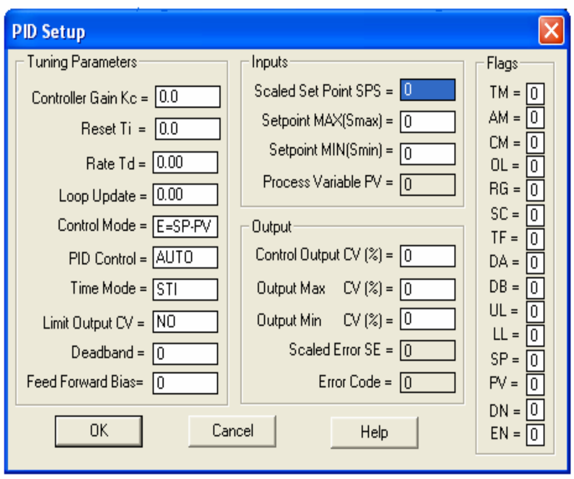
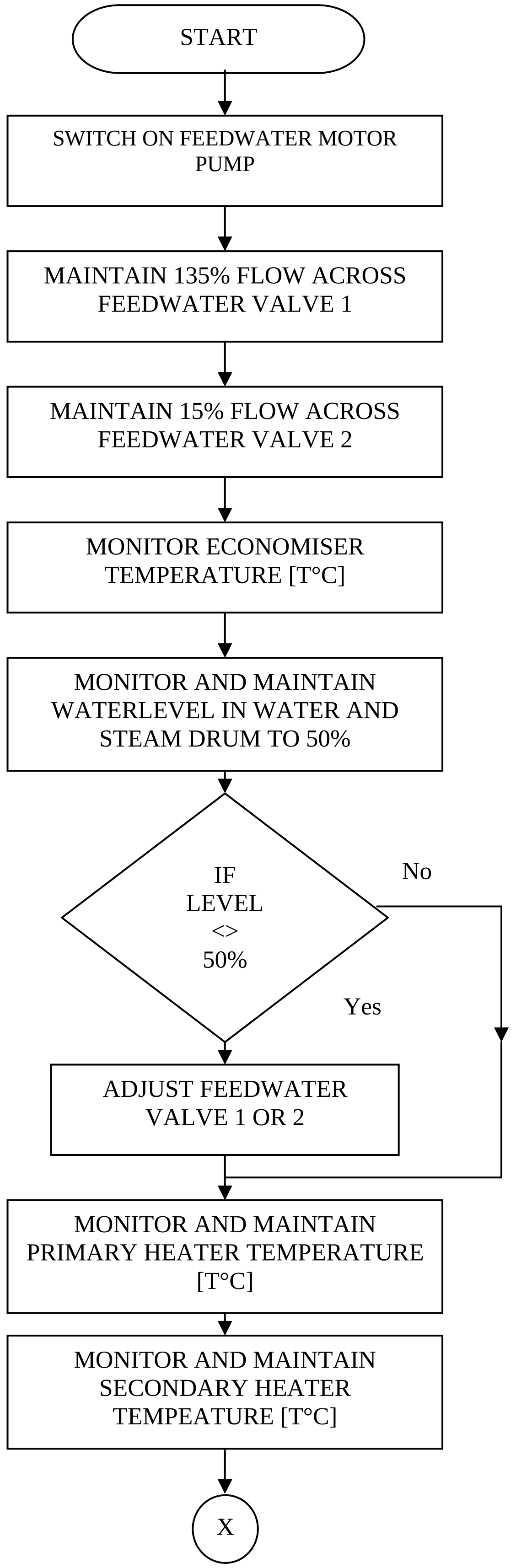


Fig. 3, PID Controller in SCADA

A. Flowchart

The operation is summarized as flowchart as below



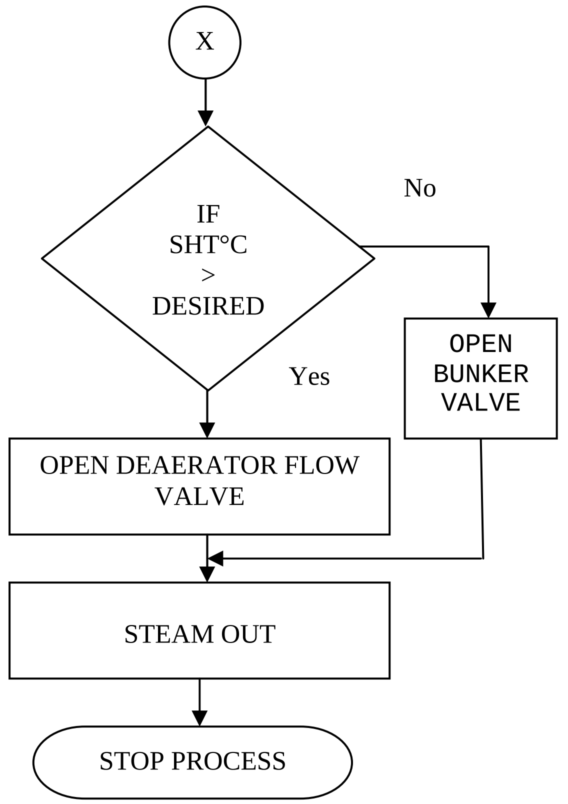


Fig.4, Flow chart of Boiler Operation

IX. CONCLUSION

The most important aspect of any power plant is the boiler control. Several techniques can be implemented to control the boiler in power plant. The method that has to be used relies on varied objectives like superior quality, increased efficiency, high profit and other such points depending upon the purpose of the company that implies it. With the prime objective of catering to these necessities and the needs of the industrial sector, significance has been given here to automation.

This paper presented here has kept in mind, the ceaseless changes that are relentlessly taking place in the contemporary scenario of the industrial segment. Emphasis has been given to the automation process that is now rapidly taking its place in all the power plants across the globe. The Paper has furnished itself to study the integral parts of the entire process involved, their implementation and the problems that may show up have also been given their due importance. The future work deals with the purification of water to the boiler and the air circulation for the boiler to burn the fuel using same automation technique.

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X. RESULT

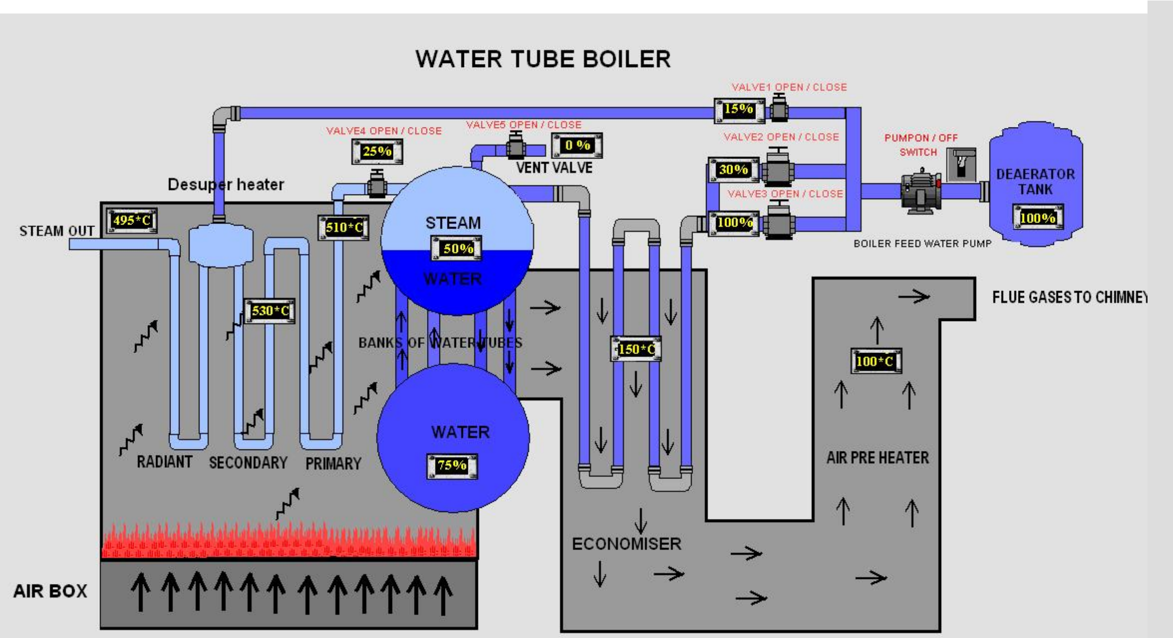

Fig.5, SCADA Screen result

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Mr. K. Gowri Shankar obtained his B.E (Electronics & Instrumentation) from Madras University in 2002. Master degree M.Tech. (Control Systems & Instrumentation from SASTRA Deemed University 2005. He worked as Quality Engineer in Plastic Industry and working as lecturer of the Department of Electronics & Communication Engineering, Rajiv Gandhi College of Engineering & Technology, Pondicherry, India. His areas of interest in process control are non linear control, PID Control and Automation.