PLC & SCADA Based Effective Boiler Automation System for Thermal Power Plant

S.Kalaivani, M.Jagadeeswari

***Abstract*— Boiler is one of the most important equipment in any power plants which require continuous monitoring and inspection at frequent intervals. There are possibilities of errors at measuring and various stages involved with human workers. So a reliable monitoring system is necessary to avoid catastrophic failure, which is achieved by Programmable Logic Controller & Supervisory Control and Data Acquisition system. This paper outlines the design and development of boiler automation system using PLC, SCADA and sensors. PLC and SCADA interfaced via communication cables. 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. SCADA is used to monitor the boiler temperature, pressure and water level using different sensors and the corresponding output is given to the PLC which controls the boiler temperature, pressure and water level. If the temperature and pressure inside the boiler exceeds the predefined value then the entire system is shut down. In case of emergency different automated check valves are used to release pressure, steam and inform the concerned authority through alarm. Boiler automation ladder diagram is designed using WPL soft and SCADA design is done by Intouch wonderware.**

***Index Terms*— Communication cables, Programmable Logic Controller (PLC), Power Plant, Supervisory Control and Data Acquisition system (SCADA).**

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 it is having number of boiling section. This boiling section produces the high temperature water of the steam level temperature. This steam level temperature is used for power generation and the steam waters are applied to the turbine section. After the power is generated, steam waters are supplied to various plants for reuses. If the supply of the high temperature is reduced to low temperature, it will be used for all other plants which needs the low temperature. There are possibilities of errors at measuring and various stages involved with human workers. In order to automate a power plant and minimize human intervention, there is a need to develop a PLC &SCADA system that helps to reduce the errors caused by humans.

Manuscript received May, 2015.

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SCADA is a centralized system used to supervise a complete plant and basically consists of data accessing features and controlling processes remotely. It is used to monitor the boiler temperature, pressure and water level using different sensors and the corresponding output is given to the PLC which controls the boiler temperature, pressure and water level. If the temperature and pressure inside the boiler exceeds the predefined value then the entire system is shut down. In case of emergency different automated check valves are used to release pressure, steam and inform the concerned authority. PLC 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/ output modules various types of machines processes.

The section II describes the study of various techniques and its research work. The section III summarizes the Need for Boiler Automation. The section IV deals with boiler Automation using PLC and SCADA. The section V describes the PLC & SCADA. The section VI illustrates the Experimental results and finally the section VII deals with Conclusion and Future work.

II. RELATED WORK

Comprehensive historical perspectives of different boiler automation techniques are discussed below. This survey provides critical reviews and highlights the concepts, advantages and disadvantages among survey results. This contribution adds more thoughtful ideas in the design and development of boiler automation techniques.

In present situation conventional PID control is being used for boiler control. These conventional controllers in power plants are not very stable when there are fluctuations and, in particular, there is an emergency occurring. Continuous processes in power plant and power station are complex systems characterized by nonlinearity, uncertainty and load disturbances. The conventional controllers do not work accurately in a system having nonlinearity in it. So, an intelligent control using PLC& SCADA is developed to meet the nonlinearity of the system for accurate control of the boiler steam temperature and pressure level.

Embedded system based boiler automation system consist of GSM (Global System for Mobile Communication), PIC (Peripheral Interface Controller) and different sensors which is capable of monitoring the entire boiler temperature and pressure. The obtained temperature and pressure measured data are transferred through the PIC microcontroller. The microcontroller read the available data and processed.

ISSN: 2278 – 1323

If the temperature and pressure exceeded the maximum value then the user will be able to get information about the current temperature in any boiler by simply sending a boiler identification number [1], [3].

Microcontroller is programmed with the fuzzy knowledge base rule to control the boiler temperature. The temperature sensor is interfaced with the microcontroller to monitor the steam temperature and a level indicator circuit is used to indicate the water level inside the boiler chamber which is interfaced with the microcontroller and the corresponding outputs are given as the two inputs for the Fuzzy Inference System. After fuzzification of the inputs and applying suitable rules and defuzzifying the output the microcontroller generates appropriate control signals [2].

Fuzzy PID controller is used for temperature superheated steam of boiler based on the fuzzy control methodology. The control process is simulated through the Simulink MATLAB software. It shows that the system can demonstrate good control ability and dynamic effects even in large delay and stochastic disturbance circumstances [4]. From the literature works that are discussed; it is evident that have several disadvantages. In the proposed system the previous papers disadvantages are overcome by using PLC & SCADA for boiler automation to monitor and control the boiler temperature, pressure and water level in thermal power plant.

III. Need for Boiler Automation

Boiler is one of the most important parts in any power plant. Which require continuous monitoring and inspection at frequent interval. In Power plants it has number of boiling section. This boiling section produces the high temperature water of the steam. Boiler steam temperature in thermal power plant is very complex and hard to control, due to poorly understand the working principles; Boilers have many serious injuries and destruction of property. It is critical for the safe operation of the boiler and the steam turbine. Too low a level may overheat boiler tubes and damage them. Too high a level may interfere with separating moisture from steam and transfers moisture into the turbine, which reduces the boiler efficiency.

Various controlling mechanism are used to control the boiler system so that it works properly, many control strategies have been applied to it. In order to automate a power plant and minimize human intervention, there is a need to develop a Boiler Automation system.

It is achieved by using Programmable Logic Controller & Supervisory Control and Data Acquisition system that helps to reduce the errors caused by humans and avoids the catastrophic failure.

IV. Boiler Automation Using Plc And Scada

In order to automate a power plant and minimize human intervention, there is a need to develop a PLC &SCADA system that helps to reduce the errors caused by humans. PLC and SCADA interfaced through communication cables. SCADA is used to monitor the boiler temperature, pressure and water level using different sensors and the corresponding output is given to the PLC which controls the boiler temperature, pressure and water level.

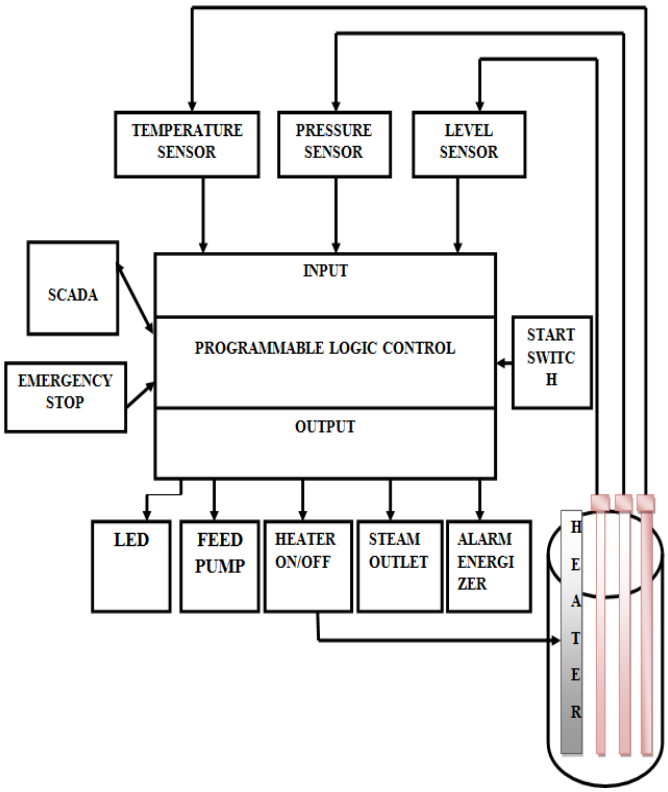

Fig. 1. Block Diagram of Boiler Automation

Figure 1 shows the block diagram of boiler Automation which consists of PLC, SCADA and sensors to monitor and control the entire operation of boiler. Here Resistive Temperature detector Pt 100 (RTD PT 100) is used to measure the temperature, RT pressure switch is used to measure the pressure inside the boiler and float switches are used to detect the feed water level inside the boiler.

A. Boiler operation

Water plays a major part in the generation of steam. Initially Pushbutton is switched ON then the PLC, SCADA, different sensors are switched ON. Feed water pump is switched ON by using feed water pump switch. Coal from the coal chamber passed to the water tube boiler.

And the water from the water tank is allowed to pass through two parallel pipes to boiler and its temperature is measured. In one pump the flow rate is maintained at 130% and in another it is 75%. Thus the failure of any one pipe does not affect the boiler operation. Heater is switched ON by using PLC. Forced draft fan is used to force the air into the boiler to improve the combustion efficiency and its corresponding temperature and pressure are measured by sensors.

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 Float switches are used. When the level is lesser than or greater than 50%, Float switches senses the level change and sends the appropriate control signal to the PLC. Thus, in spite of any changes in disturbance variable, the water level can be maintained at 50% by proper tuning of PID controller. Water in the water drum is maintained at more than 75%.

ISSN: 2278 – 1323

When the water is less than 2000 liters then motor will be switched ON. If the temperature and pressure inside boiler exceeds then entire system will be in OFF state. The corresponding automated check valves are opened to avoid catastrophic failure.

B. Control parameters

- Temperature Control
  Steams drum temperature, Underbed boiler temperature, Force draft temperature, Flue gas temperature, Induced draft temperature, feed water temperature.

- Pressure Control
  Force draft pressure, Induced draft pressure, Steam drum pressure, Turbine inlet steam pressure, and flue gas pressure.

- Level Control
  Steam Drum level, Water level

C. Boiler

Boiler is essentially a closed vessel into which water is heated until the water is converted into steam at required pressure. There are mainly two types of boiler – water tube boiler and fire tube boiler.

At first Fuel (generally coal) is burnt in a furnace and hot gasses are produced which is shown in Fig.2. These hot gasses come in contact with water vessel where the heat of these hot gases transfer to the water and consequently steam is produced in the boiler. Then this steam is piped to the turbine of thermal power plant. There are many different types of boiler used for different purposes like running a production unit, sterilizing equipment, sanitizing some area, to warm up the surroundings etc.

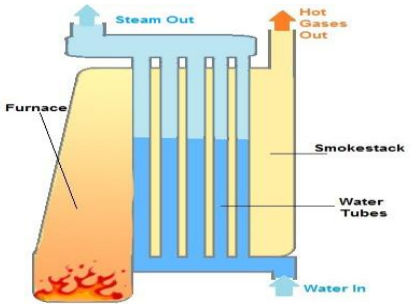

Fig. 2. Water Tube Boiler

D. Temperature sensor

Resistance Temperature Detector (RTD PT 100) is used to sense the temperature variation. It is a passive circuit element whose resistance increases with increasing temperature in a predictable manner. A PT-100 is a precision platinum resistor that exhibits 100 ohm at 0^0c. Fig.3 shows the typical RTD. To measure the resistance, it is essential to convert it to a voltage and use the voltage to drive a differential input amplifier. The differential input amplifier will reject the common mode noise on the leads of the RTD and provide the greatest voltage sensitivity.

The RTD signal is usually measured one of two ways: either by connecting the RTD element in one leg of a Wheatstone bridge excited by a constant reference voltage or by connecting it in series with a precision current reference and measuring the corresponding IR voltage drop.

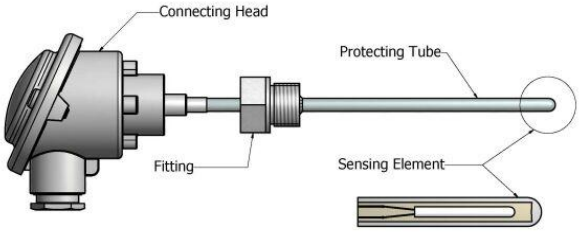

Fig. 3. Resistance Temperature Detector

E. Pressure Sensor

RT pressure switch is used to sense the pressure inside the boiler. RT Series pressure switches utilize a seamless bellows as sensing element. The bellows can be either phosphor bronze or stainless steel to suit various kinds of process medium. The mechanism is enclosed in a weather proof (IP66) enclosure which can be of either DMC (Die Cast Aluminum).Pressure ranges between -1 to 30 bar [8].

F. Float switches

A float switch is a device used to detect the level of liquid within a tank which is illustrated in Fig.4. The switch may be used in a pump, an indicator, an alarm, or other devices. Float switches range from small to large and may be as simple as a mercury switch inside a hinged float or as complex as a series of optical or conductance sensors producing discrete outputs as the liquid reaches many different levels within the tank [7].

Fig. 4. Float Switches

V. PLC AND SCADA

A. Programmable Logic Controller

Programmable Logic Controller (PLC) is a digital computer used for the automation of various electromechanical processes in industries [6]. PLC consists of a microprocessor which is programmed using the computer language. The program is written on a computer and is loaded into the PLC via communication cable. These loaded programs are stored in non volatile memory of the PLC. During the transition of relay control panels to PLC, the hard wired relay logic was exchanged for the program fed by the user.

A visual programming language known as the Ladder Logic was created to program the PLC. The Architecture of PLC is illustrated in Fig.5.

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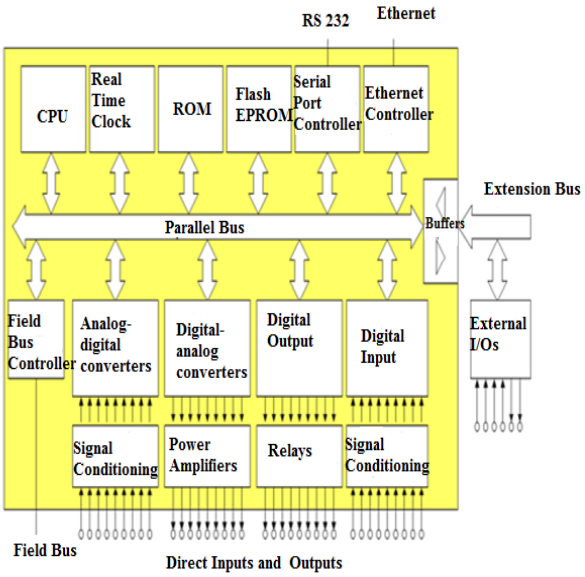

Fig. 5. Architecture of PLC

B. *Supervisory Control and Data Acquisition System*

SCADA (Supervisory Control and Data Acquisition) is a centralized system used to supervise a complete plant and basically consists of data accessing features and controlling processes remotely. Fig.6 shows the Architecture of SCADA. It is a system operating with coded signals over communication channels so as to provide control of remote equipment (using typically one communication channel per remote station). The control system combined with a data acquisition system by adding the use of coded signals over communication channels to obtain information about the status of the remote equipment for display or for recording functions [5].

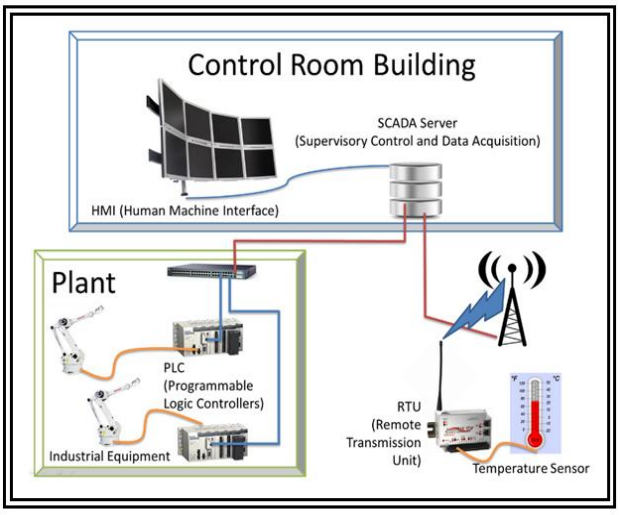

Fig. 6 Hardware Architecture of SCADA

VI. EXPERIMENTAL RESULTS

In this the results of Boiler Automation using PLC and SCADA are discussed. Ladder diagram of boiler Automation is generated and execution is carried out in WPL soft and corresponding SCADA design is generated using Intouch wonderware and the corresponding output is viewed. PLC and SCADA interfaced via communication cables.

A. *Ladder Diagram of PLC*

Boiler automation ladder diagram was simulated using WPL soft. For ease of PLC programming ladder diagram is used.

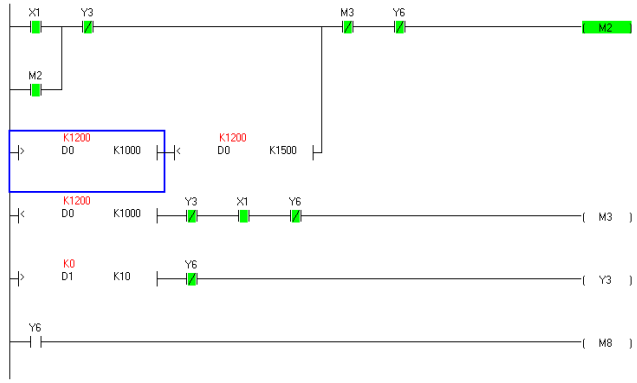

Fig. 7. Ladder Diagram for Temperature & Pressure Condition

Figure 7 illustrates the ladder diagram for Temperature and Pressure. When X1 is switched ON heater 2 will ON when the temperature exceeds 1000^0 C heater 1 will switch ON. If the temperature exceeds 1500^0 C both heaters will switched off.

If pressure exceeds 10bar then automated check values switched on to release the stem and pressure and the alarm will energized. Figure 8 shows the ladder diagram for water level control.

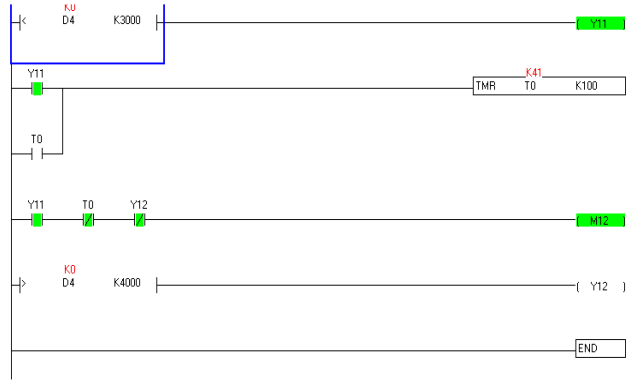

Fig. 8. Ladder Diagram For Water Level Control

B. *SCADA design*

The SCADA design for boiler Automation is designed and executed by Intouch wonderware software and the corresponding increase in temperature, pressure and water level is monitored and the output is given to PLC which controls the overall operation of thermal power plant. Wonderware is world-famous Intouch HMI (Human Machine Interface) software for visualization and industrial process control offers outstanding ease of use and simple-to-configure graphics. Powerful wizards enable users to quickly create and deploy customized applications that connect and deliver real-time information. Fig. 9 illustrates the SCADA design of Boiler Automation.

ISSN: 2278 – 1323

If temperature and pressure exceed then the entire setup will be shutdown and automatic check valves are opened to release the temperature and pressure inside the boiler to avoid damage of boiler and the remaining flue gases are passed out through chimney.

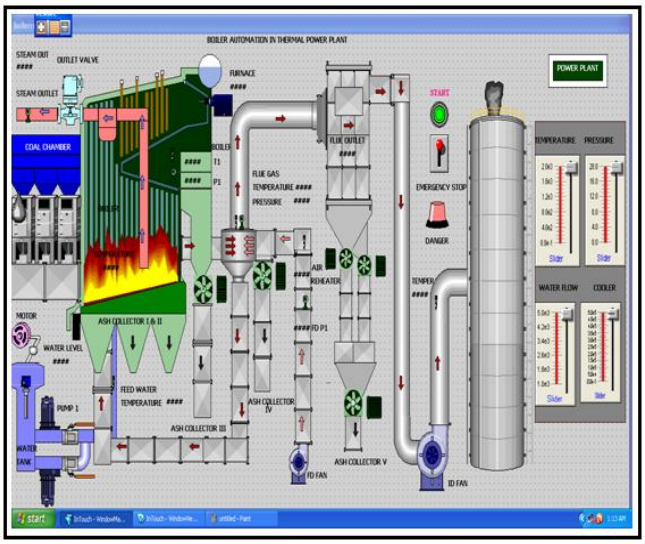

Fig. 9. SCADA Design of Boiler Automation

VII. Conclusion

In this paper, Boiler Automation using PLC and SCADA was designed and implemented. Different sensors are used to measure the temperature, pressure and water level. SCADA is used to monitor the parameters and PLC used to control the operation. If the temperature and pressure exceed predefined value then the entire setup will shut down and automatic check valves are opened to release the steam and pressure. In case of emergency alarm was energized and automatic check valves are opened to avoid catastrophic failure. Ladder diagram of Delta PLC is simulated using WPL soft and the SCADA design of boiler automation is simulated using Intouch wonderware software.

The future research is to focus on the application oriented implementation of remote monitoring of boiler Automation by SCADA internet access.

Acknowledgment

The authors would like to thank Sri Ramakrishna Engineering College for providing Excellent computing facilities and Encouragement.

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ISSN: 2278 – 1323