Study on Boiler Automation using PLC and SCADA

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Abstract— Various controlling mechanism are used to control the boiler system so that it works properly. In order to automate a power plant and minimize human intervention, there is a need to develop a Boiler Automation system. Safety and efficiency are always given a prime importance by the boiler manufacturers and steam users. Over the time, there has been a significant improvement in boiler performance as far as these to parameters are concern. As the technology advances, there is always a scope to perform still better on safety and efficiency. Study of wireless SCADA system, which is powerful setup for monitoring and controlling the various applications from remotely, placed, is presented. Wireless SCADA is required in those applications when wire line communication to the remote site is probability expensive or it is too time consuming to construct. The seminar discusses the concept of monitoring, recording and controlling of a small part of the boiler process. This is done by using PLC and SCADA. The PLC and SCADA are connected with a wireless medium that is the Bluetooth module. The boiler process consists of parameters such as, temperature, level, and pressure. The effect of these parameters, when they exceed their limit is shown in SCADA and its resulting control is done on the real time operation of the boiler. This is done with the help of Bluetooth module, which will be wirelessly used to connect the PLC and SCADA.

Keywords: PLC, SCADA, Boiler Automation

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. Power plants or any other industries having boiler equipments require continuous monitoring and inspection at frequent time intervals. In boiler there are many different sections to be controlled at same time, primary sections such as boiler drum which is basically a boiling section produces the high temperature water for steam generation. Too high water level leads to improper steam generation. In order to automate the system and minimize human errors, Steam & Drum Level is both critical and difficult to measure and maintain. Precise control of the water level in the drum is important factor. Precise control of the water level in the drum is important factor. It can be done with by developing a PLC (Programmable Logic Controller) &SCADA (Supervisory Control and Data Acquisition) SCADA system helps to reduce the errors caused by humans and able to provide the better control and monitoring of the plant or process operations. Through SCADA system which is a centralized system used to supervise a complete plant and ongoing process and provide the require data respective to process changes. There is a wireless block consists of a Bluetooth module connected to OMRON PLC and the Bluetooth receiver present in the system containing SCADA software. The PLC is further connected to a process which is controlled by the SCADA system through wireless medium. This technique of operation can be used over a certain range of area, for example, it can be used in industries and plants. The transfer of data from the application to the PLC is done using wire, whereas from the PLC to the system is done is wirelessly using Bluetooth. The processes we operate is a boiler based process. In this process we control the parameters such as, temperature, level and pressure, and also show its effects on the process using SCADA software. In this project we use two types software's for the operation. These both connect with each other and operate uniformly and instantly for giving the desired output.

II. LITERATURE REVIEW

A. *Programmable Logic Controller*

PLC stores the instruction to the functions that are sequencing, timing, and counting, which controls the machine.PLC is composed in two sections (CPU) central processing unit and (I/O) Input/output interface system. It measures the input signal coming from a machine and through that it provides output and control back the machine. Ladder logic is the programming language used to represent electrical sequences of operation. In hardwired circuits the electrical wiring is connected from one device to another according to logic of operation[1].

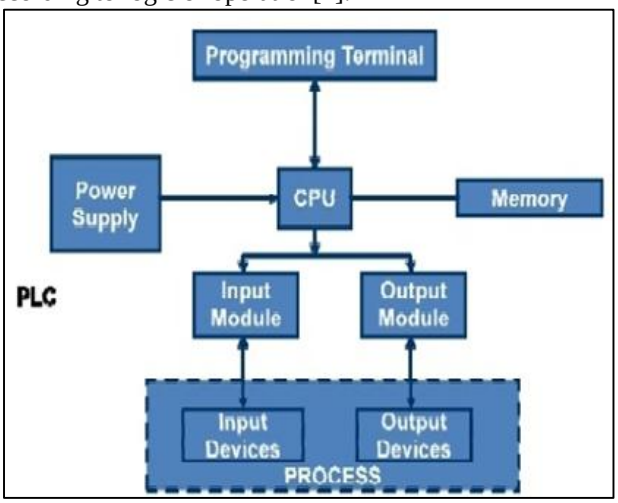

Fig. 1: PLC Hardware Block Diagram

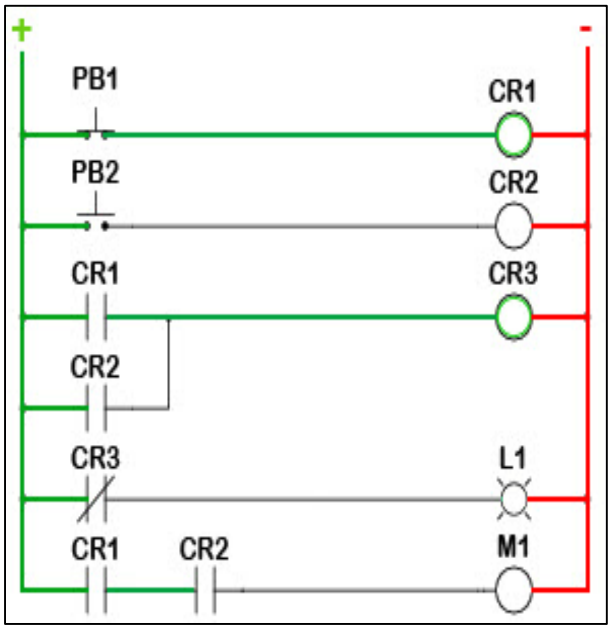

Fig 2: Ladder PLC Programming.

1) How PLC works?

The PLC functions are continuous scanning program and which is divided into three groups.

1) Testing input status.
2) Programming execution.
3) Checking and correction of output status

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 a process of input signal. This internal memory of cpu is called input image[2].

2) Advantages of PLC

Reduced space, modular replacement, energy saving, economical, error diagnostics programmer, easy trouble shooting, greater life and reliability[2].

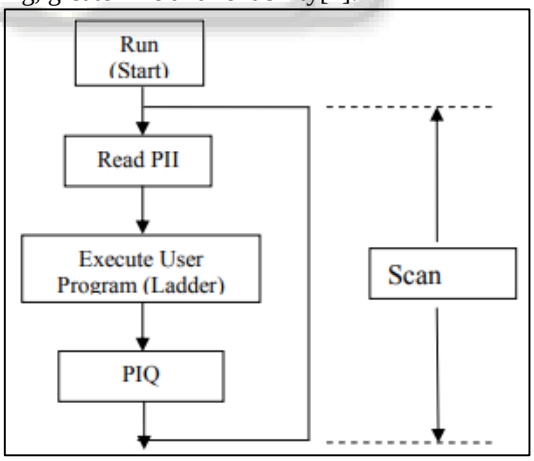

Fig. 3: Ladder program

B. What is SCADA?

A Scada system consists of a number of components. SCADA stands for supervisory control and acquisition. As it indicates, it is not a full control system, but rather focuses on the supervisory level. It is used to monitor and control plant. The controls may be automatic or manual. The data acquisition system accomplished first by plc scanning to field inputs and connected to plc. The plc remote the terminal unit. The master central scada system[2].

1) Three Layer SCADA System Architecture

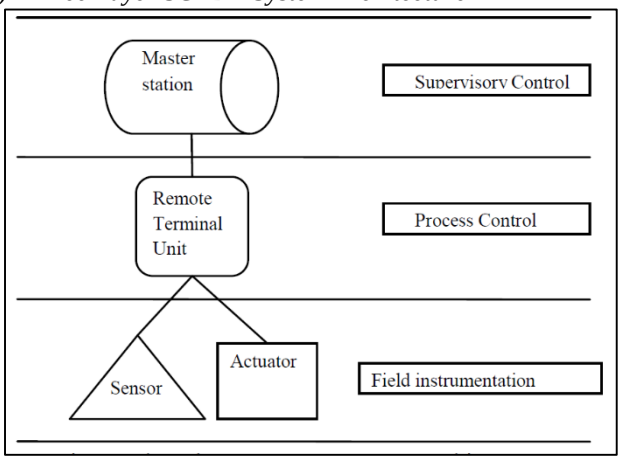

Fig. 4: Three layer SCADA

Figure 4, below illustrates the three layer SCADA system architecture. This is the latest trend of SCADA system which depends on open system technology rather than a vendor controlled proprietary environment. As shown in the above figure1 SCADA system consists of three layers. They are Fig. 1: Three layer SCADA system architecture. 1. Supervisory control layer: Master station consist of one or more personal computers which are configured to be dedicated to master station duties, although they can function in a multi-purpose mode. The duties of master station may include trending, alarm handling, logging archiving, report generation, and facilitation of automation. These duties may be distributed across multiple PCs, either standalone or network. Master stations have two main functions: 1) Periodically obtain data from PLCs (and other master or sub-master station). 2) Control remote devices through the operator station. 2. Process control layer: This layer consists of more than one device depending upon the situation, these devices like 1) Programmable Logic Controllers: PLC is a special purpose computer consists of CPU and different kinds of memory. Typically modern Remote Terminal Unit (RTU) use Ladder Logic programming approach. PLCs are quickly becoming standard in the control system. 2) Analog Input and Output modules: The configuration of sensors and actuators determines the quantity and the type of inputs and outputs on a PLC. Depending on the model and manufacturer modules can be designed. An analog input and output module 4,8,16 or 32 inputs or outputs. 3) Digital Input and Output modules: Digital input modules are typically used to indicate status and alarm signals. 3. Field instrument control layer: This layer mainly consists of sensors and actuators. Sensors perform measurement and actuators perform control. Sensors get the data and actuators perform actions depending on this data. The processing and determination of what action to take, is done by master control station i.e., SCADA. Communication among three layer SCADA system is provided with a standard communication interface. At the supervisory control layer between peers, communications are usually through a standard networking protocol such as TCP/IP or IPX over Ethernet[4].

2) Field Work of SCADA.

Scada is a system to automate industrial control and monitoring as shown in figure. It includes field sensors, plc,

remote telemetering unit(RTU) and it can used to monitor parameters such as temperature, pressure, flow rate etc.

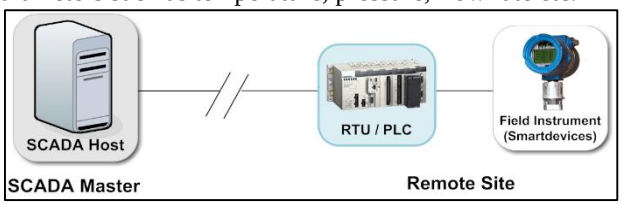

Fig. 5: Scada Program

C. Need For Boiler Automation

Boiler is one of the most important parts in any power plant. Boiler needs complete monitoring and inspection at frequent time interval. In power plant there are number of boiling sections are there which produce the high temperature water of steam. The temperature of steam in boiler is 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[4].

1) 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.

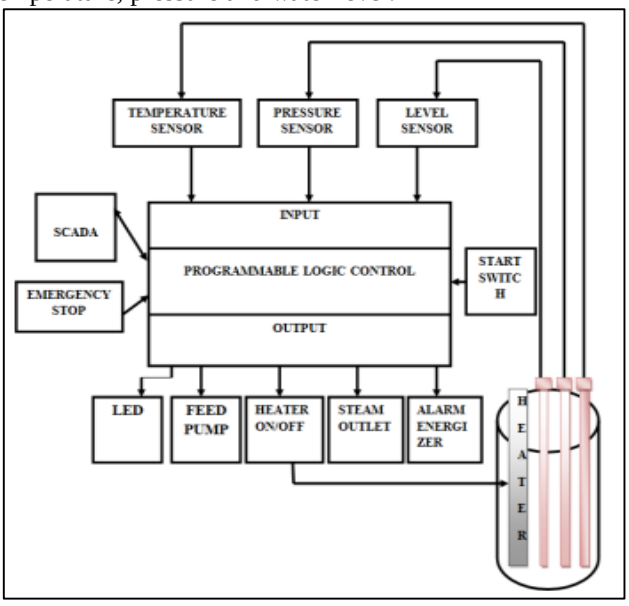

Fig. 6: Block Diagram of Boiler Automation

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[1].

2) Operation of Boiler

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%.When the water is less than 2000 litres 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[1].

III. METHODOLOGY

A. Process

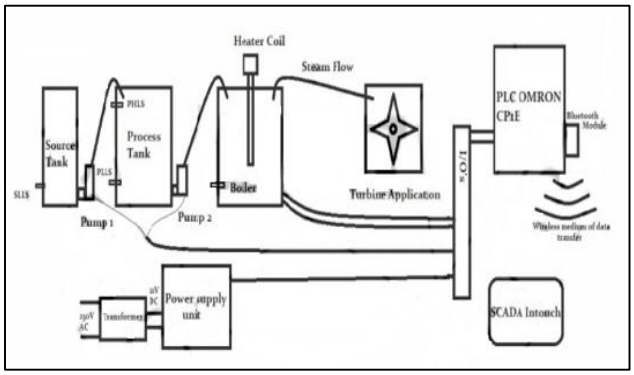

Fig. 7: Block Diagram of Process

Figure 7 process starts with manual feeding of water into the source tank. Then the low level sensor in the source tank is in the on the state. Also the low level sensor of the process tank is also in the "on" state. This causes the pump1 to turn "on", thus causing the water from the source tank to move into the process tank. This increases the level of water in the process tank causing it to activate the high level sensor present in the process tank. Now, when the high level sensor gets activated,

the pump1 turns "off", causing an interruption in the flow of water from the source tank to the process tank. Also the low level sensor in the steamer is in "on" state. Now, when the high level sensor of the process tank and the low level sensor of the steamer are in "on" state, the pump2 automatically turns "on". This causes the flow of water from the process tank to the steamer. Also the water flow from the process tank to the steamer is interrupted after the boiler reaches a particular set point defined by the user/operator. Once the water level in the steamer reaches the defined set point, the pump2 turns "off". This prevents the flow of water from the process tank to the steamer to get interrupted. Also the steamer consists of a temperature sensor that senses the temperature and gives its analog value to the PLC. The level sensors from the source and the process tank and from the steamer are connected to the LM324 comparator block, which is also connected to the ULN2803. These values are given to the PLC for using Input/output modules. The values from the PLC are transferred to the SCADA operating system using Bluetooth medium of wireless transfer. The data's are logically analyzed and sent back to the PLC which performs the required function, by controlling the water level and temperature. SCADA system consists of software required for interfacing which is known as PLC CX-programmer. The CX-programmer used ladder diagram for its operation[3].

1) Control Parameters

a) Temperature Control

Steams drum temperature, boiler temperature, Force draft temperature, Flue gas temperature, Induced draft temperature, feed water temperature.

b) 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[1].

c) Pressure Control

Force draft pressure, Induced draft pressure, Steam drum pressure, Turbine inlet steam pressure, and flue gas pressure[1].

d) Float Switches

A float switch is a device used to detect the level of liquid within a tank. The switch may be used in a pump, an indicator, an alarm, or other devices as shown in figure 8. 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[1].

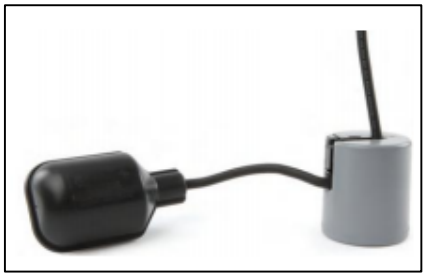

Fig. 7: Float Switches.

B. 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 degree c. Fig. 6 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[1].

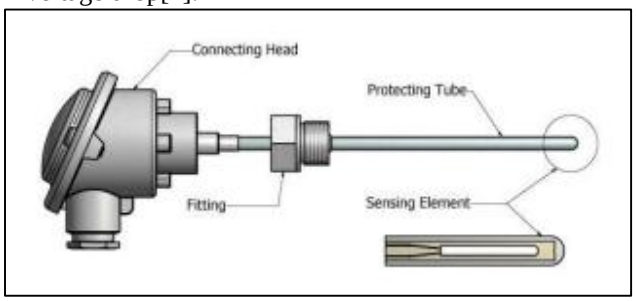

Fig. 8: Resistance Temperature Detector.

IV. Conclusion

The process of controlling boiler application, water level using cables and wire are found commonly in many industries. The wired communication is used in the industries have some disadvantages, such as:

1) Cost of laying down of cables and wires for long distance is high.
2) Cost of maintaining the cables is also high.
3) Loss of data in the wire transmission due to attenuation.

To overcome these limitations we use wireless communication for the process. In this medium of communication, we use wireless medium for communication and also prevent the above limitations from occurring along with the below advantages:

1) Since it is wireless, it is possible to connect more than 1 field devices and operate them simultaneously.
2) Also the loss of data can be prevented. With the above advantages and the limitations, we prefer the use of wireless communication over wire communication.

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