PROCESS FLOW CONTROL USING SCADA AND PLC

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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 synopsis outlines the design and development of boiler automation system using SCADA and sensors. PLC and SCADA interfaced via communication cables. The initial phase of the Synopsis 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 SCADA design is done by wonderware Intouch.

Keywords: Boiler, PLC, SCADA, sensors.

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 SCADA system that helps to reduce the errors caused by humans. 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

II. RELATED WORK

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.

**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 Supervisory Control and Data Acquisition system that helps to reduce the errors caused by humans and avoids the catastrophic failure.

**3.1 Boiler Automation Using PLC and SCADA**

In order to automate a power plant and minimize human intervention, there is a need to develop a 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.

![Figure 1 BOILER AUTOMATION](image)

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) 34 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.
3.2 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%.

3.3 Control parameters

1. **Temperature Control**
   Steams drum temperature, Under bed boiler temperature, Force draft temperature, Flue gas temperature, Induced draft temperature, feed water temperature.

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

3. **Level Control**
   Steam Drum level, Water level

3.4 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.

3.5 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 00c. 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.

Figure 3 TEMPERATURE SENSOR

A. 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

B. 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.

Figure 4 Float switches
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.

3.6 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. 5 shows the Architecture of PLC. 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.

![Figure 5 HARDWARE OF PLC](image)

**IV. 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. 6 illustrates the SCADA design of Boiler Automation. If temperature and pressure exceed then the entire setup will be shut down 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.
4.1 IMPROVING DIRECT EFFICIENCY OF BOILERS-ROLE OF AUTOMATION
Safety and efficiency are always given a prime importance by both boiler manufacturers and steam users. Over the time, there has been a significant improvement in boiler performance as far as these two parameters are concerned. As the technology advances, there is always a scope to perform still better on safety and efficiency. This article explains how intelligent PLC (Programmable Logic Controller) can help steam users ensure a more efficient and safer boiler operation. In case of conventional manual fired solid fuel boilers, the gap between the indirect and direct efficiency is quite high. Generally, the typical efficiency guaranteed is somewhere around 73-77%. The efficiency which is actually obtained lies in the range of 50-55%. This huge gap between direct and indirect efficiency is on the account of many losses taking place which can be certainly reduced with the help of boiler automation. With the help of automation it is possible to provide alerts/inputs to boiler operator which assist him to operate the boiler efficiently. The system can also be used by utility managers for monitoring performance. This system, thus, when used properly can lead to substantial savings for users. This article tries to understand the cause of gap between direct and indirect efficiency in case of manual fired solid fuel boilers and the role instrumentation can play.

4.2 Indirect and Direct efficiency
As we are aware, indirect efficiency is found out by calculating individual losses. Whereas direct efficiency is the ratio of heat energy generated by the boiler and energy supplied to the boiler in the form of fuel. This article explains the reasons behind gaps between direct and indirect efficiency.
4.3 How does manual operation lower the boiler efficiency?

In conventional manual fired boilers, boiler operations and adjustments like fuel feeding, setting ID fan damper position etc. are done by plant personnel. Just for an example, ideally, ID fan damper setting should not be same for the different boiler loads. It is impossible to manually optimize the damper settings along with the load and hence, boilers are run at same ID fan damper setting for all the loads. This significantly brings down the actual obtained efficiency - i.e. the direct efficiency. Another typical example is that of manual feeding of fuel which significantly shoots up unburnt and stack losses taking place. Operators often overfeed or just front feed the boiler. Because of this, the air available for the combustion is insufficient to burn the fuel completely. This suddenly increases the unburnt losses. At the same time, when the operator keeps the door open for a time period longer than required, ambient air is sucked inside the furnace and leaves through the chimney at a higher temperature which results in increased stack losses. From the two examples discussed above, it is quite clear that manual operation lowers down the actual obtained boiler efficiency because operators are not aware of real time parameters and hence are unable to take right steps accordingly. In other words, if operators are prompted by the automated alerts, these losses can be brought down. This is where intelligent PLC plays an important role.

V. EFFICIENCY REPORT OF SCADA AND PLC INSTALLATION

Boiler and turbine are closely linked, and digital turbine control systems control the flow to steam turbines using turbine throttles, governors, and control valves. Control systems prevent dangerous operating conditions using setpoint controls, and open and closed-loop control. Steam turbine control systems have to include steam turbine automatic startup and protection, speed/load control, and servo valve control. Automation should include turbine-specific electro-hydraulic and hydraulic systems, and electrical generator auxiliaries like excitation system, synchronisation, and generator. Steam turbine control can include rotor stress calculations and select the best accelerations, speeds and generator loadings. Coordinated boiler/turbine control improves stability, responsiveness and thermal efficiencies. That gives tighter overall control of plant operations; and a concise view of key plant and turbine parameters. Emerson's Ovation® expert control system, designed specifically to meet the unique challenges of the power generation industry, provides tight start-up control of acceleration and pressure for quick and efficient turbine starts, as well as safe turbine shutdown through a controlled reduction of generator load at a designated rate. Automatic turbine protection control ensures safe, efficient operation during abnormal conditions and events. HRSGs must also be tied into the control system, and this is not always simple. The steam turbine requirements set the steam conditions for combined-cycle systems, but in a CHP system the steam demand, steam pressure and temperature are all set by the process requirements. Here as elsewhere, redundant controls may be needed for critical elements. "Coordinated boiler/turbine control improves stability, responsiveness and thermal efficiencies." Controls have to be deterministic, to ensure response within a determined time, with fast response times fast. The Ovation system, which features a mission-critical, fast Ethernet network for high-speed communication of plant information; a powerful controller with fast duty cycle; and analogue, digital and special-purpose turbine and boiler I/O modules, can simultaneously execute up to five process control tasks at loop speeds down to 10ms. Each control task has I/O process point input scan, control and output scan. Ovation offers seamless communication with intelligent field devices, widely adopted bus standards such as HART, Foundation fieldbus, Profibus DP and DeviceNet, and integrated asset management software to deliver predictive intelligence to operations and management personnel. The Ovation system is a key technology that powers Emerson's PlantWeb® digital plant architecture, a digital bus-based system that incorporates high-speed communications networks, intelligent field devices, wireless communications, asset management software, and bus I/O technologies. Decisions for all control and protection systems are made by the plant operator, so operator interfaces must also be easy to use. Often, operators have only been able to choose between discrete operating load levels, and have
found it slow and difficult to change loads to desired levels. They should also be able to come on line quickly at start-up or after a fault, which is essential for peaking units. Often, conditions causing a turbine shutdown either correct themselves or can be quickly corrected. After the safety checks, control systems must therefore allow fast automatic restart. OUTER MONITORING LOOP IMPROVES EFFICIENCY "Power plants must always know their exact boiler and turbine efficiencies, and take immediate action when they drop." Maximising availability means moving the maintenance focus from reactive to proactive, preferably based on performance monitoring. This continuously compares actual plant and equipment performance to the expected values. Performance monitoring involves gap analysis, looking at deviations between performance and design values for key performance indicators. A major effect on reliability is how closely equipment operates to its design limits over various speeds and loads. ABB's Optimax software optimises combustion using predictive control to reliably find the best set points for improving the heat rate and reducing emissions like NOx. The system can recommend when to blow soot based upon changes in heat-transfer data. Steam generator components are stressed by varying steam pressures and high thermal stresses during start-up and shutdown. The varying loads lead to cyclic strain exhaustion, and the flow of hot steam causes time-dependant creeping. Both of these affect service life. Boiler protection and burner management systems ensure boiler furnace safety and fuel shutdown. ABB's Boiler Life system tracks life consumption based on fatigue and creep of its major thick walled components. Systems can have pulverised coal flow monitoring and carbon content in ash measured in real-time. ABB recommends monitoring for components with operating temperatures exceeding 350°C and/or those subjected to frequent changes of operating conditions. This applies to high and intermediate pressure rotors in reheat turbines, turbine casings, valve housings, crossover pipes and pipe elbows. Power plants must always know their exact boiler and turbine efficiencies, and take immediate action when they drop. Metso Automation reports that a 1% improvement in boiler efficiency means annual fuel savings for large boilers of up to €200 000. The company's boiler performance monitoring can be used with fluidised bed boilers, pulverised coal fired boilers, oil/gas fired boilers and grate-fired boilers. The extensive storage of history data enables also long-term monitoring of gradual component deterioration and thus better scheduling of maintenance. Metso Automation's Machinery Condition Monitoring System similarly monitors the exhaust levels of boiler components. Real-time performance monitoring with simulation and calculation helps maximise efficiency under various operational conditions. Steam plant optimisation helps optimise the operating mode, and enables flexible load allocation between different plant units. The software also helps with energy budgeting and negotiating power contracts. A 1% improvement in boiler efficiency means annual fuel savings for large boilers of up to INR 200 000. ABB's AdviseIT Turbine Lifetime Monitoring continuously computes the effect of actual operation on service life of steam turbine components and associated valves. It provides operators with information related to service life of the steam turbine. The software tracks turbine life consumption based on fatigue and creep of steam valves, casing and rotor. That leads to improved turbine maintenance scheduling, based on actual documented service life. Siemens' SPPA-M3000 similarly monitors individual components and systems. Calculations for gas turbines include heat balance (inputs, outputs and losses), main performance parameters like turbine inlet temperature, specific fuel consumption, heat rate, thermal efficiency and electrical efficiency. The SPPA-M3000 helps develop maintenance strategies, and integrates power plant and business data. Siemens recommends looking at auxiliary items when upgrading plant automation systems. Vibration monitoring equipment should be added or upgraded to monitor the health of the rotor and associated bearings. Sensors can often profitably be added to monitor temperatures of bearing lube oil and metal, valve metal, steam chest and elsewhere. The system should continuously measure and monitor key parameters, and alert the operator when any begin to indicate weakness in the turbine components. That can include bearing failures, imbalance or misalignment and shaft cracks.
VI. RESULTS
In this the results of Boiler Automation using PLC and SCADA System are discussed. PLC and SCADA design is generated using In Touch wonder ware and the corresponding output is viewed.

REFERENCES


