Development of Advanced Boiler Automation for Sugar Industries

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Abstract: To maintain the accurate water level inside the boiler is the very typical task to do so from single element to three elements PID controller is used in the system. The various methods and critical parameters are explained in this review paper along with the history of automation. It also explains the steps involved in the automation and steps and methods need to increase the efficiency of the boiler. In this project, I have been gotten an opportunity to work with the expert team of Sunlax Systems and Technologies Pvt. Ltd. Mumbai, which supplies solutions for industrial automation. Its expertise and know how in this field are setting the standards and its responsible development is anchored in a process of continuous improvement. Sunlax is a strong and vibrant business unit serving the process industries, which include water and wastewater applications, Electrical, Cement plant automation, Refining, Oil and gas, Sugar industry, Boiler automation, pharmaceutical etc. Sunlax experts help me to identify key focus areas and detail a proven alarms methodology that will enable you to save precious time, allocate resources optimally and enhance profitability and productivity.

Keywords— boiler automation, ControlLogix, ControlNet, Flex I/Os, DCS based boiler automation, advanced boiler automation, advanced boiler control.

1. Introduction

There has been tremendous increased in the demand of automated machine in industrial sector of power plants and with the greater efficiency and high quality. Continuous monitoring and frequent inspection has to done in power plants. There are possibilities of occurrence of errors while measuring. As microcontroller lack some features and also various stages involved with the human workers. That is what this explains the need of the automation in the industries.

The boiler is the most crucial part of the power plant and to increase the efficiency of automation the precise efforts is been taken. Sugar plants are totally based on boiler system. The very critical operation in any boiler system is to control the level of the water in the drum of the boiler. Nowadays, modern techniques are being used in the industries in place of the conventional techniques. The boiler systems which are multipurpose and which produce the byproducts such as Heat, Steam and Chemical Gasses etc. are installed in the sugar industry. In many industries the steam generated by the plant instead of going to waste it is used for the generation of electricity generation. Various new methods of controlling the boiler system are installed so that the system works finely. Fig.1 below is the basic structure of boiler. The greater source as input to the sugarcane plant are fuel which is easily available, feed water and the air. The main output of the system is the steam pressure, steam temperature and the flue gasses electrical power and some of the heat loss. Boilers do have much strength which make them the greater feature of the system. They are durable have long life and can with stand with the climatic changes in surroundings, they can achieve the efficiency up to 95% or can go even further. They provide the effective method of heating and in case of system which is based on the steam may require little pumping or no pumping energy.

2. Followed Rules

Guidance are provided by the ASME (American Society of Mechanical Engineers) and they are for the construction of the system, operation, and maintenance of boilers. From which the following resources are produced.

- In the Section 4-2007 of the “Boiler and Pressure Vessel Code” are the Rules for construction of boilers.
- In the Section 7-2007, of the “Boiler and Pressure Vessel Code”, are the rules for the care and operation of boilers.

In the whole system Boilers are the greater energy consumer. Many a time it happens that the boiler system are never attended for the regular maintenance and management and thus the boiler cost increases up by 15% every year. And hence to save the energy and
the money or cost on the boiler regular check and the maintenance should be there regularly.

2.1. Drawback of previous system

Previous systems are common to occur errors in it as it is handled by human in the data collecting and to process the collected data of the mathematical expressions which are typical. So we require is raw data collector systems which can process it and compare it verify it and compare the data with the standard values. As with the microcontroller ,it require coding for the implementation , fast processing with efficiency also other part depend on the strength of the sub-routine of code. It is a challenge with system involved.

3. Methods

The system architecture of the project is given bellow; it includes the Operator station, Engineering Station, Automation Station and plant overview. The function of operator station is to monitor plant instruments and alarm status. Maintenance and design part will be handling by engineering station. We will place hardware of DCS in automation station. In plant overview where various instruments are installed whose status is to be monitored at the operator station and if any abnormal condition occurs so that operator come to know the error of the process parameter and can take corrective action immediately.

Our main aim is to generate coding for Distribute Control System using programming languages like ladder logic, FBD....etc. After installing this programming in DCS we will operate whole part of hardware automatically by sitting in single room only using monitoring screen. For monitoring screen we are using SCADA (supervisory control and data acquisition system).

First of all for boiler very first thing is the need of the water and which is very pure and the input water to the industry is not so pure and to make pure there is process known as Dearation process.

3.1. Proportional Integral derivative

The PID controller calculation involves three separate parameters: the Proportional, the Integral and also the derivative. These three parameters form the PID calculation. The proportional worth determines the reaction to this error; the integral worth determines the reaction supported the total of recent errors and also the derivative value determines the reaction supported the speed at that the error has been ever-changing. The weighted total of those three actions is employed to regulate the method via an effect element comparable to the position of an effect valve or the ability provide of a heating element.

By calibration these three constants within the PID algorithmic rule, the management will offer control action designed for specific method needs. The response of the controller will be delineated in terms of the responsiveness of the controller to a mistake, the degree to which the controller overshoots the set point and also the degree of system oscillation. It should be noted that the utilization of the PID algorithmic rule for management doesn't guarantee optimal management of the system or system stability.

Some applications might need exploitation only one or two of the parameters using the appropriate system management. this can be achieved by setting the gain of unwanted management outputs to zero. PID controllers are significantly common, since derivative action is incredibly sensitive to measurement noise, and also the absence of an integral value might forestall the system from reaching its target value because of management action.

3.2. Deareator

This is the process which removes the oxygen form water and the other gases like carbon dioxide and other non condensable gases from feed water and by doing this is the reducing of the corrosion in the parts of the boiler and equipment longevity and safety of operation.

Dearations are of two type viz. Mechanical deaeration and chemical Dearation. The Henry’s Law of physics that works in the Mechanical deaeration. In Dearation before feeding water to the boiler the dissolved gasses in the water is removed .usually the oxygen and the carbon dioxide are present in the water which is natural and those gases are of more concern to the steam plant operation. The gasses present in the untreated water oxygen and carbon dioxide cause the steam plant material to corrode. And the rate of corrosion is directly proportional to the amount of gasses present in the water and as the heat increase any reactions multiply and accelerate the rate of the reaction.

3.2.1. Working Principle of Deareator

The primary purpose of the deareator is to lower down and eradicate the presence of the oxygen and the other gases present in the feed water and that too to the level that there potential of corrosion with even under high pressure and that prevailing the steam temperature is eliminated . The dissolved oxygen in the feed-water gets attached to the walls of the boiler,
the metallic piping and the other metallic instruments, equipments and form oxides and rust and thus corrodes the boiler. Carbonic acid is formed when water combines with any dissolved carbon dioxide and that also causes further to corrode. Only allowable level of the oxygen that can be present in the feed water is 7ppb by weight (0.005 cm³/L) or less.

4. Drum level:-

- To control the level of boiling water comprise in the boiler drums and offer a constant supply of steam.
- Level too high, flooding of the steam refinement equipment can occur.
- Level too low, reduction in efficiency of the handling and re-circulate function.
- Pressure can also build to dangerous level.
- Drum level control system control the level regardless and decrease of steam demand, feed flow variation.
- Boiler drum level is critical for the protection of plant and equipment.

Drum level control:

The main aim of the drum level controller is to maintain the level at the boiler startup and at constant steam load. Decrease in the level damages tubes due to overheating. Increase in the level may disturb the process of separating moisture from steam present in the drum, and thus reducing the boiler efficiency.

- Function control module are
- Operator adjust the setpoint of boiler
- Shrink and swell effects
- Automatic drum control
- Feed water valve controlled manually
- Easy transfer between auto and manual mode
- Drum level and steam flow indication
- Indication of feed water valve and flow
- Deviation alarms for drum level

Three options available for drum control are:

4.1. Single element drum level control:

The simplest form of drum level control and is effective

This contains only one process variable (PV) which comes from drum level transmitter. This Process variable is compared to a set point and difference is the deviated value.

On this deviated value controller performs operation and generates the corrective action and as proportional output. The corrected output is then passed to boiler feed water floe in the drum. This requires only analogue input and output and only applicable to single boiler or single feed pump configuration. It has no relation in between drum level or feed water flow. Due to swell effect there is possibility of inadequate control.

4.1.2. Two elements drum level control:

The two elements drum level controller is very suitable for single drum boiler where the pressure of feed water is constant. The elements in it are

Level Element: The output signal from the drum level is the process variable or proportional signal. This signal and the set point are compared and the result is the deviated value. Then signal is the corrective response of the controller which is proportional.

Steam Flow Element: It is a signal of mass flow and is used to control the feed water flow, giving instant corrections to feed water in response to load changes.
The difference in mass flow and the feed water mass flow, the controller correct it.

4.1.3. Three elements drum level control:

The three element drum level control is perfectly suitable for the boiler plant which has multiple working boiler and multiple feed water present variation in the pressure or the flow. The three element drum level is consist of the following

Level Element & Steam Flow Element: This is to correct the unvalued unwanted interruption present within the system like Boiler blow down, Boiler and super heater tube leaks.

Feed water Flow element: This is quick in response and rapidly to the difference feed water requirement From either steam flow rate feed water signal or the feed water pressure or the flow fluctuations

If we want to achieve the optimum control over both steam feed water flow it is necessary to correct the values for density.

The three element system provides compact control for the drum level with unsteady steam load.

Enhanced three element drum level control: The three element system is used only when there is demand of high steam. The two element system is used only when there is a failure in the measurement of steam flow and the single element system is used when there is need of low steam.

The drum level will be derived from up to three freelance transmitters and is density remunerated for pressure among the boiler drum.

4.1.4. Draft:-

The deviation between atmospheric pressure and static pressure is the draft.

A) Natural Draft
B) Mechanical Draft

Natural Draft: A stack of compulsory height to cause sufficient pressure creates natural draft with the resulting air and fuel as flow

Mechanical Draft:-
Mechanical draft is partially created by the use of mechanical fans.

Forced Draft:-
The function of the Forced Draft is to push the air and ignition gases into the boiler.

Induced Draft:-Induced Draft is used to pull the air and ignition gases inside the boiler.

Furnace Draft:-Furnace Draft is sustained at atmospheric pressure (or just below)

By using combination of ID and FD fan, draft is mentioned to as balanced system

4.1.5. Critical Parameters/Control Parameter of boiler

Level Control
De-aerator level, Drum (steam) level and hot well level

Temperature Control
Deaerator temperature, temperature of Steam-Drum, Steam in Turbine temperature, Waste gas temperature and under bed boiler temperature.

Pressure Control
Turbine inlet steam pressure, balanced pressure of draft, Deaerator pressure, Force draft pressure and induced pressure of draft.

Flow Control: Water flow, Air flow, Steam flow.

5. Automation

Main aim of automation is to transfer the human control of the machine to the technical equipment.

Advantages
High end quality product and productivity. Efficient usage of raw materials and enhances every amount of
energy, improved safety and secure working condition.

5.1. History of Automation and Control

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5.2. DCS elements

**Domain:**

Network of group of station make the Domains. By using (ABC) converter domains are linked. Domains are of two types’ real domain and virtual domain. Real domain stations are connected straight to network. Virtual Domains stations are indirectly connected to network.

**Field control unit:**

Field controls are the “lower level in Distributed control system, there are separate individual function for every function unit of the system placed in the field. These units are strong autonomous subsystem of automation. Whose influence is limited to (8, 16, 32) points or control loops. As they are autonomous in function and placed in field. The subsystems are known as field stations. The primary working of field station is as follows:

- Analog and digital signals collected and preprocess it before forwarding.
- Monitor the alarming messages and log it.
- Perform open loop control function and closed loop control functions as well.

6. Proposed Work

The design of Distributed control system of this project is given below. It includes the operator station, Engineering station, and Automation station and plant summary. The function of the operator station is to watch plant instruments and alarm status. Maintenance and design part are handle by engineering station. We’ll place hardware of Distributed control Systems in automation station. In plant summary wherever numerous instruments are put in whose status is to be monitored at the operator station and if any abnormally happens so operator return to grasp the error of the process parameter and may take corrective action in real time.

Our main aim is to get coding for Distributed control system using programming languages like Ladder Logic, FBD, etc. when putting in this programming in Distributed system we’ll operate whole a part of hardware automatically by sitting in single area solely using monitoring screen. For monitoring screen we have a tendency to using subordinate control and data acquisition system.

The system architecture of this project is given below. It includes the operator station for monitoring plant instruments and alarm status, Engineering station for maintenance and design, Automation station for storage of DCS hardware and plant summary wherever varied instruments are put in whose status is to be monitored at the operator station and if any abnormal condition happens in order that operator come back to grasp the error of the process parameter and may take corrective action.
7. Efficiency

The amount of energy contained in fuel is absorb by working liquid (e.g. water) in the boiler is the combustion efficiency of the boiler. The result is a complete combustion only when the burning of the hydrocarbon gives output carbon dioxide, water and heat. When there is insufficient supply of the oxygen or impure fuel results in incomplete combustion and thus efficiency is reduced by directly 10% or more. Safety concern is that the unburned fuel can ignite and could explode. Efficiency of the fuel can be increased by forcing small amount of air but will reduce the efficiency when large of excess air passed above the limit as shown in the graph above.

The excess air must be between 2-3% and excess enough to suit the variation in the temperature, humidity, density. The excess air flow must be same through the firing range.

Mechanical jackshaft control: this is the simplest type to control the boiler burner and usually used to control small boiler. This is single point control because control assembly control air and fuel both.

Parallel positioning controls: The separate motors are deployed for the flow of air and fuel so that they can be adjusted. Typically 10-25 points are mapped during setup to map the curve of air flow and corresponding fuel flow.

Cross limiting controls: it is used to control large boiler and controls are used to sense and compensate air and fuel factors that could reach at optimum air fuel ratio. The flow of air and fuel are adjusted initially and maintained through the firing range. Oxygen trim control is used adjoining parallel positioning or cross-limiting controls. First it checks oxygen in the fuel and control the flow of air to flue ratio to maintain the amount of oxygen in fuel.

Flue Gas Economizers
To increase the fuel efficiency it is best practice to use the fuel gas economizer for heat recovery. These are basically heat exchanger in the boiler exhaust to transfer heat from waste gas to feed water or combustion air. There is increase in boiler efficiency with use of economizer by three to four percent.

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