International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-9 , June 2014

`

PROCESS AUTOMATION IN BOILER

Sunil Pasalkar
Department of Electronics Engineering P.D.E.A'S COEM, Pune, India
(Suniket_76@yahoo.co.in)

***Abstract*- Plant operators have to physically monitor performance values and the quality of outputs to determine the best settings on which to run the production equipment. Maintenance is carried out at set intervals. This generally results in operational inefficiency and unsafe operating conditions. A process automation is used to automatically control a process such as food, chemical, oil refineries, paper and pulp Industries while considering energy efficiency. This paper focus on process automation used in boiler. Steam is most economical, flexible and versatile tool for industry wherever heating is required. It uses a network to interconnect sensors, controllers, operator terminals and actuators. The information is stored and analyzed on a computer and the entire plant and each piece of production equipment can be monitored on a large screen in a control room.**

***Keywords*- boiler , instruments, PLC, process automation, SCADA**

I. INTRODUCTION

Process automation involves using computer technology and software engineering to help power plants and factories in industries as diverse as paper, mining and cement operate more efficiently and safely. Process automation simplifies this with the help of sensors at thousands of spots around the plant that collect data on temperatures, pressures, flows and so on. The information is stored and analyzed on a computer and the entire plant and each piece of production equipment can be monitored on a large screen in a control room. Plant operating settings are then automatically adjusted to achieve the optimum production. Plant operators can manually override the process automation systems when necessary optimum production. Water can exist in the form of solid, liquid and gas as ice, water and steam respectively. Steam is produced by evaporation of water, which is a relatively cheap and plentiful commodity in most parts of the world. Its temperature can be adjusted very accurately by the control of its pressure, using simple valves; it carries relatively large amounts of energy in a small mass, and when it is encouraged to condensate back to water, high rates of energy flow into the material being heated are obtained, so that the heat using plant does not have to be unduly large[8]. The chemical energy, which is contained in coal, gas or other boiler fuel, is converted into heat energy when the fuel is burned. That heat energy is transmitted through the wall of the boiler furnace to the water. The temperature of the water is raised by this addition of heat energy until saturation point is reached – it boils. The heat energy which has been added and which has had the effect of raising the temperature of the water is known as the liquid enthalpy. At that point of boiling, the water is termed Saturated Water. The water in our boiler is now at saturation (boiling) point at 100 °C. Heat transfer is still taking place between the furnace walls and the water. The additional enthalpy produced by this heat transfer does not increase the temperature of the water. It evaporates the water, which changes its state into steam. The enthalpy that produces this change of state without change of temperature is known as the enthalpy of evaporation. The job of a boiler is to supply good quality dry steam at the correct pressure at the right time.

II. BOILER

Boiler is a closed vessel in which the heat produced by the combustion of fuel is transferred to water for its conversion into steam at the desired temperature and pressure. Boiler

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-9 , June 2014

accessories are Feed pump ,Injector, Economizer , Air pre-heater, Super heater , Steam separator.

Boiler efficiency = $(E_{out} - E_{fw})/E_{fuel}$ (1)

E_{out} : amount of energy in the steam or hot water

E_{fw} : amount of energy in feedwater

E_{fuel} : amount of energy in fuel

A boiler is a closed vessel in which water or other fluid is heated. The fluid does not necessarily boil. The heated or vaporized fluid exits the boiler for use in various processes or heating applications including central heating, boiler-based power generation, cooking, and sanitation. The basic components of a water-tube steam boiler are the furnace, where air and fuel are combined and burned to produce combustion gases, and a water-tube system, the contents of which are heated by the combustion process. The tubes are connected to the steam drum, where liquid and vapor are separated and the generated water vapor withdrawn. If superheated steam is to be generated, the steam from the drum is passed through the superheater tubes, which are exposed to the combustion gases. A 1% loss in efficiency on a 100,000 lb/hr (45,360 kg/hr) boiler will increase its yearly operating cost by about $20,000. A 1% efficiency loss can result from a 2% increase in excess oxygen or from about a 50°F (28°C) increase in exit flue-gas temperature[7].

Fig.1.boiler

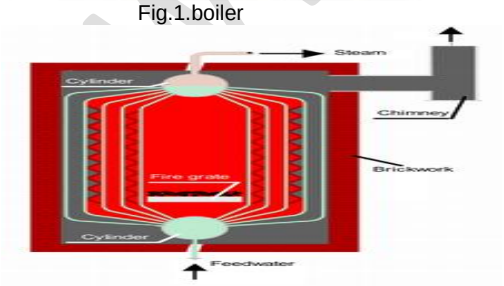

Fig.2.Water tube boiler

III. PROCESS AUTOMATION

Various Instruments, sensors are used like RTD ,flow transmitter ,Self Acting Temperature Control Valve ,Compact on-off Valve, PID base Temperature Control System ,temperature gauge, control valve, level transmitter etc.

Fig.3,RTD

Fig.4,flow meter

Fig.5.temperature gauge

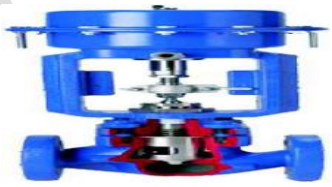

Fig.6.valve

A.CONTROL LOOP TYPES.

A single control loop includes a controlled variable sensor, controlled variable transmitter, controller, automatic-manual control station, and final control element. Control loops used for boilers may be of the pressure, temperature, liquid level type, or flow type [9]

PRESSURE

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-9 , June 2014

Pressure control loops may be used for the control of boiler pressure or fuel oil pressure. For the control of boiler pressure, the final control element regulates fuel flow to the boiler in response to boiler drum steam pressure. For the control of fuel oil pressure, the final control element is usually a pressure reducing control valve that regulates in response to downstream pressure**.**

TEMPERATURE

Temperature control loops may be used for the control of steam temperature from boilers or fuel oil temperature from fuel oil heaters

LEVEL

Liquid level control loops may be used for the control of boiler drum water level. FLOW

Flow control loops may be used for the control of fuel flow into the boiler burners, burner draft airflow, feed water into a boiler, or steam flow out of a boiler

ALARMS

Furnish alarms to announce the approach of unsafe conditions. Provide shutdowns to shut the equipment down under unsafe conditions

BOILER DRUM LEVEL

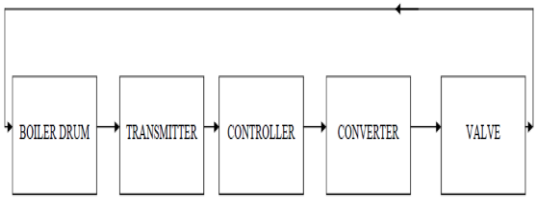

Fig.7.boiler control

The block diagram of boiler control is shown in above figure the output from the boiler i.e, the steam outputs and the level of water is given to transmitters. The output of transmitter is given to the controller which act as level indicator controller and flow indicator controller. If there is any error corresponding to desired set point, the signal from controller is given to the converter which will open or close the valve and the water will be drained out or filled according to required steam.

Drum Level Control Systems are used extensively throughout the process industries and the Utilities to control the level of boiling water contained in boiler drums on process plant and help provide a constant supply of steam.

If the level is too high, flooding of steam purification equipment can occur.

If the level is too low, reduction in efficiency of the treatment and recirculation function.
Pressure can also build to dangerous levels.
A drum level control system tightly controls the level whatever the disturbances, level change, increase/decrease of steam demand, feedwater flow variations.

It Provide controls to always maintain the boiler drum level within the boiler manufacturer's specifications under all operating conditions. Three types of control systems used in boiler plants are single element, two element and three element.

A single element control system utilizes just a level transmitter to maintain control of the boiler drum water level. Use a single element control system only for boilers operating at steady loads.

A two element control system utilizes a level transmitter and the amount of steam flow from the boiler to maintain control of the boiler drum water level. A two element control system provides some compensation for variable loads. It does not adequately correct for the expansion of water within a boiler due to the decreased boiler pressure that occurs when a large amount of steam is required, or for the contraction of heated water in a boiler due to the addition of cold feedwater.

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-9 , June 2014

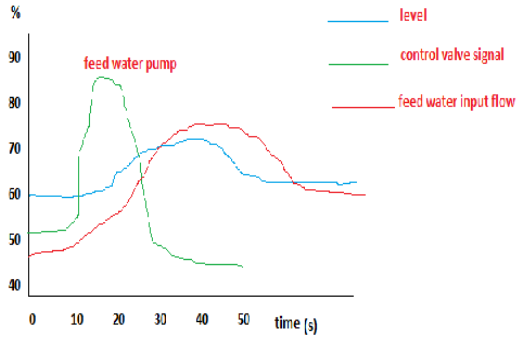

Fig 8.two element control

A three element control system utilizes a level transmitter, the amount of steam flow from the boiler and the amount of water into the boiler to maintain control of the boiler drum water level. The steam flow from the boiler is usually compensated for pressure and temperature. A three element control system corrects the problems associated with a two element control system and provides the best method of compensating for variable loads[9].

Metering control system

In this system control is regulated in accordance with the measured fuel and air flows. This maintains combustion efficiency over a wide load ranges & over long period of time. Feedwater control is the regulation of water to the boiler drum. It provide a mass accounting system for steam leading and feedwater entering the boiler.

Combustion efficiency

It can be determined if proper information is available on fuel analysis, fuel gas analysis, combustion air temperature and stack temperature using manometer.

B. Temperature control

Temperature control can be achieved by manually throttling the steam valve and manipulating steam flow, in the same way that a gas tap is used to regulate the supply of heat on a domestic cooker. Unfortunately, such anarrangement may call for frequent manual adjustment if the heat requirements of the equipment in question are liable to fluctuate significantly. More accurate control can be obtained by the installation of a pressure reducing valve but the need for manual adjustment still remains. The ideal answer is to fit one of the Automatic Self Actuating Temperature Control System

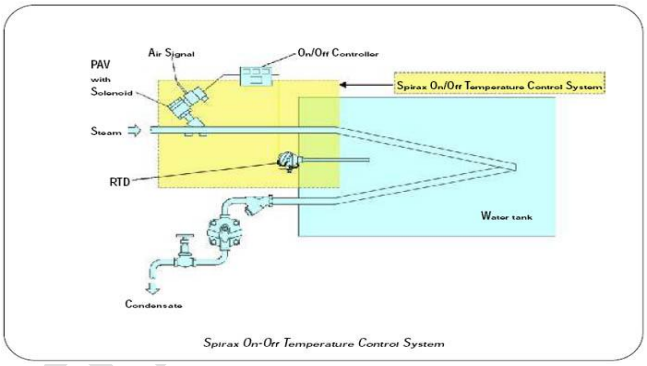

Fig .9.on-off temperature control system

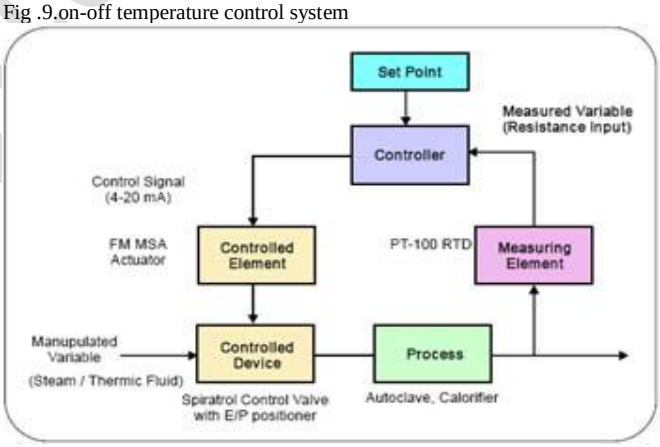

Fig .10.PID temperature control system

Mathematically proportional+integral+derivative mode controller can be expressed as,

$$P(t) = Kp\ e(t) + KpKi\ e(t)dt +)KpKd\ de(t)/dt + p(0) \quad (2)$$

Where p(0) = initial value of the output.

C.PLC

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-9 , June 2014

To overcome the disadvantages of relay logic controller, a programmable logic controller was developed .A Programmable Logic Controller, PLC or Programmable Controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLC consist of processor, input modules ,output modules, programming software . Scan time tells how much time is required for plc to complete cycle of i/o scan and execution. Typical scan time of PLC is 20 ms. Programming unit is an interface between the user and the PLC. Ladder diagram is a special schematic representation of the hardware elements and its connection, used to make the combination of hardware and description of sequence of events clear is called ladder diagram. In ladder diagram address number is specified to each device.

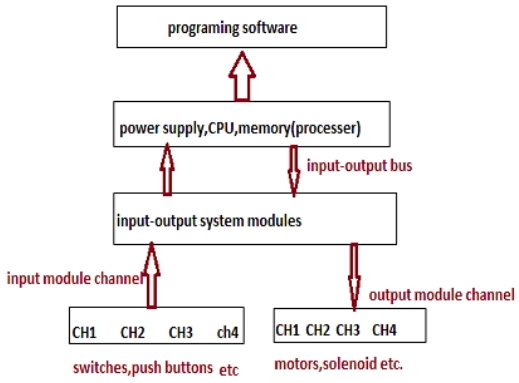

fig.11.PLC block diagram

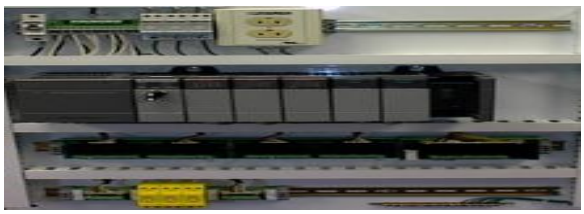

Fig.12. Allen-Bradley PLC

D.SCADA

supervisory control and data acquisition is a type of industrial control system(ICS). Industrial control systems are computer-controlled systems that monitor and control industrial processes that exist in the physical world.

E. HMI

A human–machine interface or HMI is the apparatus or device which presents processed data to a human operator, and through this, the human operator monitors and interacts with the process. The HMI is a client that requests data from a data acquisition server.

PLC , SCADA interfacing required communication cable, driver ,server etc.

F. The EffiMax 2000 package

It provides a complete monitoring and data acquisition solution for boiler performance. This sophisticated yet simple to use analyzer operates on-line continuously, monitoring your boiler efficiency every instant of its operation.

EffiMax calculates the efficiency of the boiler based on indirect efficiency computation and computes individually the total amount of losses like stack loss, enthalpy loss, radiation loss and blow down loss in your boiler. Using the data generated on the system losses, on-line suggestions can then be used to fine tune the system to generate more steam with a lower quantity of fuel.

The Model 353 Process Automation Controller is a stand-alone, microprocessor-based industrial controller designed for a broad range of process applications. It can serve as a simple single-loop controller or as a multi-loop controller with complete control and logic functions for a small unit batch or continuous process. The Model 353's field bus and networking options enable it to function as an integral element in a plant system. Loops are configured for control, sequence, or logic as needed within the Model 353. Each configured loop can have a virtual operator display that is viewed locally using the LOOP button on the faceplate and is mapped to network communication for a plant operator station. Alarm management is handled using the L (Loop) & S (Station) indicator lights along with the priority assignments and flashing options of each alarm.

The MICROCON DCS system is modular and expandable and

International Journal of Innovative Technology & Adaptive Management (IJITAM)
ISSN: 2347-3622, Volume-1, Issue-9 , June 2014

provides unique solutions to handle both continuous and batch applications in the same hardware. Automation for different types of fuel fired boilers and turbines. Special techniques for combustion control. Sequence of event recording @ 1 ms time stamping.
Also Advanced PLCs, DCS with remote IO Capability , TCP/IP communication upto 1Gbps, Mesh Topology for reliable network,Graphical Drag and Drop facility for logic configuration,Boiler Tube Leakage Detection System ,Furnace TV,Management Information System interface with external world and office automation system can be used in boiler automation.

IV. ADVANTAGES

To increase labor productivity, to reduce labor cost, to mitigate the effects of labor shortages, To reduce or remove routine manual and clerical tasks, to improve worker safety, to improve product quality, to reduce manufacturing lead time, to accomplish what cannot be done manually, to avoid the high cost of not automating.

V. CONCLUSION

Thus process automation plays an important role in boiler used in various fields.

VI. FUTURE SCOPE

Make automation system more efficient and more user friendly.

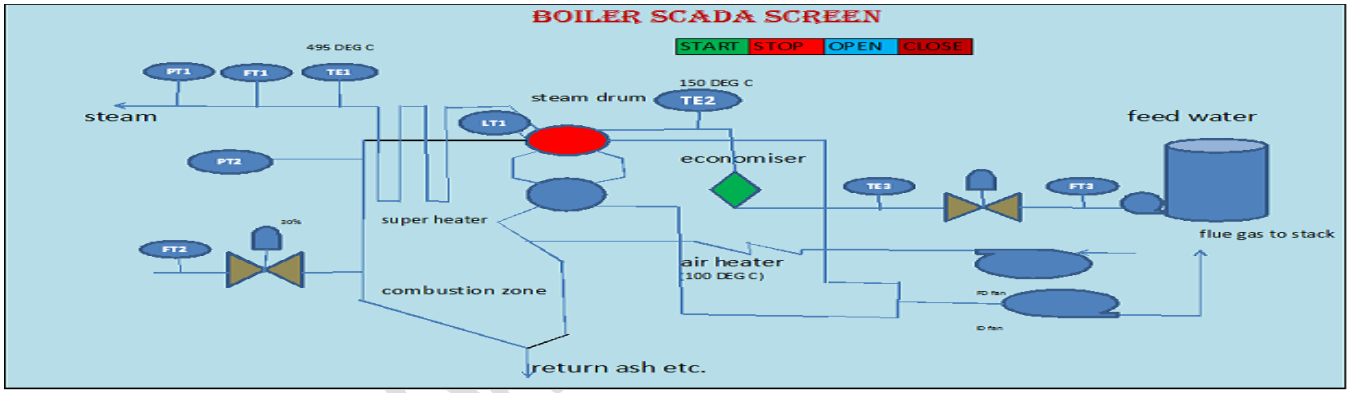

Fig. 13.boiler SCADA SCREEN

VII. ACKNOWLEDGMENT

I am grateful to Prof .R.M.SAHU, Prof. R.K. MOZE, Prof. S.M.BANKAR for their support and encouragements

REFERENCES

[1]. Ezell, Barry, "Supervisory Control and Data Acquisition Systems for Water Supply and Its Vulnerability to Cyber Risks" available on the internet at: http://watt.seas.virginia.edu/~bce4k/home.html.
[2]. Rockwell Automation SCADA System Selection guide Allen-Bradley, Publication AG-2.1.
[3]. Hillenbrand, Cary, Expert Three, Technical expert specializing in the planning and design of SCADA based and Distributed control system.
[4]. Boyer, Stuart, A. SCADA: Supervisory Control and Data Acquisition, Instrument Society of America, Research Triangle, NC. 1993.
[5]. Ezell, Barry, "Scenarios One and Two: Source to No 1 PS to No 1 Tank to No 2 PS to No 2 tank (High level) for a Master-Slave SCADA System", SCADA Consultants, SCADA Mail List, scada@gospel.iinet.au (August 1997).
.[6].MICHEL P GROVER :automation computer integraed system and manufacturing system.
[7]. Process control & optimization, VOLUME II: B.G.liptak.
[8].Forbes Marshall services &product.
[9].Introduction to Boiler Control Systems: J. Paul Guyer, P.E., R.A., Fellow ASCE, Fellow AEI.