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Programmable Logic Controller Application in Boiler Automation-A Case Study

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Abstract **:** The purpose of presenting this paper is to introduce a system constituting a PLC (Programmable Logic Controller) that is connected to the water tube boiler which thereby increases the quality and also ameliorates its efficiency. This system does monitor all the parameters of the boiler like its temperature, pressure and volume with their respective sensors that serves as an input to the PLC. The boiler temperature and pressure is controlled by the output of the PLC and the user will be receiving the required volume and steam. All the measured variables are controlled through SCADA and are indicated on the SCADA screen. This is connected to the PLC with the help of a communication cable. By altering the variables in SCADA the entire process is controlled as required. This paper is proved to be very efficient pragmatically as the need of automation enhances in our daily life.

Keywords : PID, SCADA, PLC

1. INTRODUCTION

There has always been an augmentation in the demand for an improvised quality,higher efficiency and machines that are automated in the industrial field of power plants. Continuous monitoring as well as continuous inspection at frequent intervals of time is required. There is a very high possibility that the measurements taken by the workers are wrong. This paper takes a devout attempt in listing the surplus advantages the companies will be gaining after the advent of automation into them. The control of boiler with automation is the precise effort of this paper. To reduce the human intervention and to automate the plant, the very basic step is to introduce SCADA (Supervisory Control and Data Acquisition) which keeps the plant under observation and records the values required thereby minimizing the human errors. Now the PLC (Programmable Logic Controller) is used for storing the instructions internally for the implementation of functions like logic, sequencing, arithmetic and counting for the control through the analog input/output and various machine processes.

2. PROPOSED SYSTEM

The steam generator was controlled manually before. At the advent of automation the process is now no longer manual and hence everything is automatic by the SCADA with its statuses being updated.

2.1. Boiler

A closed vessel or a drum which heats the water or other fluids inside it is called as a boiler. It is not mandatory for the fluid to boil. The fluids that are heated or vaporized exits the boiler for its application in water heating, central heating power generation based on boiler and a lot more. They designed to produce steam by heating water. The

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fluid in the boiler drum called as shell and the thermal energy in relation to the fuel combustion is utilized to produce steam at a desirable temperature and pressure. It is an amalgamation of apparatus designed for producing, recovering heat together and also transferring.

There are few factors which are considered for the selection of a good boiler :

- The working pressure and the steam quality.
- Higher steam generation rate.
- Simple construction and design.
- Low initial and maintenance cost.
- There should be an accessibility for repair and inspection.

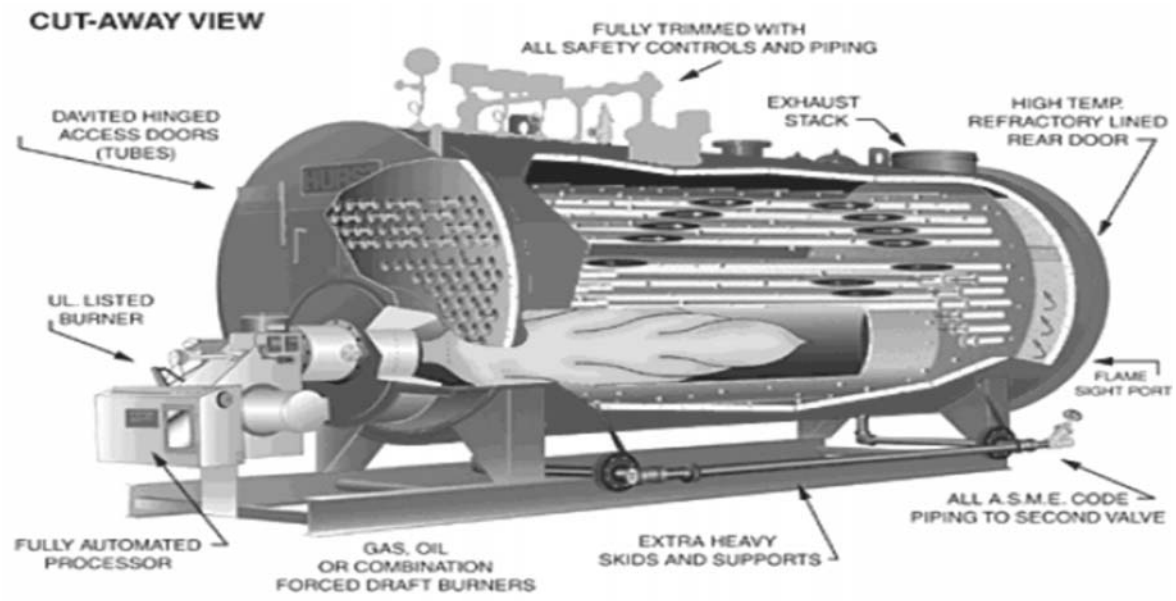

Fig. 1. Fire-tube boiler [1].

Efficiency of a Boiler

The efficiency of a boiler may be defined as the ratio of amount of steam generated per hour to the amount of heat supplied by fuel per hour.

$$\text{Efficiency } (n) = ms\,(h1 - h2)/(m1 * \text{C.V of the fuel}) \quad (1)$$

Where,

ms = mass of steam generated per hour

mf = mass of fuel used per hour.

$h1$ = enthalpy of feed water

$h2$ = enthalpy of steam produced

C.V of fuel = Calorific value of the fuel.

Applications of a boiler

They have various applications in several fields, which are as follows :

- Boilers are mainly used in the generation of electricity in power plants through its high pressure steam which is expanded through nozzles to run the steam turbine.
- Heating of the buildings also takes place in countries that have extreme cold climatic conditions through the hot water producing boilers.
- It is also used in various industries like the textile industry for bleaching and other industries like the chemical industries or sugar industry.
- It also contributes to the production of cement and in the field of agriculture for soil steaming.

Boilers can be used in stationary applications like providing hot water to industries and also mobile applications that provides steam for locomotion in application.

Boiler operation

Water is an inevitable source in the production of steam. The water should be purified with its PH balanced and stored in a de-aerator tank. The water from the de-aerator tank passes through two parallel pipes when the feed water pump is switched on. The failure or malfunctioning of any pipe will not affect the boiler operation because those individual pumps are maintained at a flow rate of 130% and 5%. The water is made to pass through the economizer thus the heat lost in the outgoing gases is again recovered, by transferring heat to the water.

This heated waternow flows through the water drum. The water should at least be maintained at 50%. The water levels are now sensed by using a PID controller in AB PLC. When the level is not 50% than the change is sensed by the PID controller and it sends appropriate control signal to the feed water valve 1 or 2. This is re-circulated to the water drum. There is a high amount of steam generated due to the difference in temperature. The temperature of the generated steam might be altering in comparison to the desired temperature. Thereby based on the scenario the steam generated is than passed via the primary heater followed by secondary heater. The secondary temperature is under observation. There are three cases which are considered.

Case (*i*) : If there is a condition where in the Secondary heated temperature is of a higher value than the temperature that was desiredthan an approximate control signal is delivered to control valve 3 of the super heater tank by the application of PID controller. This is done to decline the temperature via spraying cool water from the de-aerator tank.

Case (*ii*): If the secondary heated temperature gives an output value less than the desired temperature than an approximate control signal is delivered to bunker valve than to the control fuel flow. This is done by using the PID controller.

Case (*iii*) : If the secondary heated temperature gives an output value equivalent to the desired temperature than there is no such control signal is sent.

2.2. Automation

Consignment of human control and his work on an equipment which is technical and is aimed towards achieving it. Its primary target to be accomplished is to minimize the human intervention. It is a use of an amalgamate control system for supervising an equipment like machinery.

Advantage

It has got numerous advantages in disparate fields like increased productivity, good quality of end products, effective and efficient utilization of power and the raw materials, It also gives a scope of amelioration with respect to the safety in the working environment. It has also less space requirements, saves a lot of power and has also got greater reliability.

History of Control and Automation

Manual control
With logic gates
Electrical controlwith logic.
PLC

This paper concentrates on the programmable logic controllers as it many advantages. It occupies les space and saves up a lot of energy. It has got an easy trouble shooting and is economical as well. The compatibility of a PLC, Logic control, PID control, signaling and listing, coordination and communication makes this advantageous to a greater extent.

Programmable logic controllers

In this the desired control and automation over the boiler is achieved by using software with command statements rather than the application of wires.

Allen Bradley PLC

An intelligent system of modules is known as Programmable Logic Controller and it was bought in application of Instrumentation and Control industry in substitution of the relay based logic [4]. There has been an improvement over the period of time in its handling and more programming elements have also been added along for further improvement in its communication.

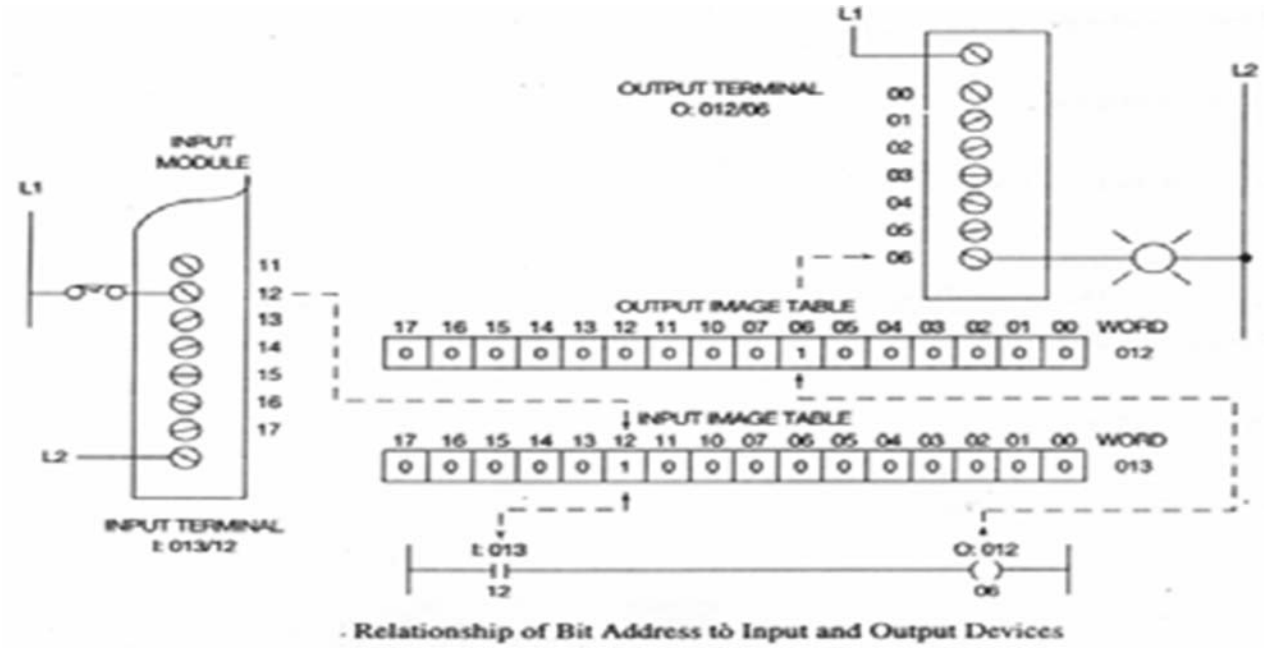

Fig. 2. I/O Pin configuration of Allen-Bradley[2].

The area can be altered by clicking the left side of the mouse on the appropriate symbol.

Working of a PLC

- At the beginning of each cycle all the field input signals are brought in by the CPU from the module and are stored into the internal memory as the process input image (PII). The PLC checks for the activation of a switch or a sensor. The information obtained in this step is stored in the memory for it to be used in the next stage.

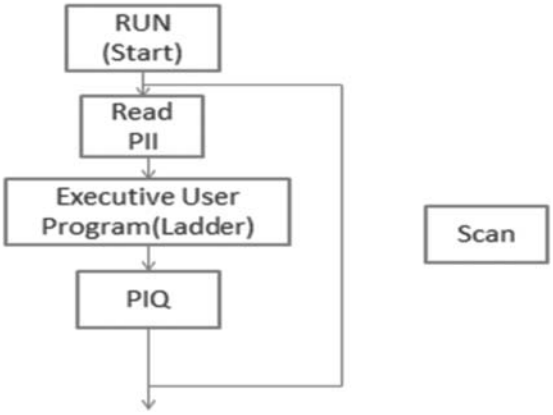

Fig. 3. Control structure of PLC[2].

- In this stage there is an availability of the of the CPU program stored in the CPU program memory. The CPU pointer moves in the ladder program after the PII is read. The input status is taken from the PII which processes all the available rungs in the user program. The output now gets stored in the CPU's internal memory which is the PIQ(Process Output Image) . At the end of the scanning cycle the signals states are transferred in the process image output to the output module and further to the field control which is done by CPU.
- Finally all the outputs are checked by the PLC and altered accordingly. Alterations are done depending on the input status that had been read during the first step and the result of the program execution. The basic function of the PLC is continual scanning which involved three basic steps. Input and the output driver's picks up PII and the images are transferred to the database by the PIQ which is used in the graphical view of the process from the operator station (OS) in the central control room.

Scanning time is the total time taken in performing all the three steps.

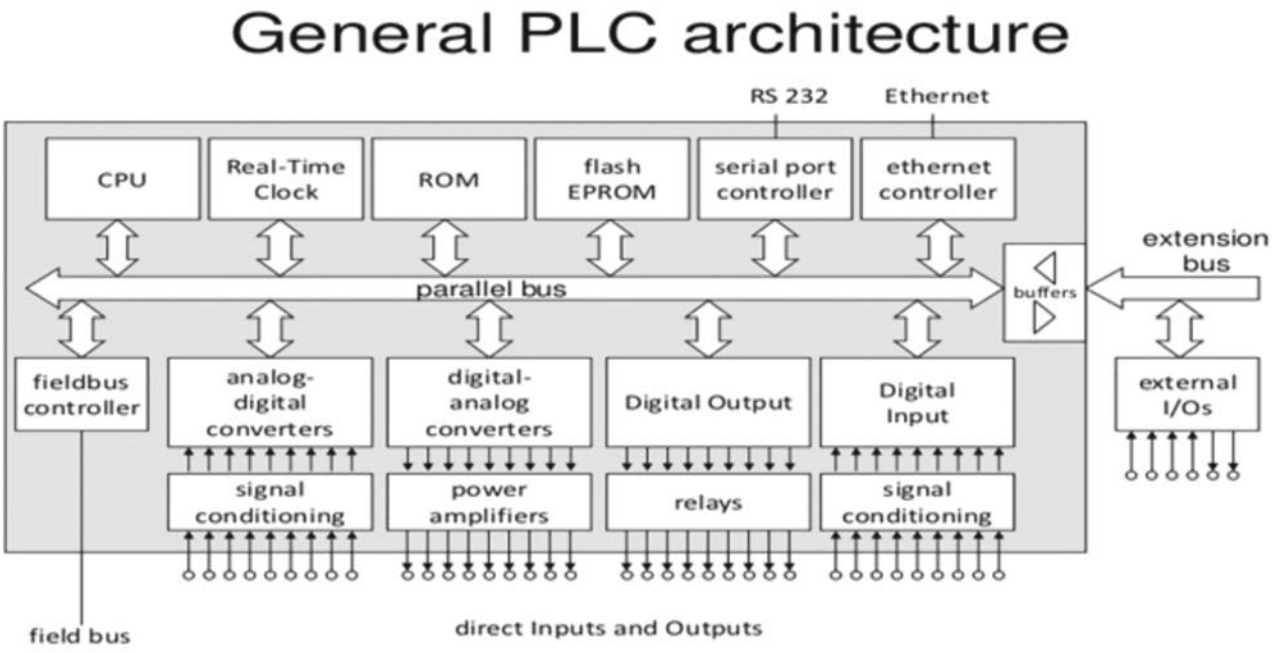

Fig. 4. General PLC architecture.[3]

2.3. SCADA

Now a days automation system contains PLCs and SCAdA software. If you amalgamate SCADA and PLCS you will have better advantages in monitoring and controlling the plant and you will also have acess to the information in the way you prefer to.

SCADA generally runs on PC and is also connected to various PLCs and also other peripherals. It helps in enabling the user to generate applications for the most requirements that are demanding by the plant engineers, operators and managers tailored precisely to the norms of each plant. SCADA constantly accumulates data from the plant in real time and then stores and processes it in the database and later it evaluates and generates alarms, display the information to the plant operators.

Size of a SCADA does range from a few 1000 to several 10 thousand Inputs/Outputs channels. SACDA system is used to run on DOS, VMS and UNIX; in recent years all the SCADA vendors have moved to NT.

SCADA systems are systems that are not only used in industrial area. This is also actively used in some of the experimental facilities such as nuclear fusion. SCADA is an software in the control systems.

SCADA can turn out to be more efficient where the operational duties are to be monitored electronically instead of local.

2.4. PID controller

PID stands Proportional(P), Integral(I), Derivative(D) controller. A PID controller acts as a general feedback system. It feeds a proportion of the actuating signal plus its derivative and integral portion for amelioration of the transient response and the steady state error of the closed loop. The first published theoretical analysis of a PID controller was by a Russian American engineer Nicolas Minorsky.

The PID controller individually calculates all these parameters *i.e* the proportional, the integral, the derivational values. The controller gives an attempt for reducing the error by altering the process control inputs. The algorithm for the controller involves three bifurcated constant parameters and is also called three-term control.

$$U(t) = MV(t) = Kpe(t) + Ki \int_0 e\,0\,dk + Kd\,\frac{d}{dt}e(t) \quad (2)$$

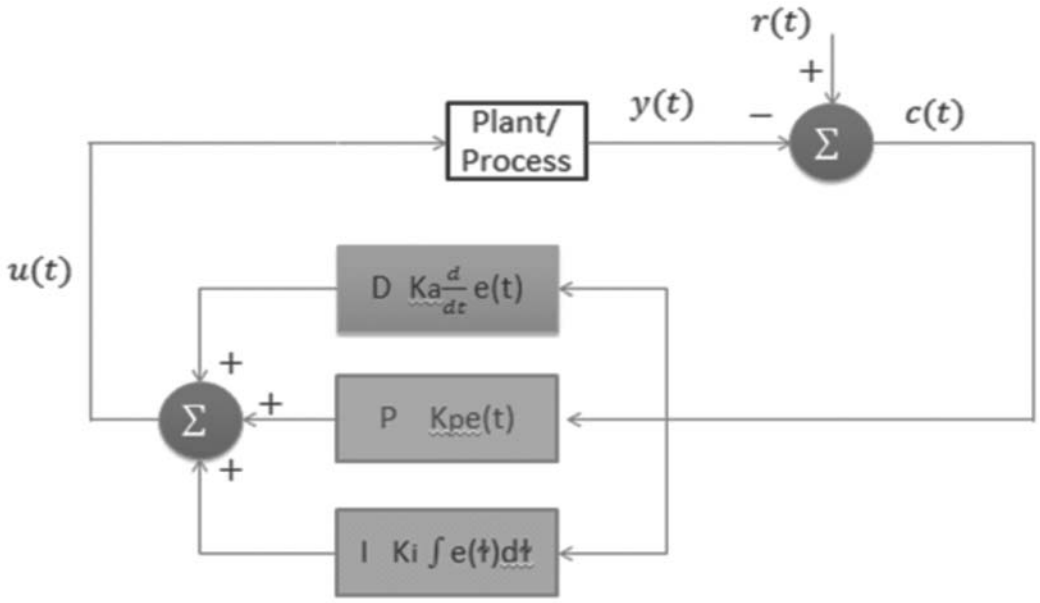

Fig. 5. PID block diagram[4].

Proportional term

This term gives an output value that is in accordance to the current error value. This response which is proportional can be altered by multiplication of the error by a constant Kp and is known as the proportional gain constant.

This proportional term is : $P_{out} = K_p e(t)$ (3)

Integral term

The magnitude of the error and the duration of the error is proportional to the contribution done by the integral term. This integral term in the PID controller is the addition of the instantaneous error over the time period and will give the accumulated offset that should have been amended before. The product of the accumulated error and the integral gain Ki is than summed to the output of the controller.

Derivative term

The slope of the error over time is determine for the calculation of the derivative of the process error and then multiplying this rate of change and the derivative gain to the overall control action which is termed as the derivative gain *kd*.

$$D_{out} = \{Kd^*[(d/dt)e(t)]\} \quad (4)$$

Applications of a PID

- These PID controllers solves many problems related to control and do perform well after the desired tuning.
- It is also used in the process industry and in many of the automation systems.

3. CONCLUSION

The primary ambition of any power plat is to acquire control over the boiler. There were several techniques which could be used but the selected method is based on objectives which vary in nature like the quality, efficiency, profit which depends on the purpose of the company.The continuous advancements at a frequent rate by the advent of new technologies taking place in the present scenario of the industries.This paper has presented all the continuous advancements bought in the industrial segment at the advent of new technologies.

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