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Design and Implementation of Intelligent Boiler Controlling and Monitoring System Using PLC

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Abstract- *This paper features on implementing controlling and monitoring system to control temperature and water level of boiler by using sensors. Boiler is requisite for steam systems of process and power plants. Basically, boilers are used to produce steam which will then use for different operations like to run the turbine which in turn produces the electricity. Safety of boiler is most important because overall safety of the workplace is depends on safe boiler operation. Boiler requires 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. So a reliable monitoring system is necessary to avoid catastrophic failure. Over the period, as technology has evolved, boiler safety can be maintained in a much better way compared to the past. In this project automation of boiler controlling system is achieved by using PLC. Boiler safety management systems can tremendously enhance the safety of boilers and personnel working nearby. At the same time this project will assure increases the quality and increases its efficiency and easy to control and maintain. The proposed system is relatively cost effective and more reliable in terms of automation.*

Keywords: PLC; Automation; Boiler monitoring system; Reliability; Sustainability.

1. INTRODUCTION

Automated machines have increased in the industrial sector of power plants to meet the demand of high quality and greater efficiency. Basically boilers are vessels used to produce steam which will then use for different operations like to run the turbine which in turn produces the electricity. After that, steam water used for different sectors for reuse. To avoid errors and damages on during process it is essential to monitor the temperature and water level for reliable operation. But with the human workers there are number of possibilities of errors while measuring at different stages which can lead boiler explosion. A boiler explosion is a catastrophic failure of a boiler while 83 percent were a direct result of human oversight or lack of knowledge (i.e., low-water condition, improper installation, improper repair, operator error or poor maintenance).

To avoid the errors due to involvement of human workers, the boiler automation techniques are very much important. To control the boiler system various controlling mechanism are used so that it works properly. The target for the boiler automation is to take care of the boiler safety to prevent dangerous conditions occurrence. Thus the boiler automation must be at the same time fast and informative and it has to be able to offer the operator a tool for his use so that he is able to control the boiler. The automation software programs and hardware are built so that the modularity is taken in account. Thus the whole automation solution is easy to handle and expand if needed. High performance, safe and reliable operation and high degree of integration are the main requirements for the boiler automation. The automation of the boiler plant is one whole that covers the entire plant. The whole power production is controlled from the main control room, besides which there are identical workstations, for example, at the water plant, fuel handling and at maintenance rooms. As the whole plant is operated by one system, the control room can be designed to be consistent and ergonomic. The number of personnel can also be kept small so the plant can be also designed to be run at 1 man shifts.

The automation of our lubrication system is carried out by using a PLC instead of microcontroller. A PLC is a digital computer used for automation of electromechanical process. PLC is designed for various features of itself such as multiple I/O arrangements, immunity to electrical noise, extended temperature ranges, resistance to vibration and impact, memory back-up.

2. RELATED WORKS

In the mid-nineteenth Century, during the industrial revolution, steam was in great demand to provide the power necessary to operate manufacturing equipment [1-3]. During this period, there was no one standard in existence to guide individuals in the construction of

boilers. Consequently, boilers of all types and sizes were being constructed. Many designs resulted in catastrophic failures like explosion of steamboat Sultana on April 27, 1865 when 1,192 of 2155 passengers were died [4].

On 1915, the American Society of Mechanical Engineers (ASME) had developed a standard for the construction of boilers which would provide a safe and reliable product [5]. Conventional equipment systems are prone to errors due to the involvement of humans in the data collection and processing using complicated mathematical expressions. Thus what we require is a system that collects raw data, processes it and presents it in values which can be verified and compared with the standard values [6]. On 1965, Zadeh introduce fuzzy set theory. A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function which assigns to each object a grade of membership ranging between zero and one. This theory plays an important role in human thinking, particularly in the domains of pattern recognition, communication of information, and abstraction [7]. On December 1974, describes a scheme in which a fuzzy algorithm is used to control plant, in this case, a laboratory-built steam engine. The algorithm is implemented as an interpreter of a set of rules expressed as fuzzy conditional statements. This is known as fuzzy controller [8]. Since the introduction of fuzzy set theory and the first invention of a fuzzy controller by fuzzy control has gained a wide acceptance, due to the closeness of inference logic to human thinking, and has found applications in some power plants and power systems [9]. On March 2002, Wei Wang, Han-Xiong Li, and Jingtao Zhang proposed an intelligence based Hybrid boiler controlling system for power plant by using fuzzy set theory [10].

Rahul Malhotra, Rajinder Sodhi discussed flow control method of boiler by using PID and fuzzy logic controller. They showed maximum overshoot for fuzzy logic controller is measured as 9.35% as compared with 47.3% given by conventional PID controller and settling time for fuzzy logic controller and PID controller is measured at 7.18 seconds and 10.14 seconds respectively which proved superiority of fuzzy logic controller over conventional PID controller [11]. On June 2012, Anabik Shome, Dr. S. Denis Ashok discussed fuzzy logic approach to control temperature and water level of boiler while they show it provides an effective means of converting the expert-type control knowledge into an automatic control strategy [12]. On March 2008, K. Gowri Shankar discussed various stages of operation involved in the conversion of a manually operated boiler towards a fully automated boiler by using PLC [13]. On July 2013, N .Divya, J. Arulvadivu, E. Arunkumar discussed about design and software simulation of fully automated boiler controlling system by using PLC and SCADA [14].

P. Hari Krishnan, S. Prathyusha discussed soft computing techniques to optimize main boiler parameters. In this technique the main control parameters of any process industries such as level of feed water, steam temperature and flow of steam were optimized by using ANFIS with PID while the simulation is done in MATLAB software and the transient response was improved and the settling time was reduced by using Neuro-fuzzy controller with PID [15].

3. METHODOLOGY

Different types of sensors are used for controlling boiler. In our controlling system instead of microcontroller, PLC is used for variable features, adaptability and reliability. Thermocouple (TC-K type) is used for temperature sensing, float less level switch (C61F-GP) is used for sensing water level and for relay switching Electromechanical Relay is used. Different PLCs are available in market. For our project, PLC SIEMENS LOGO! 230RC and LOGO! Soft Comfort is used for programming (i.e. Ladder Diagram).

In our system PLC is powered by SMPS. Physical variables from sensors are inputs of PLC. From programming and collected value from sensors, PLC operates the system by switching while switching is done by relay. Problem detection or diagnosis can be done by online operation, so diagnosis is easier.

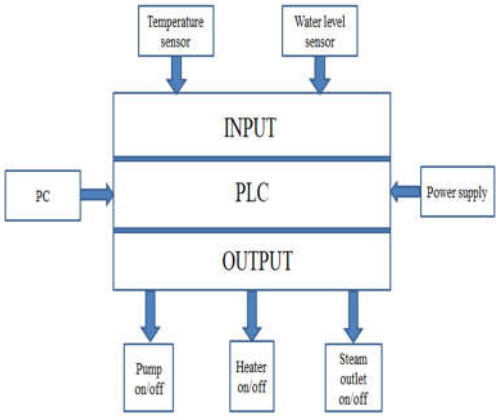

Fig. 1 Block diagram

4. SYSTEM CONSTRCUTION & OPERATION

The following equipments are used in this project:

- Boiler
- PLC SIEMENS LOGO! 230RC
- LOGO! PC CABLE & USB to RS232 converter cable.
- Analog input module AM2
- Digital input module DM8 (230R)
- Electromechanical Relay (G2R 2 – SD)
- Power supply (5 volts)
- Universal Transmitter (PR 4116)
- Water Reservoir
- Float less level switch (C61F-GP)
- Solenoid valve
- Connector
- Thermocouple (TC-K type)

4.1 Boiler

Boilers are pressure vessels designed to heat water or produce steam, which can then be used to provide space heating and/or service water heating to a building. In most commercial building heating applications, the heating source in the boiler is a natural gas fired burner. Oil fired burners and electric resistance heaters can be used as well. Steam is preferred over hot water in some applications, including absorption cooling, kitchens, laundries, sterilizers, and steam driven equipment. Boilers have several strengths that have made them a common feature of buildings. They have a long life, can achieve efficiencies up to 95% or greater, provide an effective method of heating a building, and in the case of steam systems, require little or no pumping energy. However, fuel costs can be considerable, regular maintenance is required, and if maintenance is delayed, repair can be costly. Guidance for the construction, operation, and maintenance of boilers is provided primarily by the ASME (American Society of Mechanical Engineers). For every year a boiler system goes unattended, boiler costs can increase approximately 10%. Boiler operation and maintenance is therefore a good place to start when looking for ways to reduce energy use and save money. Generally boilers are two types. Those are fire tube and water tube boiler.

4.2 PLC

A Programmable Logic Controller or PLC is an intelligent system of modules, which was introduced in the control, & instrumentation industry for replacing relay based logic. Programmable Logic Controller (PLC) has been adapted for the control of manufacturing processes or any activity that requires high reliability control and ease of programming and process fault diagnosis. They are very flexible, ruggedised and easily programmable controllers to replace hard-wired relays and timers. Since then they have been widely adopted as high-reliability automation controllers suitable for harsh environments.

The components of a PLC can be divided into three core areas. Those are

- The Central Processing unit (CPU)
- The power supply unit
- The input/output (I/O) section.

CPU module is called brain of the whole PLC. The CPU consists of a microprocessor, memory chip and other integrated circuits to control logic, monitoring and communications. The CPU has different operating modes.

Basics of a PLC function are continual scanning of a program. The scanning process involves three basic steps. Those are, Testing input status, Programming execution, Checking and Correction of output status.

Scanning time = Time for testing input status + Time for performing execution of programming + Time for checking and correction of output status.

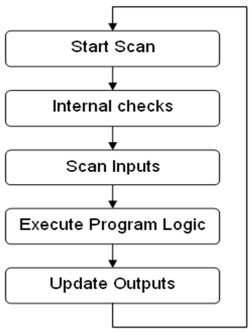

Fig. 2 CPU operating cycle

5. FLOW CHART

Fig. 3 shows flow chart of our Automatic boiler controlling system.

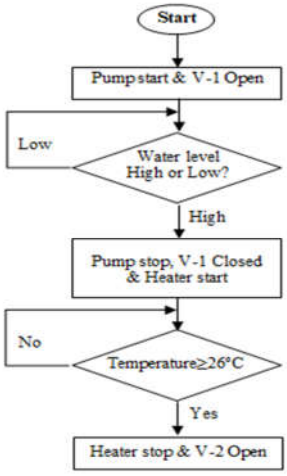

Fig. 3 Flow chart of Automatic boiler controlling system

6. SYSTEM IMPLEMENTATION

Fig. 4 shows the implementation of automatic lubrication the system.

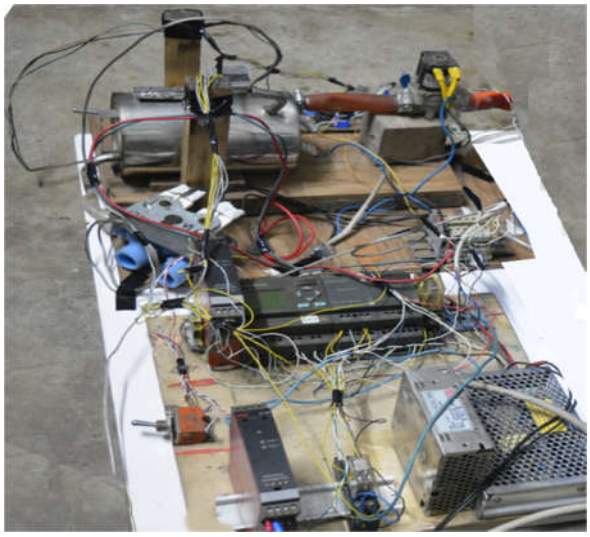

Fig. 4 Implementation of our project

7. SIMULATION AND RESULT ANALYSIS

Initially, turning boiler monitoring system ON by C3=1. At the beginning water level of boiler is low, so pump Q7 will be switched ON and inlet valve Q5 is switched ON while heater Q8 is still switched OFF, as though temperature of system is 0°C at this moment yet water level is low. Fig. 5 shows simulation of above condition.

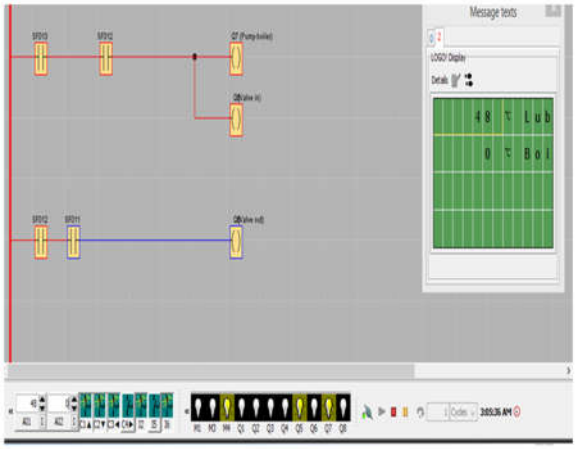

Fig. 5 Simulation of boiler monitoring system at initial condition

From flow chart (fig. 3), conditions of starting heater are water level must be high and temperature of boiler should be below 26°C. In order to starting heater both conditions should be fulfilled.

When water level of boiler reaches high inlet valve Q5 is OFF and if temperature is below 26°C heater Q8 is switched ON. Fig. 6 shows simulation of this condition.

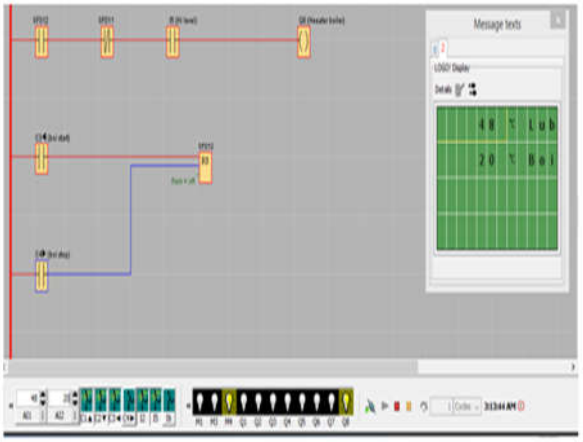

Fig. 6 Simulation of boiler monitoring system, when water level is high and temperature below 26°C

When temperature of system reaches 26°C or above heater Q8 is witched OFF until boiler a certain specified temperature is reached at this condition outlet valve Q6 is ON. Fig. 7 this conditions.

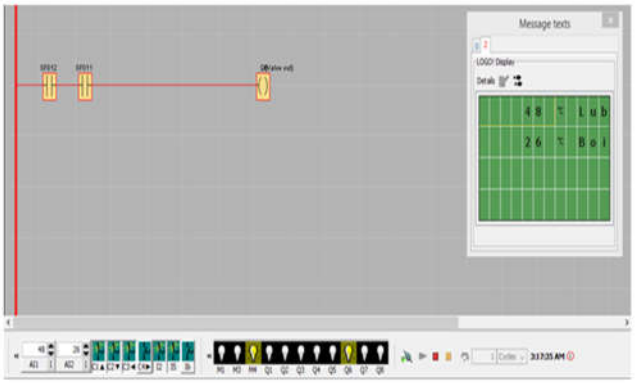

Fig. 7 Simulation of automatic boil monitoring system, when temperature is above 26°C

If the temperature of boiler exceeds predefined value then the entire setup will shut down and automatic check valves are opened to release the steam and pressure.

8. ADVANTAGES

This automatic lubrication system has following advantages:

- Simplicity
- Cost effective
- More efficient
- Faster operation of boiler
- Easy to control
- Easy to maintain
- Easy trouble shooting
- Reduces number of labor
- Centralized (Reduced space)
- Low power consumption
- Reduced wastage of lubricant
- Reduce risk catastrophic failures of boiler

9. CONCLUSION

Controlling and monitoring of boiler is the most important for a power plant. In this project based research paper, Boiler automation by using PLC was designed and implemented. The method that is used relies on varied objectives like superior quality, increased efficiency, high profit and other such points depending upon the purpose of the company that implies it. Our implemented system has the facilities of online operation mode to detect problem and to indicate of problem occurring place.

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