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by Mohammed Mezbah Uddin Shohan

DESIGN AND IMPLEMENTATION OF A SCADA-BASED BOILER MONITORING AND CONTROLLING SYSTEM

by

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BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical and Electronic Engineering
INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

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CERTIFICATE OF APPROVAL

The project entitled as "**Design and Implementation of a SCADA-Based Boiler Monitoring and Controlling System**" submitted by **Md Khaled Hossain Jahin**, bearing Matric ID. **ET191055** and **Muaz Muhammad**, bearing Matric ID. **ET191064** of session **Spring 2019**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **12th February, 2024**.

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DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this thesis/project has been submitted elsewhere for the award of any degree or diploma.

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Md Khaled Hossain Jahin

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Muaz Muhammad

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We exerted utmost diligence in order to achieve the objective of this project. During the initial phase of data collection for our study, numerous individuals made valuable contributions. We would want to convey our gratitude and heartfelt appreciation to everyone individual involved.

Authors

ABSTRACT

A boiler is a substantial apparatus utilized in industrial settings for the purpose of heating water and generating steam. A range of control mechanisms are employed to regulate the functioning of the boiler system in order to ensure its appropriate operation. The development of a boiler automation system is necessary in order to achieve the automation of a power plant and reduce the level of human intervention. In today's industrial setting, it is crucial to have boilers that operate efficiently and reliably for a wide range of applications, including power generation and industrial operations. The purpose of the project is to provide a comprehensive solution that utilizes Supervisory management and data acquisition (SCADA) technology to efficiently monitor and manage boiler systems. The explanation expressions into the theory behind using PLC and SCADA systems to track, record, and control a certain part of the boiler process, as well as how they can be used in real life. The present project involves the utilization of a PLC to govern the operational aspects of the boiler. The PLC is responsible for monitoring and adjusting the temperature, pressure, and water levels within the boiler. The SCADA system receives the data coming from the PLC and then displays it on the visual interface. The proposed automation for the boiler system aims to enhance the safety, reliability, and uninterrupted operation of the power generation facility. The boiler is created, and a pressure, a temperature, and a water level sensor are employed for the purpose of measuring the pressure, temperature, and water level within the boiler. In order to regulate temperature, a pump is installed. When the temperature exceeds a predetermined threshold, the pump is activated, thereby initiating the supply of feedwater. When the pressure exceeds the predetermined threshold, the solenoid valve is activated, resulting in the release of steam through the valve. The SCADA is positioned in order to monitor external values, sensors, and real-time data. One of the key objectives of the SCADA-Based Boiler Monitoring and Controlling System project is to improve the efficiency, safety, and sustainability of boiler systems in different industrial sectors. Additionally, the project aims to establish a basis for future advancements in automation and control technologies.

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LIST OF ABBREVIATIONS

PLC	Programmable Logic Controller
HMI	Human-Machine Interface
SCADA	Supervisory control and data acquisition
SMPS	Switched Mode Power Supply

CHAPTER 01

INTRODUCTION

1.1 Introduction

Today's industries depend on boilers to efficiently generate steam by heating water. Manufacturers and end users place a high priority on boiler efficiency and safety. Automation and the need to reduce human involvement are driving the increasing need for improved boiler monitoring and control systems in power plants. The project "Design and Implementation of a SCADA-Based Boiler Monitoring and Controlling System" explores the utilization of PLCs and SCADA systems to fulfill this requirement. Wireless SCADA systems are beneficial in situations where it is not feasible to install cables in remote places. The study investigates the utilization of them. In this project, Programmable Logic Controllers (PLCs) are employed to control and manage boiler operations, specifically regulating variables such as temperature and pressure. The SCADA system functions as a central hub that receives data from PLCs and presents it in a visual format. This automation project enhances power plant performance by enhancing safety, reliability, and uninterrupted operation. The research investigates fundamental control strategies to comprehend the proposed automation system, which is utilized in industrial and commercial buildings for boilers. This study enhances the efficiency of boilers to fulfill the requirements of contemporary power plants.

1.2 Background

A boiler is a commonly used, specialized apparatus that is extensively employed in many industrial applications. Ensuring the secure operation of the boiler is crucial. A malfunction in a boiler poses significant hazards, with a boiler explosion being one of the most dangerous risks. Boiler explosions may be categorized into two primary types: internal explosions occurring within the furnace and external explosions occurring outside the furnace. The primary factor contributing to boiler explosions is the suppression of combustion within the boiler furnace. The high pressure within the furnace results in a boiler explosion. Historically, boiler mishaps have posed significant risks to industrial operations, worker safety, and the environment. Several significant occurrences illustrate the necessity of boiler monitoring and control systems.

In 1986, the Chernobyl Nuclear Power Plant experienced a reactor explosion, resulting in the release of radioactive materials and causing lives. The disaster showed the dangers of nuclear reactor safety and control failures.

In 1988, the Piper Alpha disaster was one of the deadliest offshore oil rig accidents in industrial history. A gas explosion and fire killed 167 workers. The incident exposed safety, emergency, and equipment maintenance issues.

On July 3, 2017, a boiler explosion in a Bangladeshi textile factory killed 11 people and injured at least 50.

In 2018, a boiler explosion occurred at a packing industry in Tongi, Gazipur, causing the tragic deaths of at least 13 individuals and injuring several more.

Industrial and chemical boilers have caused fatalities, injuries, and property damage due to steam explosions, excessive heating, and ruptures of pressure vessels. These occurrences emphasize the immediate necessity for evaluating potential risks, maintaining the boiler system, and consistently monitoring it to reduce mishaps and guarantee operational dependability. Through the study of previous boiler catastrophes and the implementation of safety protocols, businesses can save both human lives and vital infrastructure. The boiler explosion in a Bangladeshi textile factory shown in **Fig 1.1.**

Fig. 1.1 Boiler explosion Gazipur [9].

1.3 Motivation

Bangladesh is an emerging country experiencing fast development, characterized by a burgeoning industrial sector that spans several industries such as manufacturing, textiles, and energy generation. As the country progresses towards the process of industrialization, it becomes progressively imperative to give precedence to the principles of safety, efficiency, and sustainability in all facets of industrial activities. The proposed project, "Design and Implementation of a SCADA-Based Boiler Monitoring and Controlling System," aims to improve the efficiency, safety, and reliability of boiler operations in industrial settings, which is a crucial requirement. Boilers are crucial in several sectors, such as power generation, manufacturing, and chemical processing. They are necessary for producing steam and providing heat. Nevertheless, conventional monitoring and control techniques have frequently been insufficient for effectively dealing with the ever-changing operational difficulties and safety issues linked to boiler systems. The occurrence of previous boiler mishaps, both on a worldwide scale and within the local area, highlights the immediate need for adopting strong monitoring and control systems to prevent disastrous malfunctions and protect human lives and essential infrastructure. Furthermore, because of the increasing need for energy efficiency, adherence to regulations, and commitment to environmental sustainability, there is an urgent need for inventive strategies that enhance boiler performance while reducing operational hazards and environmental harm. The objective of the proposed project is to address the deficiencies in boiler automation and control through the utilization of modern SCADA technology, real-time data analytics, and remote monitoring. Operators will be able to actively monitor, evaluate, and adjust boiler parameters in real-time, resulting in enhanced operating efficiency, less downtime, and a reduced chance of accidents or system failures. The primary objectives of our project are to enhance current situation of sophistication in boiler monitoring and control systems. This will result in the promotion of safer, more efficient, and sustainable industrial practices while also contributing to the general progress of industrial automation and safety standards. The deployment of a SCADA-based Boiler Monitoring and Controlling System in Bangladesh's industrial sector will show great potential, as it presents several appealing advantages.

1.4 Objectives

The objectives of our project are shown below:

- To develop SCADA system for real-time monitoring and control of boiler system.
- To provide historical data logging and reporting capabilities for analysis and maintenance.
- To improve operational efficiency by automating pressure, temperature, water level and enhancing safety by preventing accidents and system failures of the boiler system.

1.5 Report Outline

The planning and execution of our project have comprehended six chapters. Ensuing a incline of the chapters and their content:

- **Chapter 1** (Introduction): In this segment, we will deliberate the project's rationale, background, objectives, and significance.
- **Chapter 2** (literature review): Previous studies and publications relevant to this subject were reviewed in this section.
- **Chapter 3** (Design of system): This segment provides a detailed description of the equipment utilized in the experimental procedures of our project.
- **Chapter 4** (Design Methodology): This chapter offers a thorough examination of each aspect and the procedure of the project.
- **Chapter 5** (Results Analysis): This chapter analyse the results and approach of the project.
- **Chapter 6** (Conclusion): The scope of the project is expanded upon in this chapter. The project's advantages and guidelines for its advancement are deliberated.

CHAPTER 02

LITERATURE REVIEW

2.1 Introduction

This chapter presents a comprehensive summary of current research and academic literature about the design and implementation of SCADA-based systems for monitoring and controlling boilers. The study examines research on the evolution of PLC and SCADA in automation systems and related technologies, a discussion of related work and research gap.

2.2 Evolution of PLC and SCADA in automation system

The advancement of PLC and SCADA systems has had a profound impact on industrial automation. In the beginning, PLC implementations were primarily developed for discrete control applications, with a particular emphasis on tasks like changing relays and executing fundamental sequence control. PLCs have seen substantial advancements, steadily augmenting their capabilities to efficiently manage more complex and sophisticated industrial activities.

The historical progression of PLCs, starting from their inception as relay-replacement devices to becoming versatile controllers capable of handling diverse automation tasks. Kuo delves into the theoretical foundations and practical applications of PLCs, providing valuable insights into their development and increasing functionalities over the years. Bolton's work offers a practical perspective, illustrating how PLCs have evolved to meet the dynamic needs of industrial automation [1],[2].

SCADA systems have also undergone substantial expansion since their establishment. Originally centred on real-time monitoring and collection of data, contemporary SCADA systems have evolved into advanced platforms that seamlessly incorporate with PLCs, allowing for full management of dispersed industrial operations [3],[4].

The interplay between PLCs and SCADA is a crucial aspect of this evolution. Early on, PLCs and SCADA operated somewhat independently, with PLCs managing control logic and SCADA overseeing monitoring and data visualization. As discussed in the integration between PLCs and SCADA has become more seamless, allowing for a unified approach to automation. This collaboration has led to enhanced efficiency, real-time decision-making, and a more holistic control of industrial processes.

2.3 Discussion of Related work

It is crucial to optimize boiler parameters, such as temperature and pressure, in power plants and enterprises. Boilers serve a vital role in large corporations and electricity generation facilities. Hence, it is important to routinely scrutinize the parameters. The present methodology employs computerized controls to manage boiler parameters such as temperature and pressure. Nevertheless, human involvement is necessary to oversee and operate these controllers.

From this project, a system of a number of boilers are arranged in the thawing path water tank has been proposed. A water level sensor controls the level of the water in the tank, and temperature sensors in each boiler regulate the sensors in each boiler. The control procedures are accomplished by utilizing a PIC microcontroller, a GSM modem, sensors, and other interface circuits. Therefore, by above process The boiler automation performs optimally in accordance with their specified requirements and anticipated outcomes [5].

This proposed method also offers an option for monitoring at a remote location in addition to the control room. From this project they use a temperature sensor to detect the temperature of the boiler. The temperature and pressure sensor records the temperature and pressure of the boiler, which is transmitted to the microcontroller. The result of LCD shows Temperature &pressure sensor. The temperature sensor is connected in buzzer when the boiler is heated temperature are increasing the buzzer automatically gives the sound and the pressure sensor are increases then the buzzer gives sound [6].

This study presents the design and implementation of an automated boiler control system employing a PLC to minimize mistakes. The primary function of this project is to automatically initiate and terminate the boiler system based on a predetermined threshold. A sensor was employed to measure the temperature and regulate it by transmitting the signal to a PLC. Additionally, the boiler system may operate for a specific duration by utilizing the ON-OFF push button [7].

This study presents smart system for boilers. The presented system employs Arduino as the primary controller, LM35 sensors for temperature monitoring, and a buzzer for issuing warning messages. The temperature is measured using two LM35 sensors, and the Arduino processes the data. A potentiometer-set threshold causes the buzzer to go off if the temperature exceeds it. The LM35 sensors include a functional temperature range, guaranteeing precise temperature monitoring. The Arduino Uno is selected for its cost-effectiveness, open-source characteristics, and ability to be programmed, therefore enhancing the circuit with intelligence. The main purpose of the system is to oversee and regulate the temperature of the boiler, which is a crucial factor in averting any explosions. Users are notified if the temperature of the boiler exceeds safe limits by implementing a predetermined temperature threshold. This allows for prompt action to be taken and guarantees the safety of operations [29].

In this project, a PIC microcontroller manages the boiler's operation by controlling and adjusting the boiler's temperature and pressure. The SCADA system receives the data from the microcontroller and displays it on the screen. The proposed boiler automation guarantees the safe, dependable, and uninterrupted operation of both the boiler system and the power generation plant. The boiler structure involves the use of an LPG cylinder, with the heater positioned within the cylinder to function as a boiler. A pressure and temperature sensor are utilized to gauge both the pressure and temperature within the boiler. A pump is installed to regulate temperature. When the temperature exceeds a specific threshold, the pump is automatically activated and supplies feedwater. When the pressure exceeds the threshold, the solenoid valve activates and releases steam through it. An LCD display is positioned to monitor the external values [9]. The control and monitoring of operation are covered in this project shown in **Fig 2.1**.

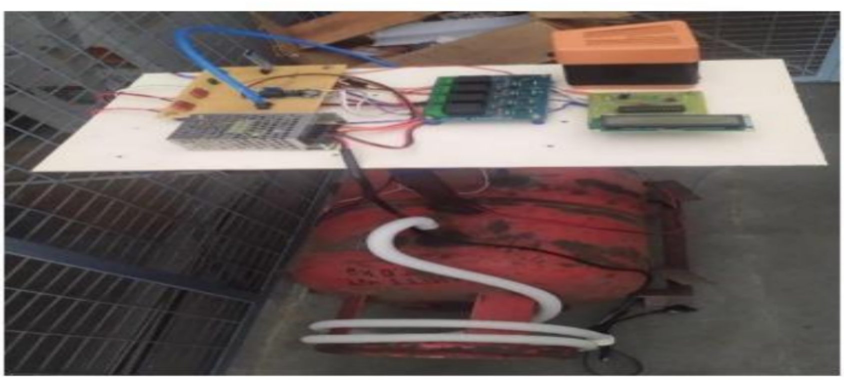

Fig. 2.1 Boiler automation system using PIC microcontroller and SCADA [8].

2.4 Summary of previous work

The previous works study offers a comprehensive analysis of different methodologies and technologies utilized in the automation and regulation of boiler systems. Current methods include computerized controls, PIC microcontrollers, PLC systems, Arduino and SCADA technologies to manage boiler settings, identify irregularities, and guarantee secure and dependable functioning. These systems utilize sensors to quantify temperature, pressure, and water levels, enabling instantaneous monitoring and regulation. However, these approaches still face issues such as the requirement for human involvement, restrictions on remote monitoring capabilities, and possible inaccuracies in parameter control. The summary of previous work is shown in **Table 2.1.**

Table 2.1: Summary of previous work

Paper Name	Author	Contribution	Limitations
Embedded System Based Laboratory Thawing Path Boiler Automation Using GSM Technology [5]	T.Karuppiah, Dr. Azha. Periasamy	Offers a fundamental structure for automating and remotely monitoring boilers, while the capacity to handle bigger systems may be limited by scalability and network stability.	Constraints include restricted scalability, reliance on GSM networks, limited resilience to faults, and potential complications in integrating with current systems.
Boiler automation using embedded system [6]	Mohana Priya R, Sowmiya K, Tharani K, Smitha M,	Provides a straightforward method for remotely monitoring boiler parameters but does not include extensive control functionalities or the potential to scale up.	The system has a restricted range of capabilities beyond basic monitoring and alerting, and it lacks a centralized control interface.

Paper Name	Author	Contribution	Limitations
Design and Implementation of Boiler Automation System Using PLC [7]	S. M. Tahsin Labib, Sohan Ul Alam, Shafayat Hossain, Md. Iquebal Hossain Patwary	Provides support for fundamental automation functions, but does not provide advanced control logic or scalability.	Limited automation possibilities, dependence on manual intervention for specific processes
Smart System for Boiler Automation [29]	Rashmi Weleker	The system employs the cost-effective Arduino platform to monitor temperature, provide warnings, and maintain exact temperature control.	Industrial applications may have limitations in terms of adaptability, and there is a possibility of accuracy concerns with LM35 sensors.
Controlling and Monitoring of Boiler Parameters using Scada [8]	Vidhyalakshmi. P, Dhanishka. K. V, Gokulapriya. P, Vasant. S,	Provides sophisticated management and monitoring features, but necessitates meticulous implementation to minimize security vulnerabilities and guarantee dependability.	The installation is intricate, with the possibility of cybersecurity risks. It may require a substantial initial cost for setup.

2.5 Research Gap

The literature study identifies significant research gaps and limitations in the current methods used for monitoring and controlling boiler systems. By analyzing the literatures, it becomes evident that there are various research gaps in boiler automation systems. These gaps mostly pertain to constraints in scalability, robustness, and control sophistication. Current studies primarily address temperature and pressure management and remote monitoring. However, they often rely on individual sensors and localized control methods, which limits their potential to adapt to bigger or more intricate boiler setups. Conventional microcontrollers and PLCs may restrict the complexity of control algorithms, disregarding changing operating situations and the optimization of energy efficiency. Furthermore, the lack of sophisticated communication technologies and data analytics frameworks hinders the ability to do predictive maintenance and detect faults. Insufficient attention is frequently given to cybersecurity measures, resulting in systems being susceptible to unwanted intrusion and manipulation. Our suggested SCADA-Based Boiler Monitoring and Controlling System combines SCADA technology with sophisticated control algorithms, real-time analytics, and strong cybersecurity protections. Our solution provides centralized monitoring and control, allowing operators to maximize performance and reduce risks in various operating circumstances. Advanced sensors, communication protocols, and predictive analytics make proactive maintenance and energy management possible. By conducting thorough testing and validation, our approach seeks to fill the current research gaps, establishing higher benchmarks for automating boilers in industrial environments.

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CHAPTER 03
HARDWARE DESCRIPTION

3.1 Introduction

In this chapter, we'll examine physical components. This document contains all the conceptual details of the project. All of the project's practical aspects are thoroughly discussed. Our understanding of the various interface standards for devices will be greatly aided by the data presented in this article. We will discuss the technical details of the tools, such as PLC, Boiler, Temperature Sensor, Pressure Sensor, Solenoid valve, Manual valve, Buzzer, Water Level Sensor, Push Switch, HMI.

3.2 List of Components

The components used in our project are given below:

- Programmable Logic Controller (PLC)
- Boiler Prototype
- Temperature Sensor
- Pressure Sensor
- Solenoid valve
- Buzzer
- Water Level Sensor
- Push Switch
- Indicator Lamp
- PC
- HMI
- Magnetic Contactor
- Switch Mode Power Supply

3.3 Programmable Logic Controller

Programmable logic controller is commonly abbreviated as PLC. A PLC, or programmable logic controller, is a versatile computing device designed to control electromechanical operations, primarily in industrial settings. A PLC, often known as an industrial PC, is a specialized computing device designed for industrial applications. PLC oversee the condition of an input device, such as signals from a light switch, and determine the subsequent state of an output device, such as turning a light on or off. PLC are also utilized for transmitting data from equipment located in factories or remote sites to centralized applications, often operating on personal computers. PLCs are frequently utilized for device surveillance and documentation, to identify malfunctions in hardware devices such as industrial machinery and equipment, and to execute device operations. [10]. Mitsubishi Fx3u 24MRES PLC shown in **Fig. 3.1**.

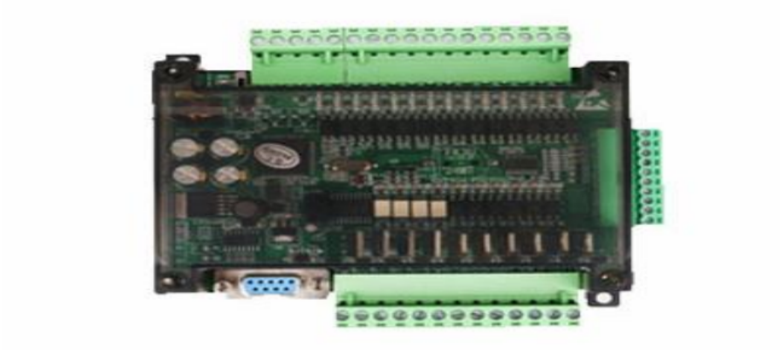

Fig. 3.1 Mitsubishi Fx3u 24MRES PLC [11]

3.3.1 Working of PLC

The Programmable Logic Controller (PLC) is responsible for receiving data from various sensors or input devices that are linked to it. Subsequently, the PLC undertakes the task of processing this data and subsequently initiating outputs in accordance with certain parameters that have been programmed into it.A programmable logic controller (PLC) may track and store real-time data related to machine efficiency and system temperature, as well as initiate and terminate operations automatically. Additionally, it is capable of generating alerts in the event of machine failures, among other purposes. Programmable Logic Controllers (PLCs) are very versatile and resilient control systems that may be easily customized to suit a wide range of applications. [12]

3.3.2 Advantages of PLC

The primary advantages of programmable logic controllers (PLCs) lie in the elimination of conventional hard-wired logic control systems, resulting in various benefits. In contrast to conventional logic control systems, Programmable Logic Controllers (PLCs) offer enhanced ease in terms of construction, installation, maintenance, and modification. Such as

Flexible in Nature: PLCs come in models that may be utilized for a variety of tasks depending on the situation.

Easy to install and troubleshooting: Relays that are in hardwired require more time to install than control panels that are PLC based.

Availability of Large contacts: PLC programming tools are equipped with a substantial number of internal contacts that may be utilized to implement modifications in various applications.

Cost effective: PLCs are produced in huge quantities and with advanced technology, making them more affordable than different controller or relay-based systems.

Simulation feature: The PLC programming software has built-in simulation capabilities.

Simple programming methods: The PLC is equipped with easy-to-use programming methods, such as Ladder or Boolean programming, to facilitate programming of the PLC.

Ease of maintenance: PLC maintenance is cheaper than relay- or microcontroller-based systems.

Documentation: The programmer may simply create and print PLC programs for future use [13].

3.4 Boiler

A boiler shown in **Fig. 3.2** is a self-sufficient combustion machine that raises the temperature of water. The boiler generates hot water or steam, which is then utilized in heating systems. While the designs may differ, the key components of boiler are as follows [14]: -

Burner: The boiler's burner is the part that generates the heat needed to warm the system's water. The possible fuel options are natural gas or oil.

Heat exchanger: The boiler's heat exchanger aids in the transmission of heat from the burner to the water in the system. The main purpose of the heat exchanger is to facilitate the transmission of thermal energy from the burner to the water without any direct physical interaction between the two substances. It is comparable to the idea of heating water in a container.

Supply lines: The supply lines are the pipes that transfer the hot water or steam to the distributor in hydronic heating systems. The heated water or steam is delivered via piping to the distribution points.

Return lines: The return lines return the cooled water to the boiler for reheating when the water cools or the steam cools and returns to water.

Firebox: In the firebox, system fuel meets air to create a flame.

Refractory: The term "refractory" really refers to the refractory materials that are utilized to seal any gaps or openings that may exist around the fire box in order to keep the fire contained.

Circulator pumps: Circulator pumps propel the heated water or fluid from the system to the heat distributors.

Fig. 3.2 Boiler [15]

3.5 Temperature Sensor

A sensor for temperature measurement is a device utilized for the purpose of quantifying temperature. The temperature might refer to the air temperature, the liquid temperature, or the temperature of solid stuff. Various temperature sensors exist, employing diverse technologies and concepts to monitor temperature. The DS18B20 temperature sensor is being utilized in this project to measure the temperature of the boiler.

3.5.1 DS18B20 Temperature sensor

The DS18B20 temperature sensor shown in **Fig. 3.3** is a specific type of temperature sensor that provides temperature measurements ranging from 9 bits to 12 bits. These numbers indicate the temperature of a certain gadget. The sensor may interact via a one-wire bus protocol, where a single data line is used to interface with an internal CPU. Furthermore, this sensor obtains its power source straight from the data line, therefore eliminating the requirement for an additional power supply. The DS18B20 temperature sensor finds utility in several domains, such as industrial systems, consumer items, thermally sensitive systems, thermostatic controls, and thermometers [16].

Fig. 3.3 DS18B20 Temperature sensor [16]

3.6 Pressure Sensor

A pressure switch shown in **Fig. 3.4** is a specific type of switch that closes an electrical contact when a predefined fluid pressure is reached at its input. The switch can be designed to trigger in reaction to an increase in pressure or a decrease in pressure. Pressure switches are often employed in the industrial sector to automatically monitor and regulate systems that utilize pressurized fluids. Another type of pressure switch detects mechanical force. In commercial buildings, pressure-sensitive mats are used to automatically open doors. These sensors are also employed in security alarm systems, particularly those that use pressure-sensitive flooring [17].

Fig. 3.4 Pressure Switch [18]

3.6.1 Construction and types

A pressure switch, which is utilized to detect fluid pressure, has a component such as a capsule, bellows, diaphragm, Bourdon tube, or piston element that undergoes deformation or displacement when pressure is applied. The motion generated is sent to a set of switch contacts, either directly or by amplifying levers. An over-center device, such as a miniature snap-action switch, is employed to ensure rapid activation of the contacts, as pressure may be changing gradually and they need to activate promptly. Mercury switches, when put on a Bourdon tube, function as a sensitive type of pressure switch. The varying weight of the mercury provides a useful over-center characteristic. The pressure switch connections can be repositioned, or the tension in the balance spring can be adjusted. Industrial pressure switches may have a calibrated scale and pointer to indicate the switch's set point. A pressure switch demonstrates hysteresis, which is a range of differences around its setpoint, often known as the switch's dead band. Within this range, small changes in pressure do not impact the state of the contacts. Some types allow for a differential adjustment. The pressure-sensing component of a pressure switch can be adjusted to respond to changes in two different pressures. These switches are useful when a significant change, such as the detection of a blocked filter in a water supply system, occurs. To avoid incorrect operation due to changes in the common mode pressure, the switches should only respond to differences. The contacts of the pressure switch are rated from a few tenths of an ampere to around 15 amperes, with more sensitive switches having lower ratings. A pressure switch has the capability to directly operate a small electric motor or another load. However, in most cases, it is used to activate a relay or another control device. The selection of internal components for the switch must achieve a delicate equilibrium between durability and strength while also ensuring compatibility with process fluids due to their direct exposure to the fluid. Rubber diaphragms are commonly used in water-related applications; however, they would quickly degrade in systems containing mineral oil. Enclosures are used to contain switches specifically designed for use in hazardous locations loaded with flammable gases. Their purpose is to prevent the initiation of a gas fire by preventing an electrical arc from occurring at the switch contacts. Switch enclosures may require waterproofing, corrosion resistance, or submersion capabilities. An electronic pressure switch utilizes an internal circuit and a pressure transducer, such as a capacitive element or a strain gauge, to compare the measured pressure with a predefined threshold. These technologies have the potential to provide superior levels of repeatability, accuracy, and precision as compared to a mechanical switch [17].

3.6.2 Air type

Uses of air type pressure switches include [17]:

- When water is taken out of the pressure tank, an automated residential well water pump switch is triggered.
- Turning off an electrically powered gas compressor once the reservoir reaches a certain pressure.
- Turning off a gas compressor anytime the suction stage's supply is absent.
- In battery cell charge regulation
- Turning on or off a warning light in the aircraft's cockpit in the event that the cabin pressure becomes dangerously low (dependent on altitude).
- Air-filled pipes that, when driven over by a car, activate switches. Often used at petrol stations and for traffic counts.

3.6.3 Hydraulic type

Hydraulic pressure switches serve several purposes in vehicles, such as indicating a low oil pressure in the engine or regulating the lock-up of the automatic gearbox torque converter. Up until the 1960s, a pressure switch in the hydraulic braking system was responsible for controlling power to the brake lights. However, in modern cars, the brake pedal directly operates a switch. A pressure switch is installed on the header of dust control systems (bag filters) to detect when the air pressure in the header falls below the required level, triggering an alert. To detect an elevated pressure, drop, which signals the requirement for filter cleaning or replacement, it is possible to put a differential pressure switch across a filter element [17].

3.7 Solenoid valve

A solenoid valve shown **Fig. 3.5**. is a valve that uses an electromechanical mechanism to operate. Solenoid valves exhibit variability in their electric current specifications, magnetic field strength, fluid regulation mechanism, and the kind and characteristics of the fluid they control. The mechanism encompasses a variety of actuator types, including linear action, plunger-type actuators, pivoted-armature actuators, and rocker actuators. The valve can utilize a two-port design to regulate the flow or employ a three- or more-port configuration to divert flows between different ports. A manifold has the capacity to accept many solenoid valves. Solenoid valves are the primary control elements in fluidics. Their tasks involve the manipulation of fluids by acts such as turning off, releasing, dosing, distributing, or mixing. They exist in several fields of application. Solenoids offer fast and reliable switching, outstanding reliability, a long lifespan, great compatibility with different materials, low power consumption for control, and a small design [19].

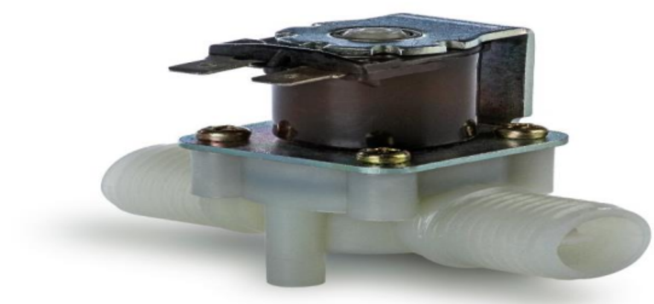

Fig. 3.5 Solenoid valve [20]

3.7.1 Operation

The valve design encompasses several variations. Ordinary valves provide for a multitude of ports and fluid paths. For example, a two-way valve consists of two ports. When the valve is in the open position, the two ports are connected and capable of fluid transmission; when the valve is in the closed position, the ports are disconnected. A valve is said to be in the normally open (N.O.) state when it remains open in the absence of electricity to the solenoid. Likewise, a valve is considered to be normally closed if it stays closed even when the solenoid is not activated. Furthermore, there exist more complex and tripartite patterns. A three-port valve connects one of its three openings, often an exhaust port and a supply port, to the other two ports. One further attribute of solenoid valves is their method of functioning. A minuscule solenoid possesses a limited capability for generating force. It is possible to have a solenoid valve that operates directly by opening and closing the valve if the force the solenoid exerts is strong enough. The correlations between the required solenoid force Fs, fluid pressure P, and orifice area A for a direct-acting solenoid valve may be approximated as follows [19]:

where d represents the diameter of the orifice. A solenoid force of 15 Newtons (equivalent to 3.4 pounds of force) is a potential average value. An application may utilize a low-pressure gas, such as 10 psi (69 kPa), which passes through a small orifice with a diameter of 3/8 in (9.5 mm). The orifice has an area of 0.11 in2 (7.1×10−5 m2) and generates an estimated force of 1.1 lbf (4.9 N). Significant levels of force are required in situations where large openings and elevated levels of pressure are present. A solenoid valve design that is internally guided has the capability to generate the required forces. In this system, a tiny solenoid regulates the line pressure, which produces the high valve forces. Internally piloted valves are utilized in dishwashers and irrigation systems that use water as the fluid, operate under pressures of up to 80 psi (550 kPa), and have orifice diameters. The measurement is 19 millimeters. Some solenoid valves have a direct influence on the primary valve through the solenoid. Some individuals utilize a larger valve by employing a small, fully-operated solenoid valve known as a pilot. The second kind is advertised and packaged as a solitary solenoid valve, despite the fact that it is really a combination of a solenoid valve and a pneumatically actuated valve. Piloted valves have a significantly reduced speed while necessitating lower power consumption for operation. A direct-acting solenoid necessitates full power momentarily to open and just minimum power to keep it open. In contrast, piloted solenoids often need continuous, full power to both open and maintain the open position. A direct-acting solenoid valve typically operates within a time frame of 5 to 10 milliseconds. The working time of a piloted valve is contingent upon its dimensions, often falling within the range of 15 to 150 milliseconds. Applications influence the solenoid's power consumption and requirements for supply, mostly determined by fluid pressure and line diameter. For example, a typical sprinkler valve with a size of 3/4" and a pressure rating of 150 psi requires a holding power of 4.6 VA and experiences a transient inrush of 7.2 VA. This valve is specifically intended for residential systems that operate at 24 VAC with a frequency of 50–60 Hz. On the other hand, an industrial valve with a size of 1/2 inch and a pressure rating of 10000 psi has an initial power consumption of 300 VA and a sustained power consumption of 22 VA. This product is specifically engineered to be compatible with 12, 24, or 120 VAC systems that are used in high-pressure fluid and cryogenic applications. When not powered, both valves do not indicate the minimum pressure required to remain closed [19].

3.8 Buzzer

A beeper, buzzer, or other auditory signaling device can be mechanical, piezoelectric, or electromechanical in nature. This is mostly used to transform the audio signal to sound. It is often powered by DC voltage and found in computers, printers, alarm clocks, timers, and other devices. It may produce a variety of sounds, including alarm, music, bell, and siren, according on the varied designs [21]. A buzzer is shown in **Fig. 3.6**.

Fig. 3.6 Buzzer [21]

3.9 Water Level Sensor

A water level sensor shown in **Fig. 3.7** is a device used to gauge the liquid level in a stationary container, whether it is too high or too low. The measurement of liquid level may be categorized into two types: contact and non-contact, based on the method used. The water level transmitter we refer to is a contact measuring device that turns the liquid level's height into an electrical signal for output. The water level transmitter [22] is presently in widespread usage.

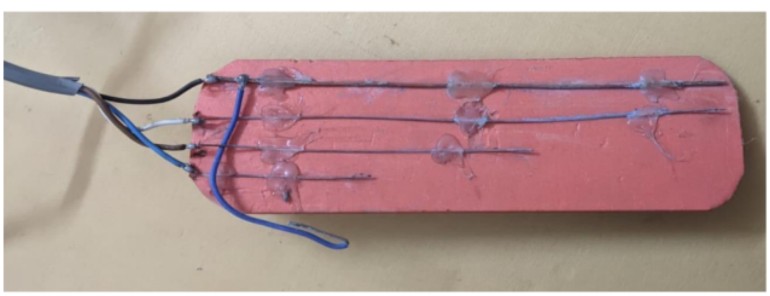

Fig. 3.7 Water level sensor

3.9.1 Water Level Sensor

The water level sensor's principle of operation is that the pressure on its front surface is translated into the liquid level height when it is submerged to a specific depth in the liquid to be measured. $P=\rho.g$ is the calculating formula. H+Po is the formula where P is the liquid surface pressure of the sensor, ρ is the liquid's density to be measured, g is the local acceleration of gravity, Po is the liquid's atmospheric pressure, and H is the liquid's depth at which the sensor descends. A gadget called a level sensor is used to measure and keep track of liquid (and occasionally solid) levels. The sensor turns the observed data into an electrical signal when the liquid level is found. The primary uses of level sensors are in the surveillance of oil tanks, rivers, and reservoirs [22].

3.10 Push Button

Push buttons are electrical switches employed to regulate the power supply of a device or apparatus. Typically constructed from metals or thermoplastics, they provide users with simple access. In electric circuits, the power flows continuously through the devices, and to regulate this power supply, we use push buttons. These are, simply push buttons that can be seen or felt and are easily operable with our hands and fingers. **Fig. 3.8** shows the push button of our proposed system used [23].

Fig. 3.8 Push button [23]

3.10.1 Working Method

Push buttons work with a simple yet ingenious mechanism. These switches are usually equipped with an internal spring mechanism. It is this spring that returns the button to its 'in' and 'out' positions. The push button is shown to be in the "on" position when the spring makes contact with two wires, allowing electricity to flow to the device. The push button is considered to be in the "off" position when the spring breaks contact with the two wires [23].

3.11 Indicator Lamp

An indicator lamp shown in **Fig. 3.9**. It is a small, yet powerful beacon of information, signaling changes or warnings through its illuminating presence. These visual guides are integral in machinery, electronics, and vehicles, alerting users to operational statuses or potential issues. They ensure safety and efficiency, shining light on the need for action. [24].

Fig. 3.9 Indicator Lamp [25]

3.12 HMI

A dashboard or user interface that links a person to a machine, system, or other device is called a human-machine interface, or HMI. Although any screen that permits human interaction with a device may theoretically be referred to as HMI, the word is most frequently used in relation to an industrial process. Although they are not interchangeable, HMIs and Graphical User Interfaces (GUIs) share many similarities. GUIs are frequently used in HMIs to provide visualization features. In work environments, HMIs may be utilized for:

- Visually display data
- Track production time, trends, and tags
- Oversee KPIs
- Monitor machine inputs and outputs

An HMI (Human-Machine Interface) is used by a plant-floor operator to monitor and regulate the temperature of an industrial water tank or to determine the operational status of a specific pump in the facility, similar to how you would interact with your air-conditioning system to adjust the temperature in your house [26].

3.12.1 HMI Software

Haiwell cloud HMI is used in this project. It is a software tool that emulates the functionality of Haiwell cloud SCADA device. It allows users to replicate the operations and features of the physical HMI on their computer for testing and development purposes. With the Haiwell cloud HMI Emulator, you can simulate the HMI interface and interact with different applications and projects without the need for a physical device. This can be useful for software developers, system integrators, and users who want to familiarize themselves with the Haiwell cloud HMI before acquiring the actual device. The emulator typically comes with features like a virtual display screen, touch inputs, and various options to configure and test the HMI's functionality. It helps users design, debug, and troubleshoot HMI applications more efficiently before deploying them to the physical HMI device.

3.13 SCADA

Supervisory control and data acquisition (SCADA) is a comprehensive system including software and hardware components that enable industrial enterprises to:

- Control industrial processes locally or at remote locations
- Monitor, gather, and process real-time data
- Directly interact with devices such as sensors, valves, pumps, motors, and more through human-machine interface (HMI) software
- Record events into a log file

For industrial businesses, SCADA systems are vital because they optimize operations, analyse data to make better decisions, and make it easier to find and fix system issues so that downtime is kept to a minimum. PLCs are the first components of the basic SCADA architecture (RTUs). Microcomputers known as PLCs and RTUs communicate with a wide range of devices, including end users, HMIs, sensors, and industrial equipment. After that, they send the data gathered from these devices to PCs running SCADA software. Because the SCADA software makes data processing, dissemination, and visualization easier, operators and other staff members are better equipped to evaluate the information and make important decisions. For example, when a batch of products shows a high frequency of errors, the SCADA system immediately notifies an operator. To find the source of the issue, the operator stops the process and uses a Human-Machine Interface (HMI) to review the data from the SCADA system. After reviewing the data, the operator concludes that there was an issue with Machine 4. When an issue arises, the operator may quickly rectify it and prevent further product loss thanks to the SCADA system's ability to notify them [27].

3.14 Magnetic Contactor

An electrical switching device is called a contactor. An electrical circuit is activated or deactivated with its assistance. Even though they are both classified as relays, a contactor and a relay are different from one another. Relays are used for applications requiring lower current needs, whereas contactors are mostly used in scenarios requiring a greater capacity for electrical current transportation. Due to their modest size, contactors may be easily placed in the field. These devices usually have many contacts installed. When the contactor coil is activated, the contacts, which are primarily in a normally open condition, provide operational power to the load. Contactors and electric motors are frequently used in tandem [28]. A contactor is shown in **Fig. 3.10.**

Fig. 3.10 Magnetic contactor [28]

3.14.1 Function

A strong magnetic field is produced by the electromagnet when electricity flows through the contactor. An electrical arc is created when the armature is forced to travel in the direction of the coil by the magnetic field. One contact on the device allows electric currents to enter and flow through the integrated contactor. As a result, the contactor's main function is to toggle an electrical circuit's state, turning it on or off.

Use of a thermal overload relay helps prevent circuit overload. The contactor can be physically withdrawn from the primary device in which it is incorporated and operational in order to deactivate it. The spring presses on the armature when there is no electric current flowing across it, breaking the connection [28].

3.15 Switched Mode Power Supply (AC to DC)

A switched mode power supply, as depicted in **Fig. 3.11**, is an electronic circuit that utilizes switching devices operating at high frequencies to convert power. Additionally, it includes storage elements like capacitors or inductors to supply power while the switching device is not conducting. It is used to get an unregulated alternating current (AC) or direct current (DC) input voltage and convert it to a controlled DC output voltage.

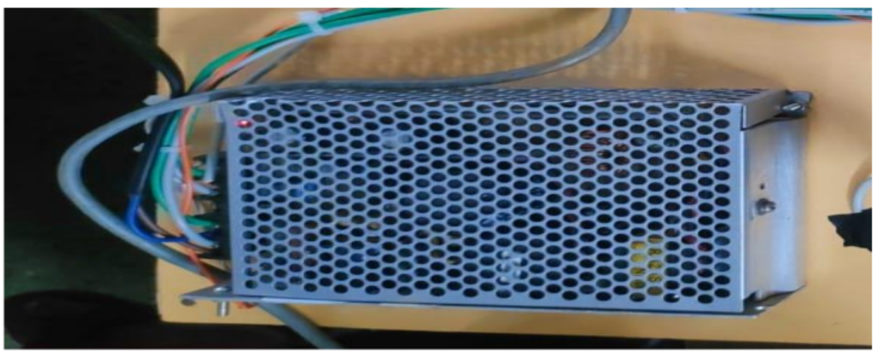

Fig. 3.11 Switched Mode Power Supply

3.16 Hardware setup

In this section the complete setup of the practical interfacing will be shown step by step.

3.16.1 Giving power to all components by SMPS

At first, power is given to all the electrical components of the project by SMPS as shown **Fig. 3.12**.

Fig. 3.12 Connection of SMPS

3.16.2 Connection of Inputs and Outputs of PLC

All the inputs and outputs connection are done with the Mitsubishi Fx3u 24MRES PLC shown in **Fig. 3.13.**

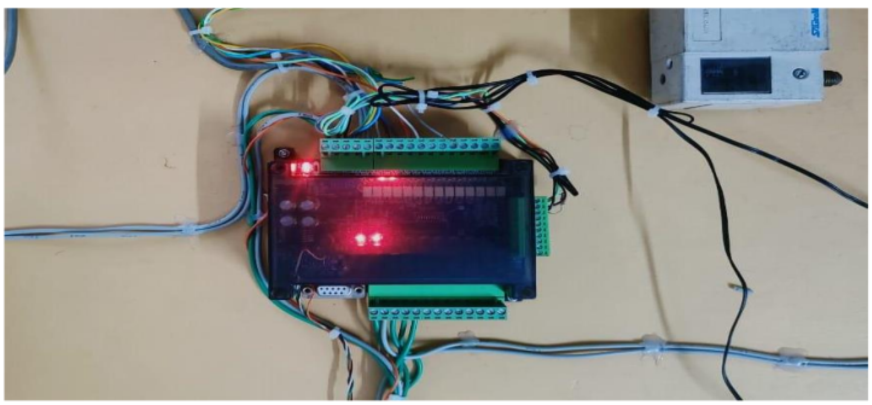

Fig. 3.13 Connection of Inputs and Outputs of PLC

3.16.3 Hardware setup of entire project

The **Fig. 3.14** shows the hardware setup of the entire project and its components. It clearly shows the placement of the boiler, solenoid valve, pressure switch, temperature sensor, magnetic contractor, water level sensor, indicator, transistor, USB cable, Mitsubishi FX3U 24MRES PLC, SMPS and push button.

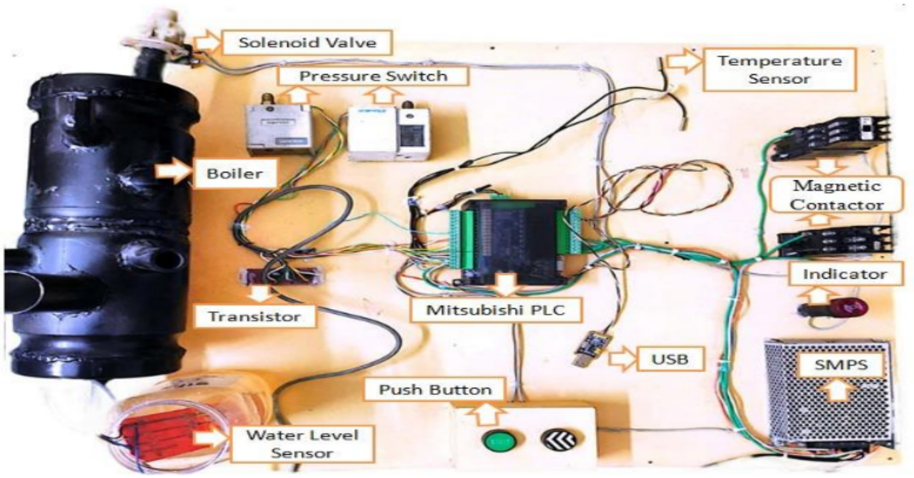

Fig. 3.14 Hardware Setup of entire Project.

3.17 Software Used

GX Works2 Software is used in this project. As a programming language ladder diagram method is used. The Mitsubishi Fx3u 24MRES PLC was enabled using this software. This program was used to create the ladder diagram for this project.

Haiwell Cloud SCADA Designer Software is used in this project. To simulate and collect real-time data of the project SCADA design is used. The Mitsubishi Fx3u 24MRES PLC was connected by this software. This program was used to draw the simulation design for this project.

3.18 Simulation Design in SCADA

In SCADA for the simulation, we have made a boiler system. We used boiler vessel, HMI, real-time data display of sensors (such as temperature, pressure and fluid level), Alarms, control elements, system log and event history. Shown in **Fig. 3.15.**

A graphical representation of historical data, such as temperature profiles and pressure changes over a specific time period, would be incorporated to help operators analyse performance and identify patterns. Shown in **Fig. 3.16.**

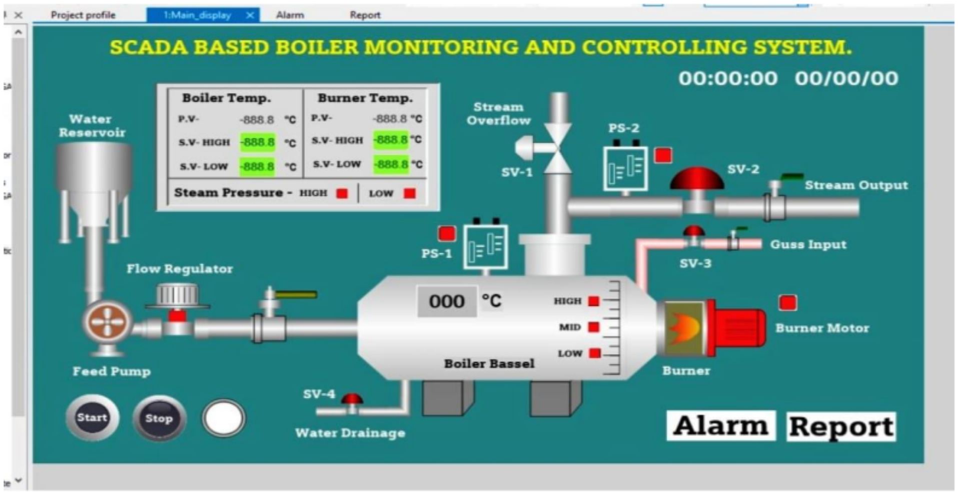

Fig. 3.15 Simulation Design of this project

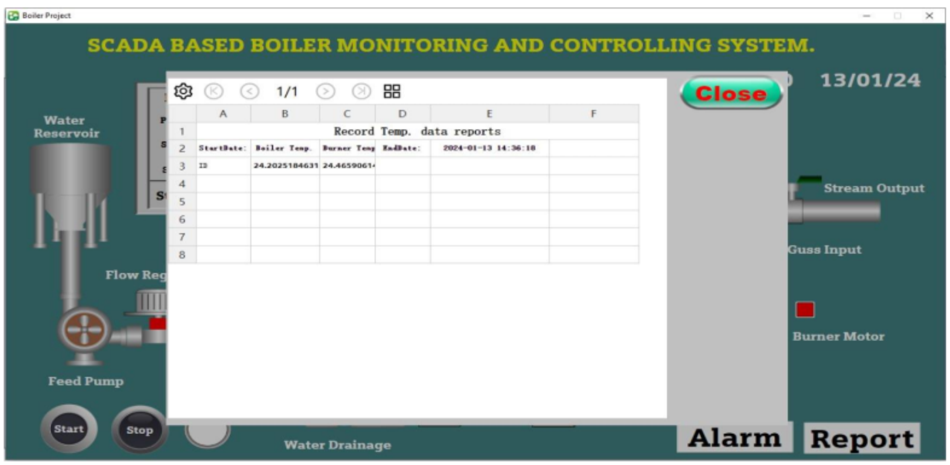

Fig. 3.16 Realtime data of this project

CHAPTER 04

METHODOLOGY

4.1 Introduction

This chapter describes the method we will use for our project. A detailed block diagram and flow chart of the project are presented in **Fig. 4.1** and **Fig. 4.2**. Our project's workflow is depicted in detail in the accompanying block diagram and flow chart. The circuit design for this project is depicted in full in **Fig. 4.3**. The circuit diagram represents the interconnections between the various parts of our project. Also, we described the whole working principle of the project.

4.2 Block Diagram

The block diagram of our project is shown in **Fig. 4.1** below. This diagram illustrates the presence of three sensors: a temperature sensor, a pressure sensor, and a level sensor, all of which are linked to the boiler and integrated with the PLC's input. The PLC's output is linked to four components: the feed pump, heater on/off, steam outlet, and alarm. The SCADA system is also linked to PLC input to control it in simulation and collect the data of sensors. The system is directly linked to both a start and a stop switch for emergency.

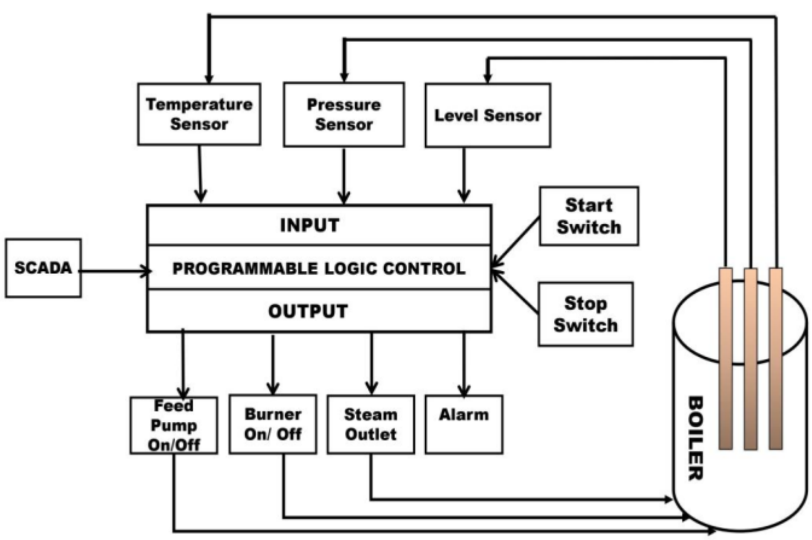

Fig. 4.1 Block Diagram of the project

4.3 Flow Chart

The flow chart of our project is shown below in **Fig. 4.2**. The flow chart outlines the control procedure for a boiler system that is under PLC and SCADA control and supervision and serves as the project's operational methodology. The process begins with PLC and SCADA activation. After that, specified values are used to analyse the water level, temperature, and steam pressure. To ensure measurement accuracy, each parameter has its own calibration system. Based on these evaluations (high, medium, or low), the pump motor, burner, or safety lamp are activated or deactivated. To ensure safety, the device will trip and alert if temperature or pressure measurements rise to a higher level. In the beginning, the PLC and SCADA systems are activated. Additionally, the water level, temperature, and steam pressure are verified in comparison to predetermined levels. If the water level falls below a certain threshold, the pump motor is turned on. When the water level rises, the pump motor is cut off. And after that, the burner will light up and start heating. The burner is turned off when the temperature crosses a certain point. The safety valve opens to release the extra steam when the steam pressure reaches a certain level. Ultimately, every parameter is meticulously adjusted to guarantee precision in the measurements. Lastly, all data on the system parameters is stored in the SCADA system. Also, we can start and stop the process through the SCADA system.

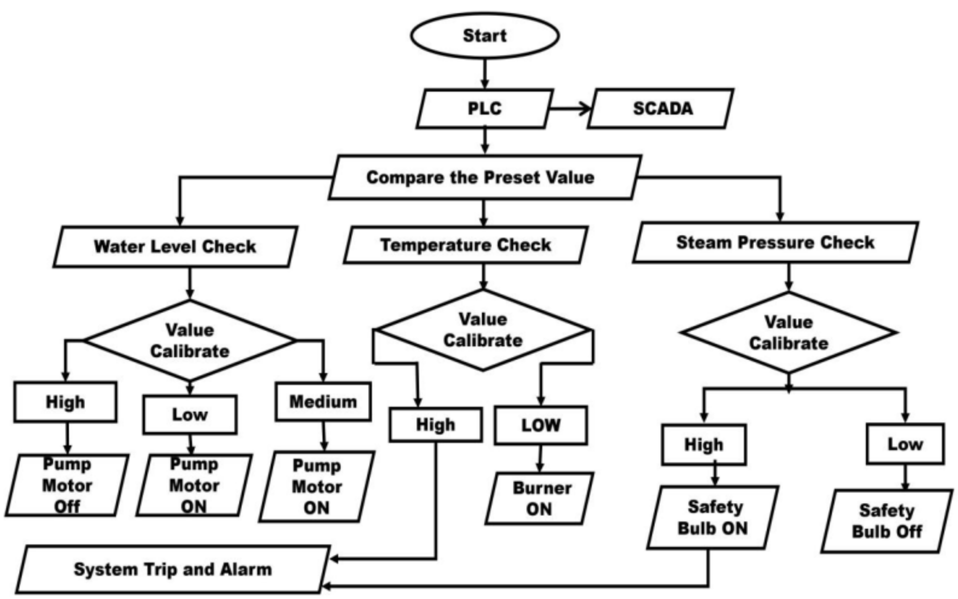

Fig. 4.2 Flow Chart of the project.

4.4 Circuit Diagram

Fig. 4.3. shows the circuit diagram of the boiler system using PLC. The focal component is a boiler, connected to diverse elements such as a PLC, alarms, steam output, heater, and feed pump. The diagram provides a clear depiction of the power supply, illustrating both the DC and AC and clearly indicating their respective connections. The depiction includes many switches together with their corresponding states (on/off) and circumstances, such as water level (high, medium, low). This offers valuable information on the operating functions of the system. In the diagram a Mitsubishi FX3U-24MRES PLC is shown. It has 14 inputs and 10 outputs [11].

In this project 10 inputs and 4 outputs were used. The specifics of input and output are given below:

Inputs:

- START ==X0
- STOP == X1
- Water Level LOW == X2
- Water Level MEDIUM ==X3
- Water Level HIGH ==X4
- Steam Temperature 01==A0-Analog IN
- Auxiliary Steam Temperature 02 ==A1-Analog IN
- Pressure Switch 01 -HIGH ==X5
- Pressure Switch 01 --LOW ==X6
- Auxiliary Pressure Switch 02-HIGH System Trip and steam outlet on ==X7

Outputs:

- Feed Pump == Y0
- Heater == Y1
- Steam Outlet ==Y2
- Alarm == Y3

The remaining inputs and outputs were used

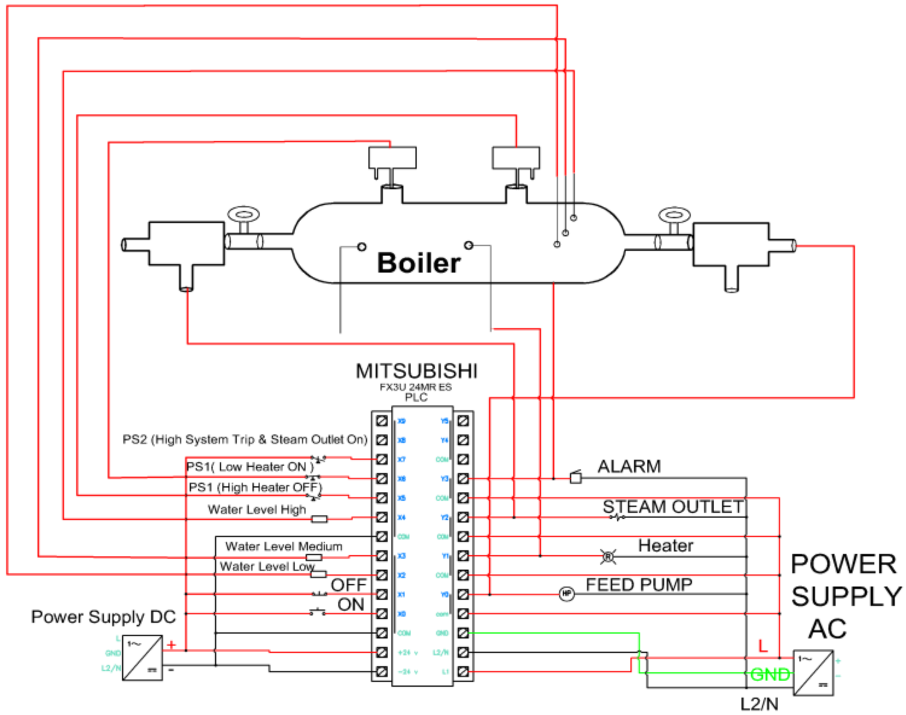

Fig. 4.3 Circuit diagram of the boiler system using PLC

4.5 Ladder Diagram

We had used sensor, making contact, breaking contact, alarm, analog input in our ladder diagram. For input operation, START input (X0), STOP input(X1), System Trip(X2), water level medium(X3), water level (X4), High and low Set from SCADA/Temp. Show in SCADA- Steam Temperature 01(A0-Analog IN), Auxiliary Steam Temperature 02(A1-Analog IN), , LOW Heater ON(X6), Auxiliary Pressure Switch 02 -HIGH System Trip and steam outlet on(X7).For output operation, Feed Pump(Y0), Heater(Y1), Steam Outlet(Y2), Alarm(Y3).

In **Fig. 4.4.** memory address M800, D424 and D430 address use for temperature in Celsius, to set temperature analog command used RD3A, K0 is channel 1, k1 is channel 2, set the value is float number, for sensors memory address used (M40, M48, M52), START input X000, STOP input X001 are shown.

In **Fig. 4.5.** set or reset command of water level medium X003, water level high X004, high and low Set from SCADA/Temp M2, pressure Switch 01-X005, pressure Switch

02-X006 and that command in output feed Pump Y000, heater Y001, steam outlet Y002 are shown.

In **Fig. 4.6.** set or rest command of water level low X003 latch with pressure Switch 02-X006 and command in output alarm Y003 are shown.

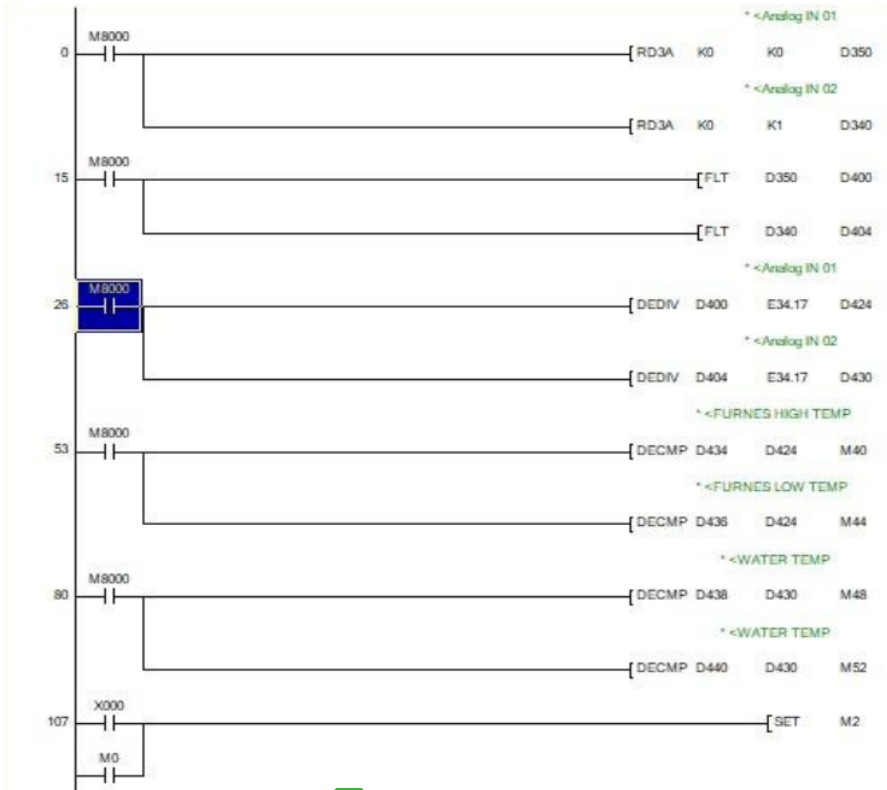

Fig. 4.4 Ladder Diagram of the project.

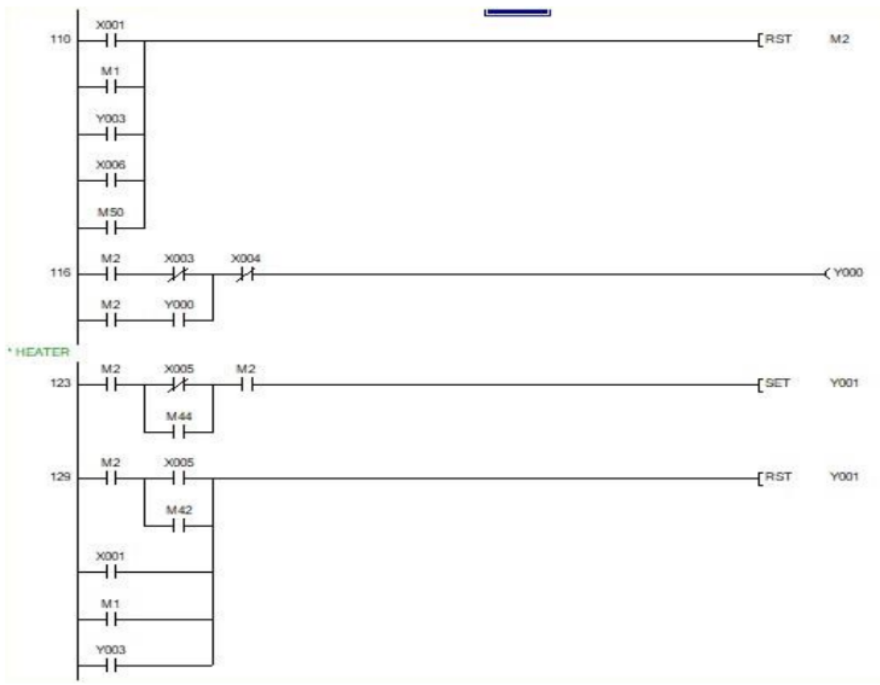

Fig. 4.5 Ladder Diagram of the project

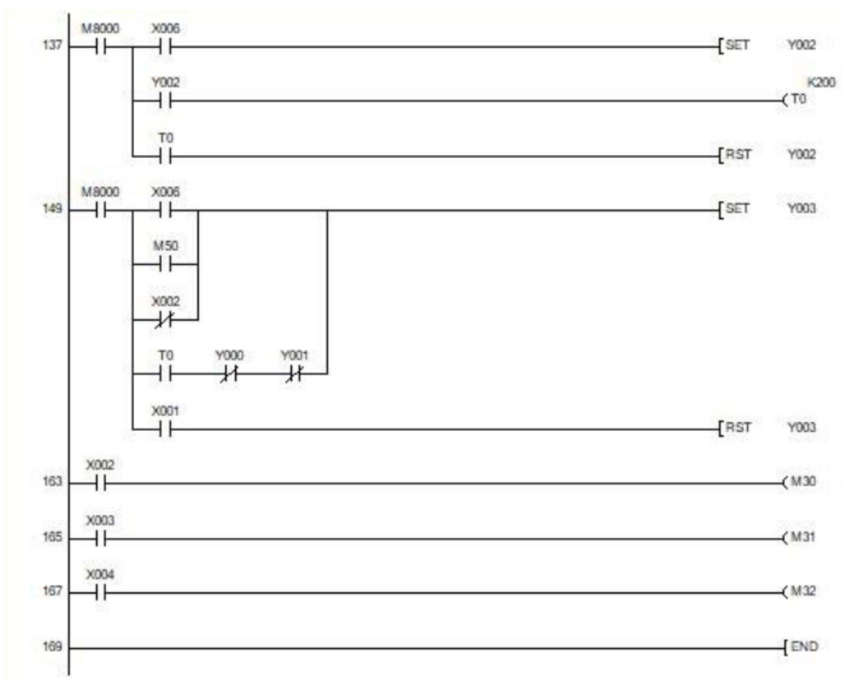

Fig. 4.6 Ladder Diagram of the project.

4.5 Working Principle

Our system operates by combining a PLC with SCADA systems to automate and enhance the efficiency of boiler operations. The PLC, acting as the central control unit, employs sophisticated control logic to efficiently regulate temperature and pressure within established safe operating ranges. PLC initiates the activation of a pump to control temperature and a solenoid valve to release steam and maintain pressure in response to varying circumstances. Wireless SCADA systems provide the distant transmission of data to the SCADA server, enabling real-time monitoring and control of activities. The SCADA interface provides operators with a comprehensive picture, including up-to-date data, past trends, and the current state of the system. An extensive alarm system alerts operators of any irregular circumstances, ensuring immediate corrective action.

- When the boiler temperature hits 30°C, the system is activated, signalling the start of automatic control. Currently, the PLC triggers the pump to start the delivery of feedwater, ensuring that the temperature remains within the predetermined safe operational boundaries. During this phase, the SCADA system offers real-time monitoring by showing crucial parameters on its graphical user interface.
- When the boiler temperature reaches 45°C, the system is immediately shut down to avoid excessive heat. The PLC, which is in charge of monitoring and regulating temperature levels, initiates the shutdown procedure. The solenoid valve ceases the release of steam, causing the pump to terminate its operation, so assuring a controlled and safe stop of the boiler.

Furthermore, the temperature-based activation and deactivation system ensures that the power plant will run well while also providing an additional degree of safety. This is accomplished by keeping the boiler from reaching temperature extremes that are not wanted. The SCADA system plays a significant role in displaying and regulating these temperature-related actions, which ultimately contributes to an increase in the overall safety and dependability of the automated boiler system.

CHAPTER 05

RESULT ANALYSIS

5.1 Introduction

This chapter focuses on the investigation and evaluation of the boiler automation system's performance. The trial functioning of this project delivered flawless results. The sensors employed in this project effectively detected and measured the temperature and pressure of the boiler. The entire process proceeded without any significant issues. Based on the specified procedure.

5.2 Sensor Performance

In this project, the sensors are an extremely important component. The DS18B20 temperature sensor, water level sensor, and pressure sensor all performed well in this project. The performance of all three sensors was pretty excellent. Furthermore, the SCADA system provided precise readings for the variables of the boiler, including temperature, water level, and pressure.

5.3 Overall Performance

The overall performance of the boiler automation system was satisfactory but some improvement can be done on this project. The switching operation of this project was fast and accurate. The overall performance of the project is shown below:

5.3.1 Hardware

In hardware, boiler system initiates when the temperature reaches or surpasses 30°C, and the voltage in the analog input A1 of the Mitsubishi Fx3u 24MRES PLC is 1.5V. **Fig. 5.1** displays the current operational condition of the boiler system.

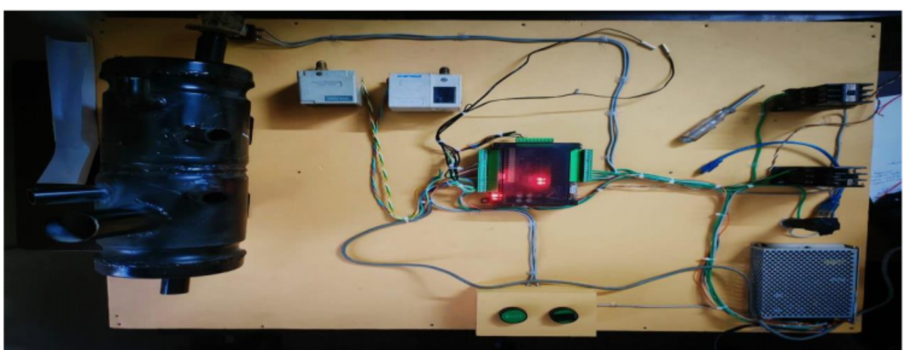

Fig. 5.1 Operational condition of boiler system

When the temperature within the boiler system reaches or surpasses 45°C and the voltage on the analog input A0 of the Mitsubishi Fx3u 24MRES PLC is 1.5V, the boiler system will stop operating. In the shutdown stage, the boiler system is shown in **Fig. 5.2.**

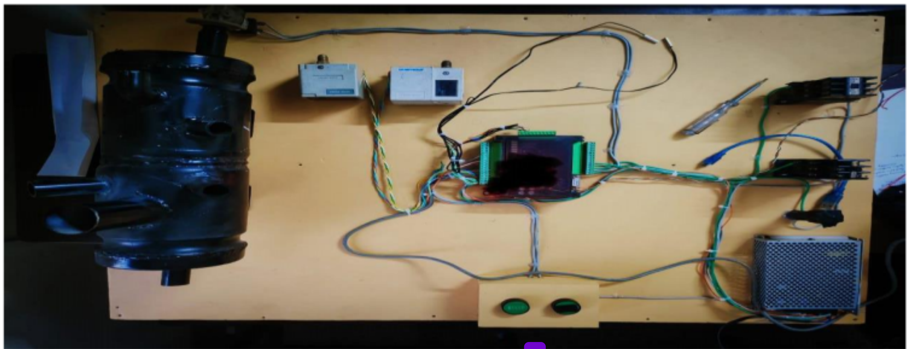

Fig. 5.2 Shutdown condition of boiler system

To deactivate the whole boiler system, a manual switch is employed. Depressing the manual switch results in the complete shutdown of the whole boiler system. The process of manually shutting down the whole boiler system is shown in **Fig. 5.3.**

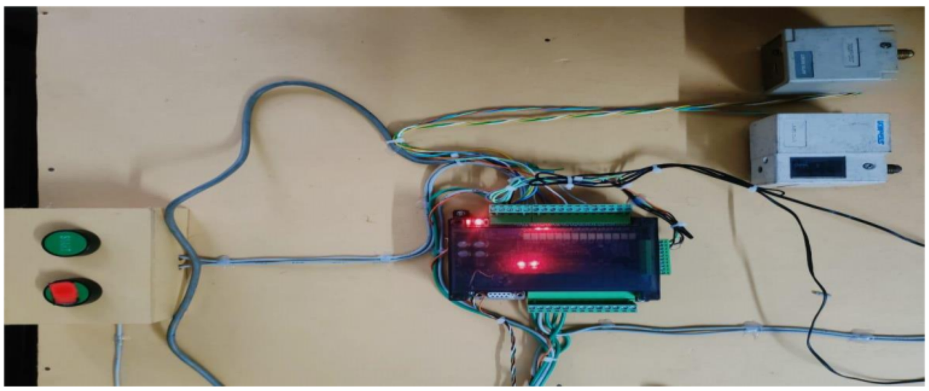

Fig. 5.3 Switching off the boiler system manually

5.3.2 Software

In SCADA system, the boiler system is activated when the temperature reaches or falls below 30℃ and the voltage in the analog input A1 of the Mitsubishi Fx3u 24MRES PLC is 1.5V. The boiler is filled with water, and the burner is activated. Additionally, the steam pressure is insufficient. **Fig. 5.4** shows the simulation of the initial state of the boiler system.

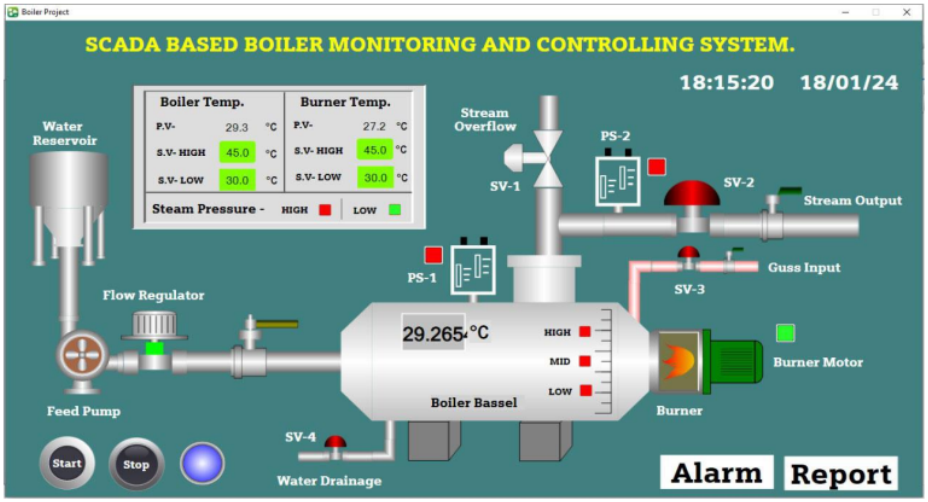

Fig. 5.4 The simulation of initial state.

The system operates when the temperature reaches or exceeds 30°C and the voltage in the analog input A1 of the Mitsubishi Fx3u 24MRES PLC is 1.5V. The water in the boiler begins to boil, causing the steam pressure to increase. **Fig5.5** displays a simulation of the boiler system's operating state.

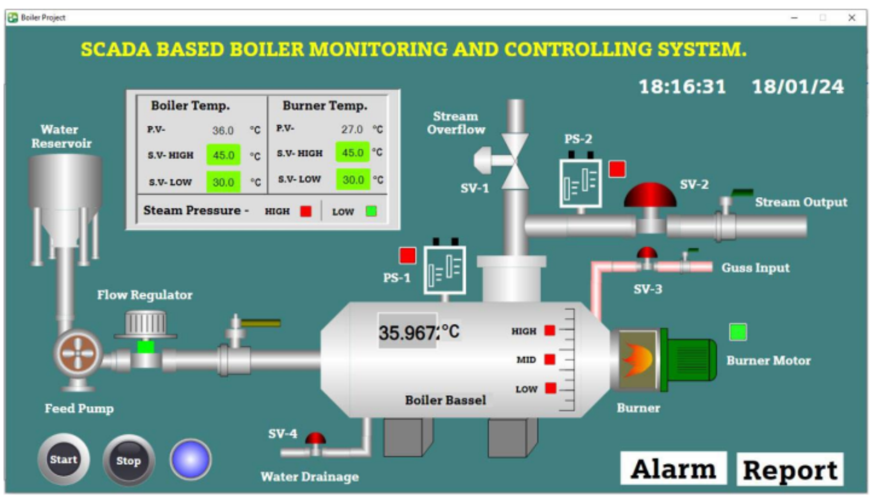

Fig. 5.5 The simulation of operating state.

The system shuts off when the temperature reaches or exceeds 45°C, and the voltage in the Mitsubishi Fx3u 24MRES PLC analog input A0 is 1.5V. The water level drops, the burner stops, and steam level is high. **Fig. 5.6** shows the boiler system's stop state simulation.

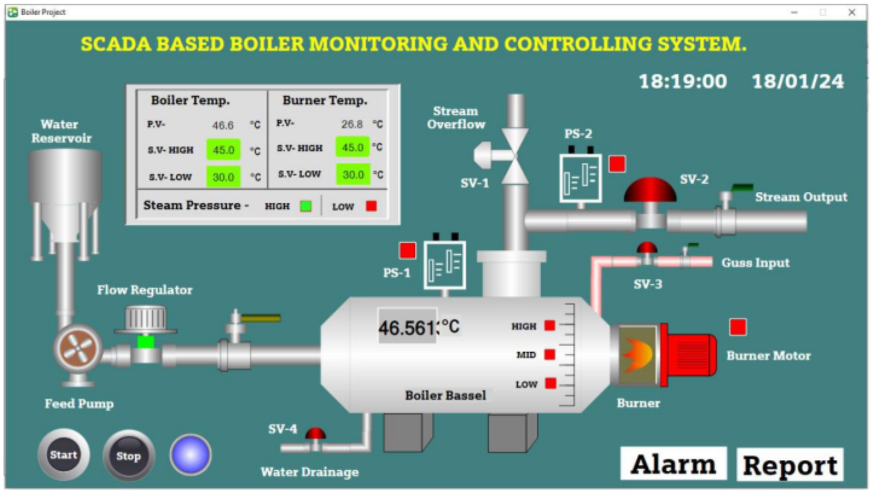

Fig. 5.6 The simulation of stop state of boiler system

5.3.2 Data Analysis

The real-time data of the project from SCADA shown in **Table 5.1.** We have shown boiler and burner temperature specified altered in real time within specified interval.

Table 5.1 Real-time data table

Record Temp. data reports					
Boiler Temp.	Burner Temp	Date	Time	Pump	Burner
28.914253	26.9534702	2024-01-18	17:09:19	true	true
38.1914	28.7094	2024-01-18	17:09:20	true	true
38.77671	28.76793	2024-01-18	17:09:21	true	true
39.83026	28.82646	2024-01-18	17:09:22	true	true
40.59116	28.88499	2024-01-18	17:09:23	FALSE	true
40.85455	28.94352	2024-01-18	17:09:24	FALSE	true
41.14721	29.03131	2024-01-18	17:09:25	FALSE	true
41.46913	29.03131	2024-01-18	17:09:26	FALSE	true
41.73252	29.08985	2024-01-18	17:09:27	FALSE	true
42.20076	29.11911	2024-01-18	17:09:28	FALSE	true
42.81534	29.17764	2024-01-18	17:09:29	FALSE	true
43.57624	29.23617	2024-01-18	17:09:30	FALSE	true
44.83465	29.2947	2024-01-18	17:09:31	FALSE	true
45.12233	29.3825	2024-01-18	17:09:32	FALSE	FALSE

5.4 Cost Analysis

We described our project's financial evaluation in this section which is currently estimated to be around 17350 BDT, to about 17500 BDT. Even though these figures suggest possible cost-effectiveness, a thorough feasibility study is necessary. Overall cost analysis of the project is shown in **Table.5.2** below: -

Table 5.2 Overall cost of the project

Component	**Price (BDT)**
Mitsubishi FX3U-24MRES PLC	12000
Temperature sensor	200
Pressure switch	1000
Solenoid valve	500
SMPS	500
Water level sensor	150
Magnetic contactor	2000
Others	1000
Total	**17350/-**

5.5 Prototype Vs Real system

The main objective of our project is to conduct research by developing the prototype. The actual system may require certain modifications. The prototype and the real system are compared as below:

- Our project features the creation of a miniature boiler using PVC pipe as a prototype. However, there is a potential risk of hot water spilling out of the pipe during the heating process. However, industrial boilers are generally metal-closed vessels. Therefore, the actual system has a reduced level of risk.
- The operation of the prototype system requires AC to DC conversion as well as several voltage conversions. Hence, additional devices are necessary. However, in a real system, these modifications may be deemed unnecessary. Thus, there is no need for any more equipment, resulting in a decreased cost.
- A PLC and SCADA are used in the prototype system to monitor and regulate the temperature, water level, and pressure of a single boiler. But in an actual system, a solitary PLC could be used by the SCADA system on a computer to

control and supervise the temperature, water level, and pressure of several boilers.

5.6 Comparative study

A comparative study shown in **Table.5.3**. In this we have compare our project work with ‘Traditional manual control boiler systems’ and ‘PLC-Based Boiler Automation System’ based on cost, features, effectiveness and safety.

Table.5.3 Comparative Study

Boiler system	Traditional manual control boiler systems	PLC-Based Boiler Automation System [7]	SCADA-based Boiler Monitoring and Controlling System (proposed work)
Cost	Lowest initial cost	High initial cost	Highest initial cost
Features	Simplified pressure and temperature monitoring with manual controls and reliance on human operators	System utilizes automated control logic, but its scalability is restricted and operates via ON-OFF control.	Enhanced analytics, remote access, centralized monitoring, and real-time data acquisition
Effectiveness	Limited	Moderated	High
Safety	Minimal safety measures, higher probability of accidents and human error	Automation offers safety but is prone to programming errors.	Improved safety measures, real-time tracking for fast identification of faults

The comparison shows the trade-offs of manual control boiler systems, PLC-based boiler automation systems, and the proposed SCADA-based boiler monitoring and controlling system. Traditional methods have the lowest initial cost but are less effective and riskier owing to human operation. Automation with PLCs has limited scalability and safety risks. SCADA-based systems have advanced features, great efficacy, and increased safety, but they cost more. The application's needs determine the system, balancing cost with boiler operating functionality, efficiency, and safety.

CHAPTER 06

CONCLUSION

6.1 Introduction

This is the final chapter of our project report. In this chapter, we will discuss about the conclusion of the project. Also, discuss about the advantages, limitations, applications and future scope of this project

6.2 Conclusion

Boiler control is one of the most crucial elements of any industrial or power plant. In this project, the SCADA system is used with the PLC to operate the boiler system. Through the design and implementation of a SCADA-based system for boiler monitoring and control, the project successfully met its objectives. The system provides improved safety precautions for boiler operations, efficient control mechanisms, and real-time monitoring capabilities. It met the requirements and needs of the industrial sector due to its long durability, high efficiency, improved safety measures for boiler operations, efficient control mechanisms, and real-time monitoring capabilities. This project overcomes the shortcomings of the previous ones. This project is more expensive than others, but it responds more quickly, and it operates in a safer and more flexible manner. Therefore, the implementation of this technology may be utilized to totally automate boilers that are now controlled manually, thereby allowing companies to go digital.

6.3 Advantages

The implementation of a SCADA-based Boiler Monitoring and Controlling System offers several advantages for industrial and power generation facilities:

- Enhanced Efficiency and improved Safety of the system.
- Operators can monitor and control the boiler remotely through the HMI.
- Data visualization, data Analysis and historical data logging of boilers.
- User-Friendly Interface and Alarm Handling to the system
- By preventing equipment failures, optimizing operations, and reducing downtime, the system can lead to substantial cost savings over time.

6.4 Limitations

While a SCADA-based Boiler Monitoring and Controlling System offers numerous advantages, it also comes with some limitations and challenges that should be considered during design, implementation, and operation:

- Designing and configuring a SCADA system can be complex and time-consuming.
- SCADA systems require regular maintenance to ensure their reliability.
- Customization Complexity and compatibility with Legacy Systems.

6.5 Applications

Applications are given below:

- This device can be used to digitalize industries.
- It's possible to for improving management level and high efficiency prices.
- This device may be utilized to regulate and oversee the temperature and pressure of many boilers simultaneously.
- Applicable in both small and big industries.

6.6 Future Scope

There are countless opportunities for enhancement within this project. The field of automation is constantly progressing. The SCADA system will be continuously improved to ensure its relevance and effectiveness in the future. Predictive maintenance enables the early diagnosis of equipment breakdown, hence preventing expensive periods of downtime. Enhanced boiler performance and reduced inefficiency may be attained through the utilization of sophisticated analytics, such as machine learning, remote diagnostics, and mobile applications. These tools provide operators and maintenance personnel with immediate control, hence improving response times and adaptability. Integrating IoT enhances the monitoring process by including additional data points, resulting in a more comprehensive picture. Users have the ability to personalize and expand the system according to their requirements and to suit future expansion. The enhancements render the SCADA-based Boiler Monitoring and Controlling System adaptable and fully equipped to fulfil industrial requirements.

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