Thesis Book

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DESIGN AND FABRICATION OF IOT BASED BOILER MONITORING SYSTEM

A project

by

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ABSTRACT

Boiler is the major part of industries and power plants. Mostly thermal power plants have boilers to produce electrical energy from steam. But thermal power plants are located in remote areas due to it harmful environment. By increasing the power demand and decreasing the cost for operating and maintenance are increase the reliability of the power plant. To satisfy the power need of the nation, power production is done in thermal power plant for 24 hours in 365 days without fail. But monitoring process is not possible for each and every second. Besides that, industrial boiler monitoring is also a major task to avoid accident. Monitoring process is very important for safety of the workers and high secured operation of the power plant. The aim of the project is to develop monitoring of boiler parameters using wireless communication and to avoid the accidents in hazardous places wherever the humans not able to work. Boiler parameters are monitored by using sensors. Temperature, humidity, fire and gas are the parameters to be monitored and monitored values are visualized through mobile apps by using Internet of Things.

CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION TO BOILER SAFETY SYSTEM

Internet of Things (IoT) is the latest emerging internet technology. IoT is used in all the home appliances, industries and in every device. IoT creates the relationship between people to people, people to things and things to things. If temperature of steam increases boiler tubes will be puncture.

So, monitoring of temperature is important to avoid the problem in power plant. Measurement of water vapour content in atmosphere and surface provides the details about physical, chemical and exobiological process in the surface.

Gas monitoring is a part of this system which monitor the LPG gas in and around the boiler. Monitoring of boiler tank level is important to avoid an increase of maintenance cost. If the water level increases beyond the limits, turbine will damage due to overflow of water. If the water level decreases below the low limit value, boiler tubes will be puncture.

So, the monitoring of boiler water level is important in the boiler. In this project various boiler parameters monitored by using sensors and controller. In IoT, interaction between the physical and digital worlds using sensors and actuators are carried out. A sensor or a network of sensors are used to sense the physical parameters or the respective environment. These processed sensor outputs are then sent to the main server or cloud with the help of various network devices. The data can be accessed over internet from anywhere around the world. Monitoring and controlling form the basic objective of IoT technology. Hence IoT based monitoring is preferred more than manual monitoring. The system is a real time monitoring of boiler parameters such as smoke, fire, over temperature.

1.2 OBJECTIVES OF PROJECT

- This project aims to design a smart IoT system by which we can check temperature, smoke and fire status and send information to mobile apps.
- To bring the benefit of technology to the user's hand.
- To save the time of the manual monitoring.
- To reduce the waste of the resource for monitoring purpose.
- To reduce the disruption of electricity.

1.3 PROJECT OUTLINE

Chapter 1: Contains overview, objectives of the project.

Chapter 2: Discuss about background and equipment of the project.

Chapter 3: Discuss about hardware implementation and experimental results of the project.

Chapter 4: Discussion and conclusion of the project.

References.

Appendix.

CHAPTER-2

BOILER ACCIDENT

2.1 INTRODUCTION

A boiler explosion is a catastrophic failure of a boiler. There are two types of boiler explosions. One type is a failure of the pressure parts of the steam and water sides. There can be many different causes, such as failure of the safety valve, corrosion of critical parts of the boiler, or low water level. Corrosion along the edges of lap joints was a common cause of early boiler explosions.

The second kind is a fuel/air explosion in the furnace, which would more properly be termed a firebox explosion. Firebox explosions in solid-fuel-fired boilers are rare, but firebox explosions in gas or oil-fired boilers are still a potential hazard.

Fig.2.1: Boiler Accident (https://www.wabash.edu/magazine/index.cfm?magazine_id=34)

2.2 CAUSES

There are many causes for boiler explosions such as poor water treatment causing scaling and overheating of the plates, low water level, a stuck safety valve, or even a furnace explosion that in turn, if severe enough, can cause a boiler explosion. Poor operator training resulting in neglect or other mishandling of the boiler has been a frequent cause of explosions since the beginning of the industrial revolution. In the late 19th and early 20th century, the inspection records of various sources in the U.S., UK, and Europe showed that the most frequent cause of boiler explosions was weakening of boilers through simple rusting, by anywhere from two to five times more than all other causes.

Before materials science, inspection standards, and quality control caught up with the rapidly growing boiler manufacturing industry, a significant number of boiler explosions were directly traceable to poor design, workmanship, and undetected flaws in poor quality materials. The alarming frequency of boiler failures in the U.S. due to defects in materials and design were attracting the attention of international engineering standards organizations, such as the ASME, which established their first Boiler Testing Code in 1884. The boiler explosion that caused the Grover Shoe Factory disaster in Brockton, Massachusetts on March 10, 1905 resulted in 58 deaths and 150 injuries, and inspired the state of Massachusetts to publish its first boiler laws in 1908.

Several written sources provide a concise description of the causes of boiler explosions:

"The principal causes of explosions, in fact the only cause, are deficiency of strength in the shell or other parts of the boilers, over-pressure and over-heating. Deficiency of strength in steam boilers may be due to original defects, bad workmanship, deterioration from use or mismanagement."

And "Cause.-Boiler explosions are always due to the fact that some part of the boiler is, for some reason, too weak to withstand the pressure to which it is subjected. This may be due to one of two causes: Either the boiler is not strong enough to safely carry its proper working pressure, or else the pressure has been allowed to rise above the usual point by the sticking of the safety valve or some similar cause"

2.3 EARLY INVESTIGATIONS INTO

While deterioration and mishandling are probably the most common *causes* of boiler explosions, the actual mechanism of a catastrophic boiler failure was not well documented until extensive experimentation was undertaken by U.S. boiler inspectors in the early 20th century. Several different attempts were made to cause a boiler to explode by various means, but one of the most interesting experiments demonstrated that in certain circumstances, if a sudden opening in the boiler allowed steam to escape too rapidly, water hammer could cause destruction of the entire pressure vessel:

"A cylindrical boiler was tested and withstood a steam pressure of 300 pounds (300 psi or 2,068 kPa) without injury." "When the [discharge] valve was suddenly opened at a pressure of 235 pounds [235 psi or 1,620 kPa] the boiler gave way, the iron being twisted and torn into fragments and thrown in all directions. The reason for this was that the sudden rush of steam from the boiler into the discharge pipe reduced the pressure in the boiler very rapidly. This reduction of pressure caused the sudden formation of a great quantity of steam within the water, and the heavy mass of water being thrown with great violence toward the opening whence the steam was being withdrawn, struck the portions of the boiler near that opening and caused the fracture."

But the highly destructive mechanism of water hammer in boiler explosions was understood long before then, as D. K. Clark wrote on 10 February 1860, in a letter to the editors of "Mechanics Magazine":

"The sudden dispersion and projection of the water in the boiler against the bounding surfaces of the boiler is the great cause of the violence of the results: the dispersion, being caused by the momentary generation of steam throughout the mass of the water, and in its efforts to escape, it carries the water before it, and the combined momentum of the steam and the water carries them like shot through and amongst the bounding surfaces, and deforms or shatters them in a manner not to be accounted for by simple overpressure or by simple momentum of steam."

Boiler explosions are common in sinking ships once the hot boiler touches cold sea water, as the sudden cooling of the hot metal causes it to crack; for instance, when the SS Benlomond was torpedoed by a U-boat, the torpedoes and resulting boiler explosion caused the ship to go down in two minutes, leaving Poon Lim as the only survivor in a complement of 53 crew.

2.4 IN LOCOMATIVES

Boiler explosions are of a particular danger in (locomotive-type) fire tube boilers because the top of the firebox (crown sheet) must be covered with some amount of water at all times; or the heat of the fire can weaken the crown sheet or crown stays to the point of failure, even at normal working pressure.

This was the cause of the Gettysburg Railroad firebox explosion near Gardner, Pennsylvania, in 1995, where low water allowed the front of the crown sheet to overheat until the regular crown stays pulled through the sheet, releasing a great deal of steam and water under full boiler pressure into the firebox. The crown sheet design included several alternating rows of button-head safety stays, which limited the failure of the crown sheet to the first five or six rows of conventional stays, preventing a collapse of the entire crown sheet.

Fig.2.2 Locomotive explosion (https://www.telegraph.co.uk/news/picturegalleries/worldnews/3867884/Latvia-train-crash-causes-fuel-tank-explosion.html?image=4)

This type of failure is not limited to railway engines, as locomotive-type boilers have been used for traction engines, portable engines, skid engines used for mining or logging, stationary engines for sawmills and factories, for heating, and as package boilers providing steam for other processes. In all applications, maintaining the proper water level is essential for safe operation.

Hewison (1983) gives a comprehensive account of British boiler explosions, listing 137 between 1815 and 1962. It is noteworthy that 122 of these were in the 19th century and only 15 in the 20th century.

Boiler explosions generally fell into two categories. The first is the breakage of the boiler barrel itself, through weakness/damage or excessive internal pressure, resulting in sudden discharge of steam over a wide area. Stress corrosion cracking at the lap joints was a common cause of early boiler explosions, probably caused by caustic embrittlement. The water used in boilers was not often closely controlled, and if acidic, could corrode the wrought iron boiler plates. Galvanic corrosion was an additional problem where copper and iron was in contact.

Boiler plates have been thrown up to a quarter of a mile (Hewison, Rolt). The second type is the collapse of the firebox under steam pressure from the adjoining boiler, releasing flames and hot gases into the cab. Improved design and maintenance almost totally eliminated the first type, but the second type is always possible if the engineer and fireman do not maintain the water level in the boiler.

Boiler barrels could explode if the internal pressure became too high. To prevent this, safety valves were installed to release the pressure at a set level. Early examples were spring-loaded, but John Ramsbottom invented a tamper-proof valve which was universally adopted. The other common cause of explosions was internal corrosion which weakened the boiler barrel so that it could not withstand normal operating pressure. In particular, grooves could occur along horizontal seams (lap joints) below water level. Dozens of explosions resulted, but were eliminated by 1900 by the adoption of butt joints, plus improved maintenance schedules and regular hydraulic testing.

Fireboxes were generally made of copper, though later locomotives had steel fireboxes. They were held to the outer part of the boiler by stays (numerous small supports). Parts of the firebox in contact with full steam pressure have to be kept covered with water, to stop them overheating and weakening. The usual cause of firebox collapses is that the boiler water level falls too low and the top of the firebox (crown sheet) becomes uncovered and overheats. This occurs if the fireman has failed to maintain water level or the level indicator (gauge glass) is faulty. A less common reason is breakage of large numbers of stays, due to corrosion or unsuitable material.

Throughout the 20th century, two boiler barrel failures and thirteen firebox collapses occurred in the UK. The boiler barrel failures occurred at Cardiff in 1909 and Buxton in 1921; both were caused by miss-assembly of the safety valves causing the boilers to exceed their design pressures. Of the 13 firebox collapses, four were due to broken stays, one to scale buildup on the firebox, and the rest were due to low water level

2.5 BOILER ACCIDENT HISTORY

2.5.1 ACCIDENT-01

Tongi, Bangladesh. A boiler explosion in a cigarette packaging factory outside Dhaka enveloped the five-story building in flames early Saturday, killing at least 23 people, fire officials said.

Fig.2.3 Firefighters trying to douse flames after an explosion on Saturday in a factory in Tongi, Bangladesh. (https://www.nytimes.com/2016/09/11/world/asia/boiler-explosion-at-bangladesh-factory-kills-at-least-23.html)

The blaze was the latest in a series of industrial disasters over the last several years in Bangladesh. At least 50 people were injured in Saturday's fire, said Mozammel Hoque, a deputy director of the fire service.

The cause of the explosion was unclear, he added.

The blast occurred at 6 a.m. at the Tampaco Foils factory in an industrial park in Tongi. The factory makes, among many other things, foil for cigarette packs for British American Tobacco and snack-food packaging for Nestlé.

By Saturday evening, firefighters had not yet completely extinguished the blaze. They tried to rescue anyone still trapped inside

2.5.2 ACCIDENT-02

Boiler blast at Vadodara factory

Fig.2.4: Rescue operations are currently underway at the chemical factory in Vadodara where the blast took place on Friday morning. (Express Photo: Bhupendra Rana) (https://www.thehansindia.com/news/national/gujarat-four-dead-11-injured-in-boiler-blast-at-chemical-factory-in-vadodara-721442)

Four persons, including a four-year-old child, were killed and 11 others were injured in a boiler blast at a chemical company located close to the railway tracks in Makarpura GIDC area of the city Friday morning. The impact of the blast was felt in a radius of about two kilometres, with several residential buildings reporting cracks, shattered windowpanes and shards of the boiler that flew across a distance of more than a kilometre.

According to police, the blast occurred around 10 am in the boiler of Canton Laboratories Pvt. Ltd, minutes after a passenger train crossed the Vadodara-Mumbai railway line, and was heard up to three kilometres away in Makarpura, Manjalpur and Vadsar areas. Residential colonies and offices located in a radius of about one kilometre felt the impact, authorities said.

The blast brought down the temporary brick structures built to house the workers, instantly killing 30-year-old Varsha Chauhan and her four-year-old daughter Riya. Two workers on duty — Ravi Vasava, 21, and Satish Joshi, 65 — were also killed.

Commissioner of Police, Vadodara city, Shamsher Singh told The Indian Express that police have initiated a process to book the owners of the factory for negligence. “There is gross negligence by the owners as the quarters to house workers — which were temporary structures — were located barely 20 feet from the boiler plant. The woman and her daughter were the only ones in the quarters as the rest of the people were at work. They suffered grievous injuries as the structure collapsed. We are also checking the documents of the company to ascertain if they had the licence to run the boiler," he said.

Teams of Manjalpur police station, Vadodara Fire and Emergency Services Department Forensic Science Laboratory (FSL) and the Gujarat Pollution Control Board (GPCB) rushed to the spot to ascertain a cause of the blast, which is yet to be known, Singh added. The injured persons undergoing treatment also include a five-year-old child who sustained major injuries.

2.5.3 ACCIDENT-03

A terrible explosion occurred in Walsall Street.

Fig.2.5 The photograph on which the above illustration was based. It must be one of the earliest industrial photos taken in the area. Courtesy of David Clare. (http://www.historywebsite.co.uk/articles/boiler/explosions.htm)

Most of the factory and some of the tightly-packed surrounding buildings had been completely destroyed and converted into rubble. Next to the factory stood Benjamin Mason's three storey malthouse, which became a pile of rubble, even though its walls were thirteen inches thick. The egg-shaped, vertical boiler had been mounted against the malthouse wall. It powered a small engine used for the fire-iron factory, and also for a grindery, and wood-turning establishment at the rear of the factory. At the time of the explosion most of the employees in the establishments had been at work. All that survived in the factory was the tall substantial chimney, to which the boiler had been fixed. The chimney completely shielded one of the employees who was behind it in the malthouse at the time of the explosion, saving his life. The grindery and the wood turning establishment had their roofs blown-off, and were badly damaged.

A piece of the boiler weighing 2 hundredweights had been hurled about a hundred yards. At the time of the explosion, Benjamin Mason junior, and the engineman, Joe Cornfield had just screwed the safety valve down because the boiler feeding pipe had burst, and the nearly empty boiler was red hot. They attempted to cool the boiler by adding cold water, which quickly boiled and produced a lot of steam. The boiler instantly exploded, killing both of them. Joe was thrown through the air and crashed through the roof of a nearby house. His clothes had been torn-off, leaving him naked and bleeding. Many of his bones were broken, and he was badly scalded. He died a few minutes later. Benjamin’s fate was even more gruesome. His body, minus arms, and the top of his head was found amongst the ruins. One arm was found in Bilston Street near the cattle market.

Another employee, Tom Nightingale, who alerted Mason and Cornfield to the damaged feed pipe, and was with them at the time of the explosion, escaped without injury. Several others were not so lucky. Another colleague, Tom Holdridge received terrible injuries and died that night in the South Staffordshire General Hospital and Dispensary, in Cleveland Road. Two children, Matthew William Turner aged 5, who had been playing in the street, and Isabella Hall aged 12 were also killed, both by falling debris. Isabella had been on an errand to buy a writing book for her father, who rushed to the scene of the explosion. He saw a policeman carrying a body away from the scene and recognised her frock. It must have been a terrible moment for him.

Another person was seriously injured, and nine others received lesser injuries. A memorial service was held on the following Sunday in front of the cattle market, and an inquest took place at the Blue Ball Inn in Bilston Street. At the inquest it was stated that the boiler had been purchased second-hand, and installed six years earlier. It had previously been enlarged, and repaired several times. It was also stated that the water in the boiler had been allowed to go so low that the metal was red-hot. The explosion occurred when cold water was poured-in.

The inquest came to the conclusion that the deceased persons died as a result of their injuries received by the explosion of the boiler, and that the explosion was caused by the gross negligence of Benjamin Mason junior.

2.5.4 ACCIDENT-04

The explosion at Millfields Iron Works

Five years later another catastrophic boiler explosion occurred about a mile and a half away from Walsall Street, at Millfields Iron Works. The explosion took place on Tuesday 15th April, 1862, at about 11.15 a.m.

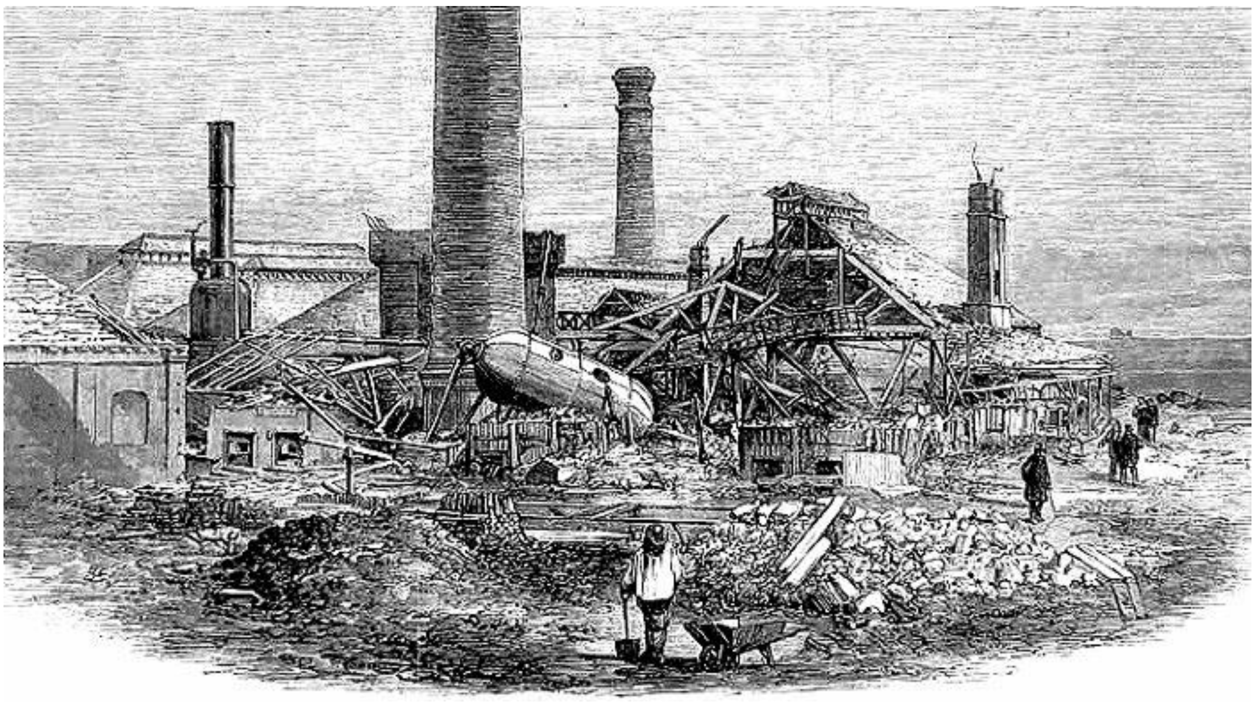


Fig.2.6 The scene of the boiler explosion at Millfields Ironworks. From the Illustrated London News 26th April, 1862. (http://www.historywebsite.co.uk/articles/boiler/explosions.htm)

The factory, previously owned by the Birmingham Banking Company, was eleven years old. It closed in 1858, and had been idle for four years. There had been a previous accident on the site, which caused the death of five workers on 5th May, 1857.

In early 1862 the factory was purchased by Thomas Rose, who had been looking for sometime for a suitably-equipped iron works. Having found what he wanted, he employed around 40 men and started production, in the hope that he would make his fortune thanks to the insatiable demand for iron at the time.

The factory consisted of two forges and three mills. At the time only one forge was in operation. It consisted of twenty puddling furnaces, a shingling hammer, a rolling mill, and an 80 hp. steam engine that worked the massive shingling hammer. Steam for the engine was provided by two cylindrical boilers with hemispheric ends, both about twenty feet long, and nine feet in diameter. The boilers were heated by the hot gases from the flues of some of the puddling furnaces. One boiler was heated by four flues, the other by two. They were made by John Elwell & Company, at Priestfields.

When the explosion occurred, the puddlers from the four furnaces attached to boiler number one, were taking their red-hot balls of puddled iron to the shingling hammer to produce puddled bars, which were cut-up, reheated, and rolled into merchantable iron in the rolling mill. About forty people were at work at the time.

2.5.5 ACCIDENT-05

A boiler explosion at a garment factory in Gazipur, Bangladesh, killed 11 people.

Fig.2.7: boiler explosion at a garment factory in Gazipur (https://www.thedailystar.net/frontpage/boiler-blast-kills-four-gazipur-1427953)

At least 11 people were killed in a boiler explosion at a garment factory at Kashimpur, in Gazipur, neighboring district of the capital city Dhaka. The first and the second floor of the four-storeyed building of Multifabs Limited collapsed when the explosion broke out at around 7 PM on Monday.

Shortly after the incident, fire fighters started the rescue operation with the help of the workers of the factory and locals. Six bodies were recovered from the ruins of the factory at night, while more than three were declared dead out of the 47 admitted to the hospital.

2.6 CAUSES OF BOILER EXPLOSION

Steam boilers are an integral asset in any manufacturing and processing unit. While investing in steam boilers, plant managers ensure that the boiler promises efficiency, reliability, optimal combustion, and steam quality. It is essential to regularly check and maintain the wear and tear of boilers, failing which, may lead to a boiler explosion. Steam boilers, if left unchecked, are potential bomb that cause severe damage to the process plant and operating team. Although the boiler explosion rate is rare compared to boiler installations annually worldwide, it does not entirely eliminate the possibility of boiler explosion.

2.6.1 WHAT IS BOILER EXPLOSION?

Boiler explosions are destructive failures of steam boilers. There are two primary reasons that commonly cause boiler explosions. One of them is the failure of pressure parts of the steam and waterside. Such failures are caused by corrosion of vital parts, failure of safety valves, or low water levels. The second-most common cause of boiler explosion is caused due to fuel/air explosion that takes place in the furnace. It is also sometimes termed a firebox explosion. Such explosions in solid-fuel boilers are rare; however, an explosion in oil-fired boilers and gas-fired boilers lead to damaging consequences.

2.6.2 CAUSES OF BOILER EXPLOSION

As discussed above, boiler explosions mainly occur due to either pressure vessel failure or fuel combustion explosion. Let us understand some of the causes of explosion in detail:

2.6.3 FAILURE OF PRESSURE VESSEL

Pressure vessel failure is usually caused by rusting or overheating of metal by low water levels or excess scale formation. The vessel is also impacted by damaged safety valves or water hammer. It occurs when the pressure range of the vessel is affected. To understand it better, the pressure change in the steam boiler operating at 100 PSIG can expand the water 1500 times than its original volume. Consequently, it leads to a substantial force that causes hazardous boiler explosions.

2.6.4 FUEL COOMBUSTION EXPLOSION

Fuel combustion explosions often take place due to failure in burners. Ignition failure, improper gas lines, or loose valves leads to combustion gas buildup in the high-temperature vessel. It results in boiler explosion along with leakage of gases throughout the process plant. An initial explosion can cause rupturing of pressure vessels, resulting in a second explosion that is tremendously hazardous.

2.6.5 STEAM PRESSURE

Usually, in a steam boiler, water is heated to produce steam that is stored in the boiler chamber. The steam is under immense pressure that requires precise operating methods to prevent boiler explosion. Operating personnel neglecting the proper guidelines and regular maintenance cause the risk of boiler explosion. As steam pressure exceeds the boiler design, it results in a hazardous explosion that severely harms the vicinity and the safety of the operating team.

2.6.6 SCALLING OR CORROSION

The presence of oxygen in feedwater or hot water leads to scale formation and corrosion in steam boilers. It results in damaging the metal of the boiler and eventually boiler explosion if left overlooked. If neglected, corrosion and scaling cause weakening of boiler metal and the welds that seal the tank.

2.7 PRECAUTIONS TO PREVENT BOILER

Negligence in management is the primary cause of boiler explosion that can be prevented by following some safety guidelines mentioned below:

- Inspection of pump inlets and loose connections
- Installation of ash removal system to avoid ash accumulation in the furnace or other equipment
- Pump priming
- Regular checking of safety valves
- The boiler should be operated as per its design pressure
- Treatment of water before feeding it to boiler
- Ensure that the boiler vents function properly
- Regular inspection for leakages of water, gases, steam, and air
- Ensure proper insulation of heated parts of boilers
- Maintenance of Forced Draft Fan and Induced Draft Fan
- Regular checking of Pressure Gauge
- Regular cleaning of accessible boiler parts
- Cleaning of boiler tubes to prevent ash accumulation or scale formation
- Maintaining the primary and secondary air ratio as per fuel feeding
- Scheduled checking of burner operation, back pressure, and line pressure to avoid thermal stress
- Follow boiler manual and standard guidelines for safety
- Periodic maintenance of steam boiler and boiler accessories
- Proper training of operating personnel on appropriate methods of operation
- In serious issues, ask for the guidance of the boiler manufacturer

Boiler explosions, though undoubtedly hazardous, can be avoided by proper operation practices and regular maintenance of steam boilers. Rakhoh Boilers, with their expertise and experience in thermal engineering for over 38+ years, offer a comprehensive solution for industrial steam boilers. We manufacture a range of world-class quality products such as steam boilers, waste heat recovery boilers, thermic fluid heaters, and boiler accessories. We also provide excellent boiler services like energy audit, steam trap assessment, boiler automation, annual maintenance contract, etc.

2.8 CONCLUSION

This chapter describes the different types boiler explosion in the world. Boiler explosions, though undoubtedly hazardous, can be avoided by proper operation practices and regular maintenance of steam boilers. Rakhoh Boilers, with their expertise and experience in thermal engineering for over 38+ years, offer a comprehensive solution for industrial steam boilers. We manufacture a range of world-class quality products such as steam boilers, waste heat recovery boilers, thermic fluid heaters, and boiler accessories. We also provide excellent boiler services like energy audit, steam trap assessment, boiler automation, annual maintenance contract, etc.

CHAPTER-3

PROJECT BACKGROUND

3.1 INTRODUCTION

In this modern era, so much equipment is discovered to get different information. In this project, we used several types of equipment, each equipment having a different function and figure. In this chapter, the different functions of this equipment are described with figures.

3.2 LITERATURE SURVEY

Gomathi Sankar A, Jesudass Rabinson Arasu S, Karthick K, Maris Murugan T are proposed a system that deals with the boiler drum level controlling system. The boiler drum level is controlled by the arduino Uno microcontroller from pulse output of ultrasonic level sensor. Arduino Uno microcontroller receives the pulse signal and send to the Liquid Crystal Display (LCD) or Personal Computer (PC) with the help of the Local Area Network (LAN). Another side the same level signal send to the Internet of Things (IoT) by using Wi-Fi module. In this concept the major advantage is boiler drum level controlling, this action is taken by the Internet of Things (IoT), which means the signal from Internet of Things (IoT) connected devices like smart phones or laptops etc., From the devices the signal will be sent to the Arduino Uno microcontroller for controlling the feedwater flow inside the boiler drum by relay action. Through the smart phones or laptop can store the N number of data's, as well as control the drum level. In this system the monitoring action can also done with the help of website address. Then paper [1] present an Internet based boiler drum level control system is developed, which enables the students for deeper understanding of the boiler theory, the real experiences on design and implementation of control system.

Analysis of combustion quality of flame images of thermal and gas turbine power plants is of great importance. Soft sensors are the state of the art. So the flame temperature based on subsequent combustion quality estimation is done using Back Propagation Algorithm (BPA) and

Ant Colony Optimization (ACO). The basic idea utilizes the colour information from the flame images.

3.2.1 INTERNET OF THINGS-CONCEPT & DEFINITION

Internet of Things (IoT) [4], [5] consists of two words-Internet and Things, The term "Things" in loT refers to various loT devices having unique identities and having capabilities to perform remote sensing, actuating, and live to monitor certain sorts of data.

IoT devices are also enabled to have a live exchange of data with other connected devices and applications either directly or indirectly, or collect data from other devices and process the data and send the data to various servers, The other term "Internet" is defined as Global Communication network connecting millions of computers across the planet enabling sharing of information. As forecasted by various researchers, 50 billion devices based on loT would be connected all across the planet by the year 2020.

The Internet of Things (IoT) has been defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual “Things" have identities, physical attributes, and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information. network, often communicate data associated wíth users and their environments", An ideal IoT device consists of various interfaces for making connectivity to other devices which can either be wired or wireless.

3.2.2 LOT ENABLING TECHNOLOGIES

Internet of Things has a strong backbone of various enabling technologies- Wireless Sensor Networks, Cloud Computing, Big Data, Embedded Systems, Security Protocols and Architectures, Protocols cnablíng communication, web servíces, Internet and Search Engines [5], [9]. Wireless Sensor Network (WSN): It consists of various sensors/nodes which are integrated to monitor varíous sorts of data, Cloud Computing: Cloud Computing, also known as on-demand computing, is a type of Internet-based computing that provides shared processing resources and data to computers and other devices on demand.

It is a sort of computer system which consists of both hardware and software to perform specific tasks. It includes a microprocessor/microcontroller, RAM/ROM, networking components, 1/O units, and storage devices.

3.3 REQUIRED EQUIPMENT

3.3.1 MICROCONTROLLER-ESP32

ESP32 [10, p. 32] is powerful SoC (System on Chip) microcontroller with integrated Wi-Fi 802.11 b/g/n, dual mode Bluetooth version 4.2 and variety of peripherals shown in fig 2.1. It is an advanced successor of the 8266 chip primarily in the implementation of two cores clocked in different version up to 240 MHz. Compared to its predecessor, except these features, it also extends the number of GPIO pins from 17 to 36, the number of PWM channels per 16 and is equipped with 4MB of flash memory.
The ESP32 chip has been developed by the Espressif Systems company, which currently offers several ESP32 versions of the SoC in the form of ESP32 Developer Kit, the ESP32 Wrover Kit, which also includes an SD card and 3.2” LCD display and last but not least the ESP32 Azure IoT kit with USB Bridge and other built-in sensors. In addition to Espressif Systems, other producers are devoted to these chips - SparkFun with ESP32 Thing DB, WeMoS with its TTGO, D1, Lolin32 and Lolin D32, Adafruid (with Huzzah32), DF Robot (ESP32 FireBeeatle) and many other manufacturers sometimes offer good and sometimes bad clones.

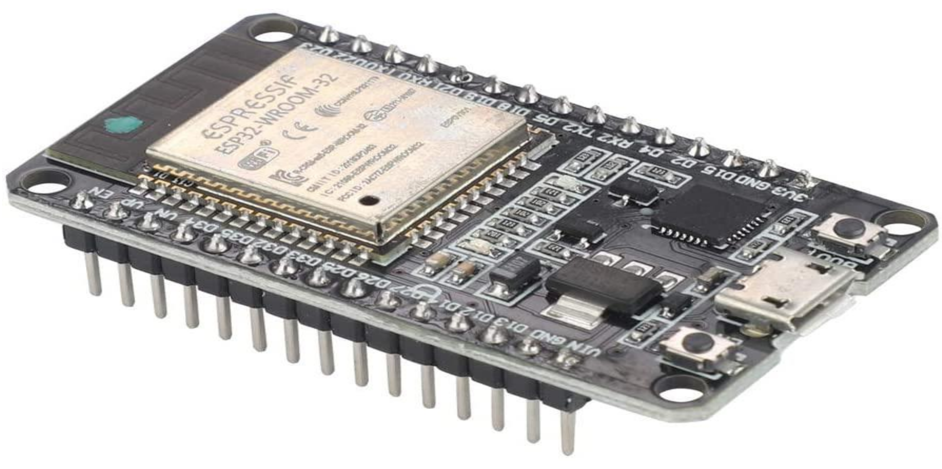


Fig.3.1: ESP32 microcontroller.

ESP32 includes two core (Xtensa LX6 processor made with 40 nm technology). CPU cores can be individually controlled. There is 520 KB of on-chip SRAM for data and instructions available.

Some SoC modules such as ESP32-Wrover features 4 MB of external SPI flash and an additional 8 MB of SPI PSRAM (Pseudo static RAM). We have the possibility to use SPI, I2S, I2C, CAN, UART, Ethernet MAC, and IR in various quantities, depending on the type of the board.

3.3.2 GAS SENSOR

This is a robust Gas sensor suitable for sensing LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide concentrations in the air. If you are planning on creating an indoor air quality monitoring system; breath checker or early fire detection system, MQ2 Gas Sensor Module is a great choice. When tin dioxide (semiconductor particles) is heated in air at high temperature, oxygen is adsorbed on the surface. In clean air, donor electrons in tin dioxide are attracted toward oxygen which is adsorbed on the surface of the sensing material. This prevents electric current flow. In the presence of reducing gases, the surface density of adsorbed oxygen decreases as it reacts with the reducing gases. Electrons are then released into the tin dioxide, allowing current to flow freely through the sensor. Used gas sensor MQ-2 is shown in fig-3.2

Pinout of MQ-2 Gas sensor

- VCC supplies power for the module. You can connect it to 5V output from your Arduino.
- GND is the Ground Pin and needs to be connected to GND pin on the Arduino.
- D0 provides a digital representation of the presence of combustible gases.
- A0 provides analog output voltage in proportional to the concentration of smoke/gas.

Fig 3.2: Gas sensor.

3.3.3 TEMPERATURE AND HUMIDITY SENSOR

Plants are evolved to be temperature and humidity sensitive just like humans or any other living begins. We prepare our self for upcoming winter or summer or rainy seasons so that we can stay comfortable. Similarly, plants do prepare themselves for upcoming seasons either to adapt them for the worst or to flourish with fruits and flowers, shown in fig-2.3.

So, temperature and humidity are important factors in deciding when crops and fruits will get ready to cultivate or begin to produce. This parameter is measured by a digital sensor called DHT11 [11] which can measure both temperature and humidity.

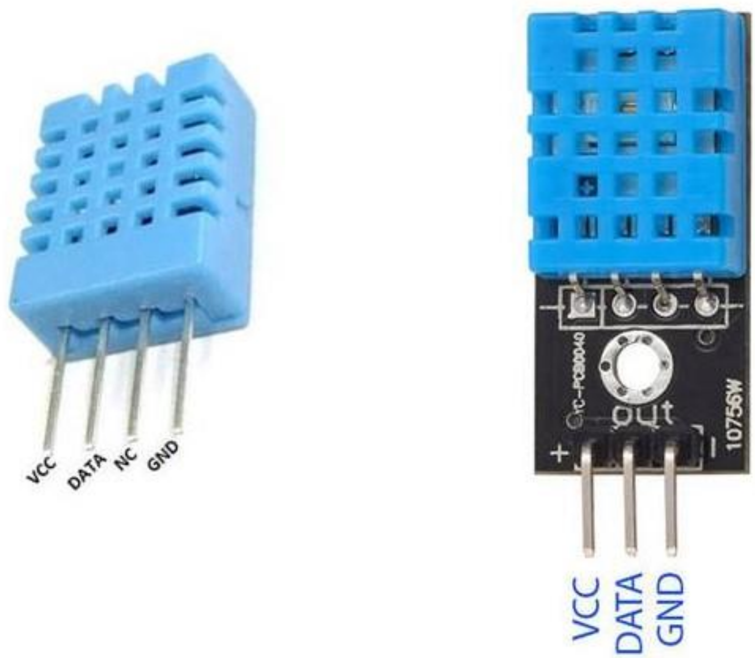


Fig 3.3: Humidity sensor.

3.3.4 CAPACITOR

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance.

While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit. The capacitor was originally known as a condenser or condensate.

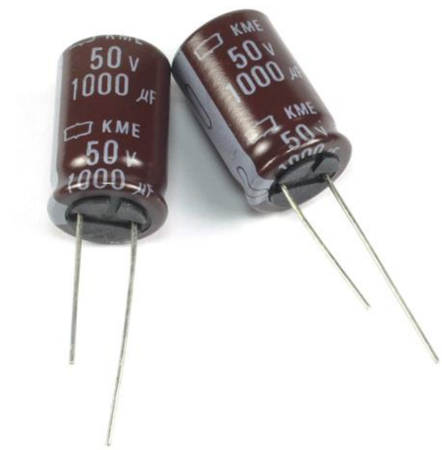


Fig 3.4.1: Capacitor 1000uF/50v

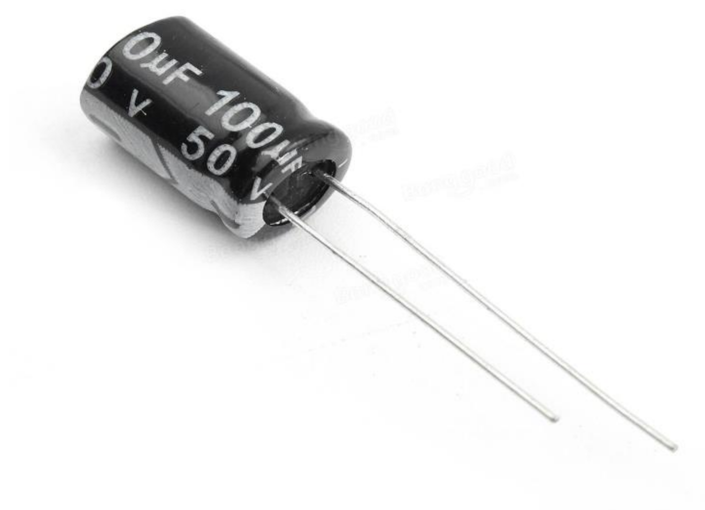


Fig 3.4.2: Capacitor 100uF/50v

3.3.5 PRINTED CIRCUIT BOARD (PCB)

A printed circuit board (PCB) mechanically supports and electrically connects electronic or electrical components using conductive tracks, pads, and other features etched from one or more sheet layers of copper laminated onto and between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it. Printed circuit boards are used in all but the most straightforward electronic products. They are also used in some electrical products, such as passive switch boxes. Alternatives to PCBs include wire wrap and point-to-point construction, both once famous but now rarely used. PCBs require additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Specialized CAD software is available to do much of the work of layout. Mass-producing circuits with PCBs is cheaper and faster than with other wiring methods, as components are mounted and wired in one operation. Large numbers of PCBs can be fabricated at the same time, and the layout only has to be done once. PCBs can also be made manually in small quantities, with reduced benefits. PCBs can be single-sided (one copper layer), double-sided (two copper layers on both sides of one substrate layer), or multilayer (outer and inner layers of copper, alternating with layers of the substrate). Multi-layer PCBs allow for much higher component density because circuit traces on the inner layers would otherwise take up surface space between components. The rise in popularity of multilayer PCBs with more than two, and especially with more than four, copper planes was concurrent with the adoption of surface mount technology. However, multilayer PCBs make the repair, analysis, and field modification of circuits more difficult and usually impractical. Due to the lack of proper support and time we had to use ready-made type PCB known as vero board, shown in fig-5.

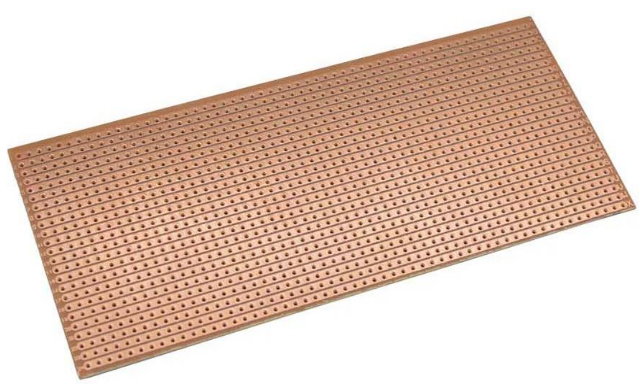


Fig 3.5: Printed Circuit Board (PCB)

3.3.6 LIQUID-CRYSTAL DISPLAY (LCD-20X4)

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

The 16×2 LCD pinout is shown below.

- Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.
- Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.
- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
- Pin15 (+ve pin of the LED): This pin is connected to +5V
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

Fig 3.6: LCD 20X4

The features of this LCD mainly include the following.

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

3.3.7 SWITCHED-MODE POWER SUPPLY (SMPS)

A switched-mode power supply (SMPS) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power when the switching device is in its non-conduction state. Switching power supplies have high efficiency and are widely used in a variety of electronic equipment, including computers and other sensitive equipment requiring stable and efficient power supply. The SMPS is mostly used where switching of voltages is not at all a problem and where efficiency of the system really matters. There are few points which are to be noted regarding SMPS. They are:

- SMPS circuit is operated by switching and hence the voltages vary continuously.
- The switching device is operated in saturation or cut off mode.
- The output voltage is controlled by the switching time of the feedback circuitry.
- Switching time is adjusted by adjusting the duty cycle.
- The efficiency of SMPS is high because, instead of dissipating excess power as heat, it continuously switches its input to control the output.

Fig 3.7: SMPS Device.

DISADVANTAGES:

- The noise is present due to high frequency switching.
- The circuit is complex.

- It produces electromagnetic interference.

ADVANTAGES:

- The efficiency is as high as 80 to 90%
- Less heat generation; less power wastage.
- Reduced harmonic feedback into the supply mains.
- The device is compact and small in size.
- The manufacturing cost is reduced.
- Provision for providing the required number of voltages.

3.3.8 FLAME SENSOR

A flame-sensor is one kind of detector which is mainly designed for detecting as well as responding to the occurrence of a fire or flame. The flame detection response can depend on its fitting. It includes an alarm system, a natural gas line, propane & a fire suppression system. This sensor is used in industrial boilers. The main function of this is to give authentication whether the boiler is properly working or not. The response of these sensors is faster as well as more accurate compare with a heat/smoke detector because of its mechanism while detecting the flame. This sensor/detector can be built with an electronic circuit using a receiver like electromagnetic radiation. This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust, water vapor, otherwise ice. The pin configuration of this sensor is shown below. It includes four pins which include the following. When this module works with a microcontroller unit then the pins are:

- Pin1 (VCC pin): Voltage supply rages from 3.3V to 5.3V
- Pin2 (GND): This is a ground pin
- Pin3 (AOUT): This is an analog output pin (MCU.IO)
- Pin4 (DOUT): This is a digital output pin (MCU.IO)

Flame-sensors are classified into four types

- IR single frequency
- IR multi-spectrum
- UV flame detectors
- UV/ IR flame detectors

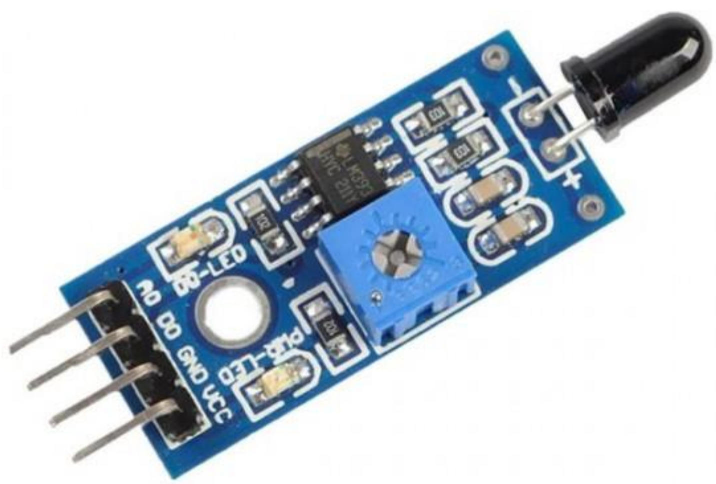


Fig 3.8: Flame Sensor.

Features & Specifications: The features of this sensor include the following.

- Photosensitivity is high
- Response time is fast
- Simple to use
- Sensitivity is adjustable
- Detection angle is 600,
- It is responsive to the flame range.
- Accuracy can be adjustable
- Operating voltage of this sensor is 3.3V to 5V
- Analog voltage o/ps and digital switch o/ps
- The PCB size is 3cm X 1.6cm

- Power indicator & digital switch o/p indicator
- If the flame intensity is lighter within 0.8m then the flame test can be activated, if the flame intensity is high, then the detection of distance will be improved.

3.3.8 PUMP

A boiler feed water pump is a specific type of pump used to pump feed water into a steam boiler. The water may be freshly supplied or returning condensate produced as a result of the condensation of the steam produced by the boiler. These pumps are normally high pressure units that take suction from a condensate return system and can be of the centrifugal pump type or positive displacement type.

Fig. 3.8: Mini pump

Product description

- Product Type: Water Pump
- Voltage: 12V DC
- Maximum Rated Current: 1.2A
- Power: 8W
- Max Flow Rate: 10 L/Min
- Made in China

Feed water pumps range in size up to many kilowatts and the electric motor is usually separated from the pump body by some form of mechanical coupling. Large industrial condensate pumps may also serve as the feed water pump. In either case, to force the water into the boiler, the pump must generate sufficient pressure to overcome the steam pressure developed by the boiler. This is usually accomplished through the use of a centrifugal pump. Another common form of feed water pump runs constantly and is provided with a minimum flow device to stop over pressuring the pump on low flows. The minimum flow usually returns to the tank.

3.3.9 FORCED DRAFT FAN

A forced draft fan (FD fan) is a fan that is used to push air into a boiler or other combustion chamber. It is located at the inlet of the boiler and creates a positive pressure in the combustion chamber, which helps to ensure that the fuel burns properly.

The working principle of a forced draft fan is based on the Bernoulli principle, which states that the pressure of a fluid decreases as its velocity increases. The fan blades rotate and impart momentum to the air, which causes the air to accelerate. This acceleration of the air creates a lower pressure at the outlet of the fan, which draws air in from the inlet.

The amount of air that is pushed into the boiler by the FD fan is determined by the fan's capacity and the pressure differential between the inlet and outlet of the fan. The fan's capacity is the amount of air that it can move per unit of time, and the pressure differential is the difference in pressure between the inlet and outlet of the fan.

The FD fan is an essential component of any boiler system. It helps to ensure that the fuel burns properly and that the boiler operates efficiently.

Fig. 3.9: Force draft fan

Here are some of the benefits of using a forced draft fan:

- Improved combustion efficiency: The FD fan helps to ensure that the fuel burns completely, which results in improved combustion efficiency.
- Reduced emissions: The FD fan helps to reduce emissions by ensuring that the fuel burns completely.
- Increased boiler capacity: The FD fan can increase the capacity of the boiler by providing more air for combustion.
- Improved safety: The FD fan helps to improve safety by preventing the buildup of flammable gases in the boiler.

Forced Draft Fan is a type of fan supplying pressurized air to a system. In the case of a Steam Boiler Assembly, this FD fan is of great importance. The Forced Draft Fan (FD Fan) plays a crucial role in supplying the necessary combustion air to the steam boiler assembly, ensuring efficient and optimal combustion processes. Its pressurized airflow promotes the complete and controlled burning of fuel, enhancing the overall performance of the system

3.4 CONCLUTION

This chapter describes the different types of equipment used in this project with their proper figure. Also discussed the literature survey of this project. Finally, we can say that from this chapter, the using equipment of this project is reliable, cheap, easily available in any place. If we want, we can add more equipment to get extra benefit.

CHAPTER-4

HARDWARE IMPLEMENTATION OF THE PROPOSED PROJECT

4.1 INTRODUCTION

This project is a combination of gas sensors, temperature sensor, flame sensor power supply etc, which have different working principles and characteristic. In this chapter, we will explain how all of this equipment work and their characteristic with diagram.

4.2 WORKING PROCESS

The proposed system uses an esp32 microcontroller get the boiler’s temperature, fire status, and surroundings gas information. These parameters can be continuously displayed on a mobile apps using IoT technology, which is a high-performance technology that integrates database recording and simulation on a single platform. The monitored parameters are compared to the rated values, and the microcontroller is programmed to take corrective action if the monitored values surpass the rated values, besides displaying the value on the app. Boiler’s temperature was detected using an DHT11 temperature sensor. microcontroller receives these values as inputs and executes the desired operation. The microcontroller will switch ON the safety system protocol according to the value of the temperature. The microcontroller is programmed to constantly scan the area and send the parameters at fixed intervals to the cloud database.

4.3 BLOCK DIAGRAM OF THE PROPOSED PROJECT

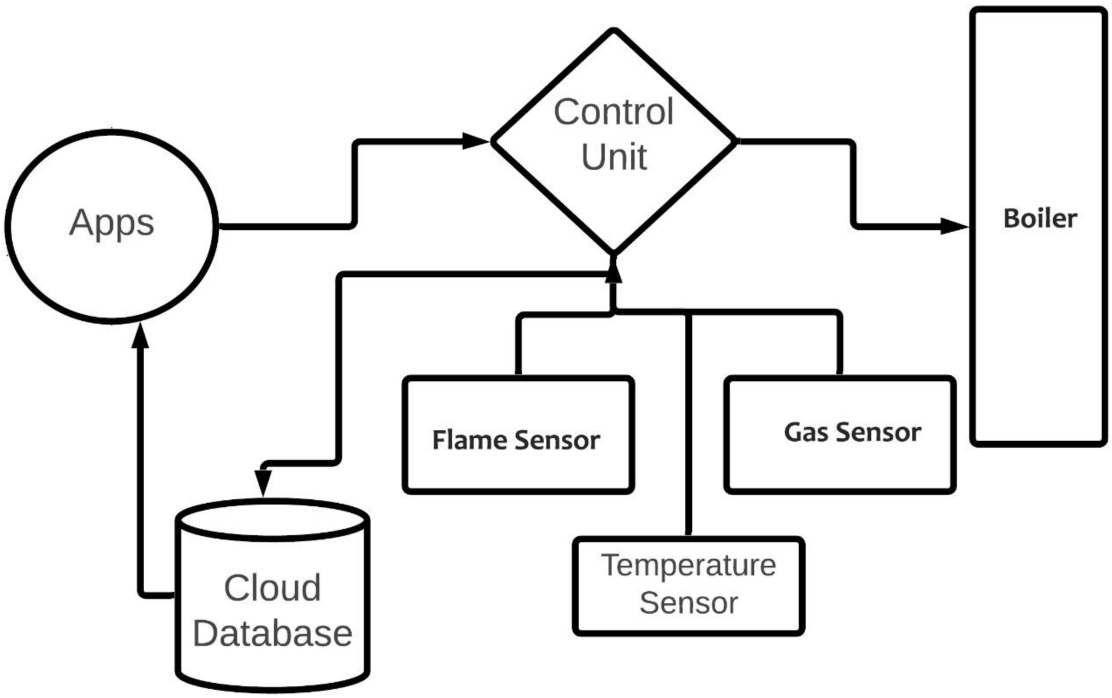


Fig 4.1: Overview block diagram of the proposed project.

4.5 FINAL VIEW OF THE PROJECT

Fig 4.2: Final Project view Font.

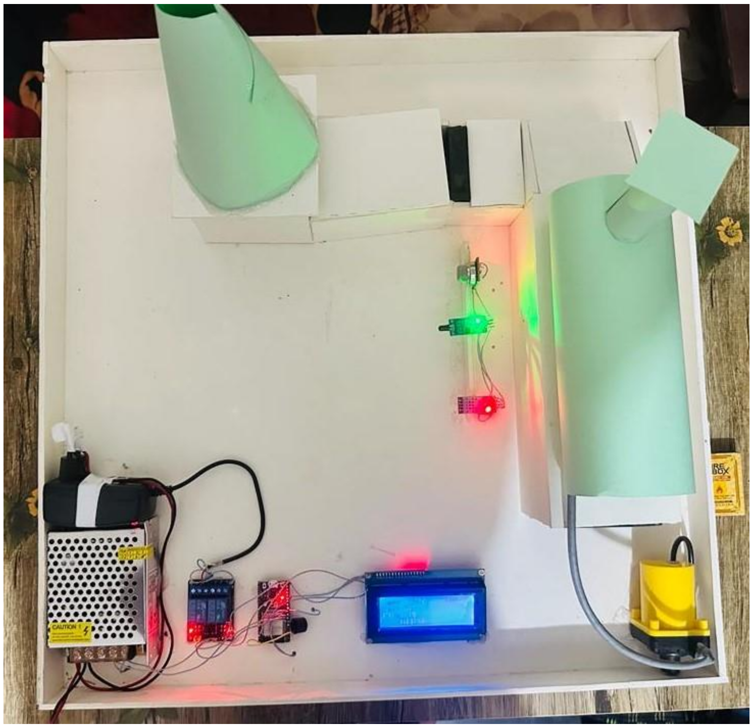


Fig 4.3: Final Project view Top.

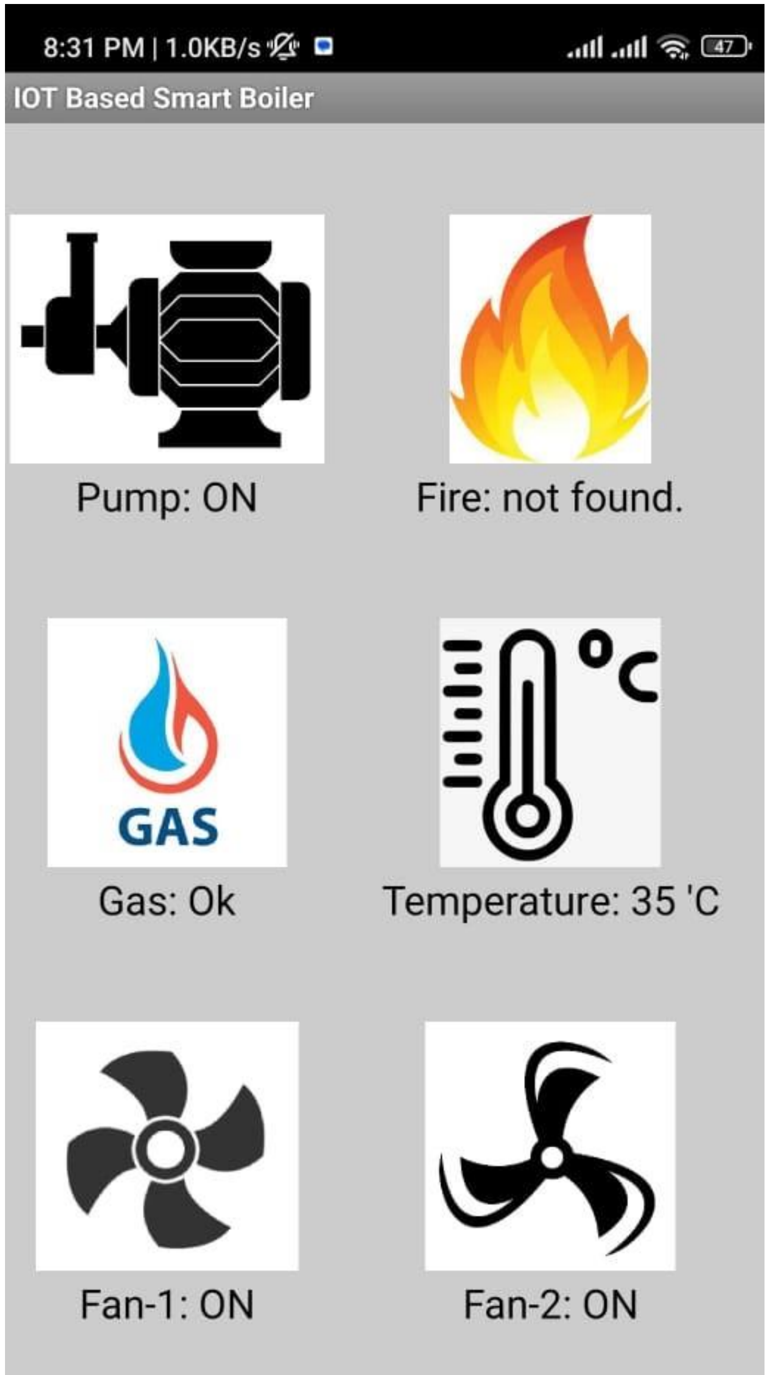


Fig 4.4: Mobile app view.

CHAPTER-5

TEST AND RESULT

5.1 IF THE TEMPERATURE AROUND THE BOILER RISES

When temperature around the boiler increases up to 35 degree Celsius then the temperature sensor start sounding the alarm.
And LED will show the reading temperature. We will also see that on our smart phone via smart boiler apps from anywhere.

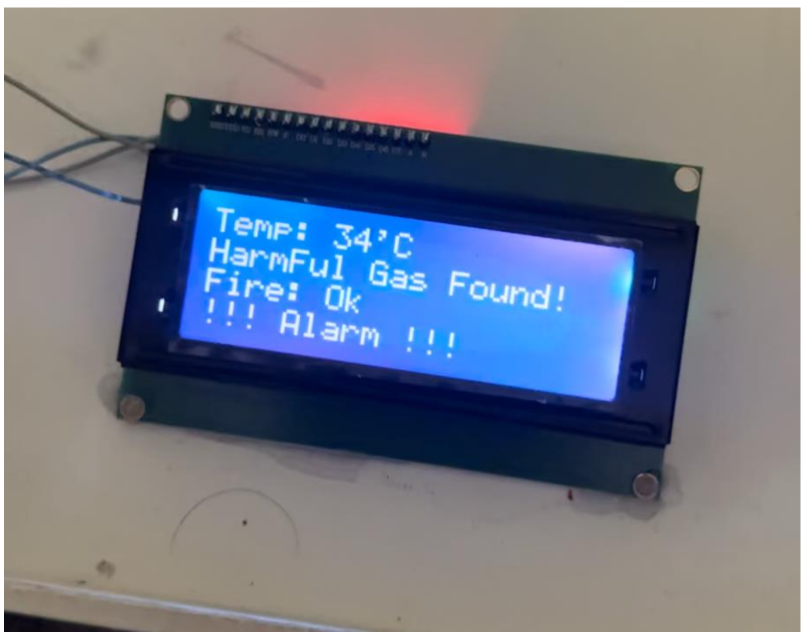
Temperature 33 degree C

Temperature 34 degree C

5.2 IF INFLAMMABLE GAS IS FOUND ARROUND THE BOILER

When inflammable gas will found around the boiler then the whole system of the boiler will stop and start sounding the alarm
And LED will show “Gas Found”. We will also see that on our smart phone via smart boiler apps from anywhere.

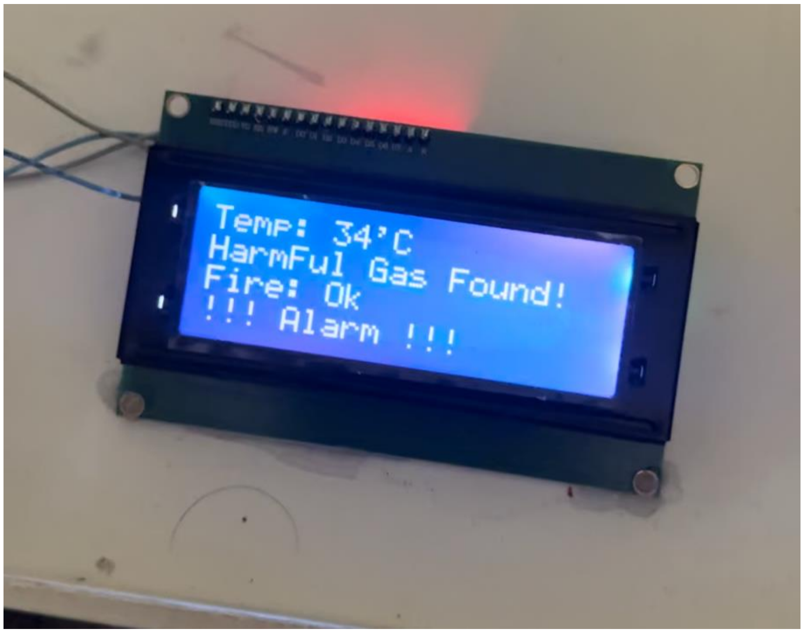
Gas is Ok



Harmful gas found

5.3 IF FIRE IS FOUND ARROUND THE BOILER

When fire will found around the boiler then the whole system of the boiler will stop with start sounding the alarm.
And LED will show “Fire Fire”. We will also see that on our smart phone via smart boiler apps from anywhere.



Fire is Ok

Fire! Fire! Fire!

CHAPTER-6

DISCUSSION AND CONCLUTION

6.1 CONCLUTION

We are successfully design a smart IOT system by which we can check temperature, inflammable gas and fire status and send information to mobile apps. Now we bring the benefit of this technology to the user's hand. We save the time of the manual monitoring. We can reduce the waste of the resource for monitoring purpose. We can also reduce the disruption of electricity.

6.2 FUTURE SCOPE

Our project can be improvised by using more hardware and networking equipment's. Long range radio frequency could be used so that the wi-fi dependency could be minimized. Besides that, internal parameter such as voltage, current reading could be added into the monitoring unit so that better understanding of the current system environment could be achieved.

6.3 DISCUSSION

Developed system is tested under various conditions. The temperature sensor test for all the conditions and results are interpreted successfully. The moisture reading at different Weather conditions is taken and updated. The wireless transmission was achieved using Wi- Fi. The data is stored in cloud server, the data is then retrieved successfully from mobile app which is used for monitoring purpose. The gas and flame sensor works well for detecting fire and sending emergency notification to the authority. Monitoring process is very important for safety of the workers and high secured operation. This system introduces a new and improved method of boiler parameter monitoring using IOT.

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APENDIX

MICRO-CONTROLLER CODING

```
#include <Arduino.h>
#if defined(ESP32)
#include <WiFi.h>
#elif defined(ESP8266)
#include <ESP8266WiFi.h>
#endif
#include <Firebase_ESP_Client.h>

//Provide the token generation process info.
#include "addons/TokenHelper.h"
//Provide the RTDB payload printing info and other helper functions.
#include "addons/RTDBHelper.h"

// Insert your network credentials
#define WIFI_SSID "DRC_WiFi"
#define WIFI_PASSWORD "%drc404#"



// Insert RTDB URLefine the RTDB URL */
#define DATABASE_URL "https://jan2023-649a3-default-rtdb.firebaseio.com/MEBoiler"

//Define Firebase Data object
FirebaseData fbdo;

FirebaseAuth auth;
FirebaseConfig config;
```

```
unsigned long sendDataPrevMillis = 0, sendDataPrevMillis2 = 0, sendDataPrevMillis3 = 0;
int count = 0, intValue, flag = 0;
bool signupOK = false;



#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Adafruit_Sensor.h>
#include <DHT.h>
#include <DHT_U.h>
#define DHTTYPE    DHT11

#define thValue 35
uint32_t delayMS;

#define Fan1 32
#define Fan2 33
#define DHTPIN 25
#define flamePin 26
#define gasPin 27
//#define buzzerPin 35
#define beep 14
#define pumpPin 15
int startCount = 0;
int flame, gas, temperature, counter = 0, gasPv = 99, flamePv = 99, tempPv = 99, flagPv, f1 = 0,
f2 = 0, f1Pv = 88, f2Pv = 88;
LiquidCrystal_I2C lcd(0x27, 20, 4);
DHT_Unified dht(DHTPIN, DHTTYPE);
void sendData();
```

```
void setup() {
  Serial.begin(115200);
  Serial.println("Starting...");
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Starting....");
  //**************************************************
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print("Connecting to Wi-Fi");
  while (WiFi.status() != WL_CONNECTED && counter < 40) {
    Serial.print(".");
    counter++;
    delay(300);
  }
  Serial.println();
  Serial.print("Connected with IP: ");
  Serial.println(WiFi.localIP());
  Serial.println();

  /* Assign the api key (required) */
  config.api_key = API_KEY;

  /* Assign the RTDB URL (required) */
  config.database_url = DATABASE_URL;

  /* Sign up */
  if (Firebase.signUp(&config, &auth, "", "")) {
    Serial.println("ok");
    signupOK = true;
  }
```

```
  else {
    Serial.printf("%s\n", config.signer.signupError.message.c_str());
  }

  /* Assign the callback function for the long running token generation task */
  config.token_status_callback = tokenStatusCallback; //see addons/TokenHelper.h

  Firebase.begin(&config, &auth);
  Firebase.reconnectWiFi(true);
  //*************************************************

  dht.begin();
  sensor_t sensor;
  dht.temperature().getSensor(&sensor);
  delayMS = sensor.min_delay / 1000;

  pinMode(flamePin, INPUT);
  pinMode(gasPin, INPUT);
//  pinMode(buzzerPin, OUTPUT);
  pinMode(pumpPin, OUTPUT);
  pinMode(Fan1, OUTPUT);
  pinMode(Fan2, OUTPUT);
  pinMode(beep, OUTPUT);

  digitalWrite(Fan1, 1);
  digitalWrite(beep, 0);
  digitalWrite(Fan2, 1);
  digitalWrite(pumpPin, 1);
  lcd.clear();
}
void runFan(int a, bool b)
```

```
{
  if (a == 1)
    digitalWrite(Fan1, !b);
  else if (a == 2)
    digitalWrite(Fan2, !b);
}
void loop() {

  flag = 0;
  //  digitalWrite(buzzerPin,1);
  //  delay(500);

//  digitalWrite(buzzerPin, 1);
  //  delay(500);
  delay(delayMS);
  sensors_event_t event;
  dht.temperature().getEvent(&event);
  if (isnan(event.temperature)) {
    Serial.println(F("Error reading temperature!"));
  }
  else {
    temperature = int(event.temperature);
  }



  gas = digitalRead(gasPin);
  flame = digitalRead(flamePin);

  Serial.println("Gas: " + String(gas));
  Serial.println("Flame: " + String(flame));
  Serial.println("temp: " + String(temperature));
```

```
if ( gas && flame)
{
  digitalWrite(beep, 0);
  //    if(startCount=0)
  //    {
  runFan(2, 1);
  f2 = 1;

  if (millis() - sendDataPrevMillis3 > 20000)
   {
    runFan(1, 1);
    f1 = 1;
    sendDataPrevMillis3 = millis();
   }
  //      startCount++;
  //    }
  //    else
  //    {
  //
  //    }
}
if ( !gas || !flame)
{

  runFan(1, 0);
  runFan(2, 0);
  f1=0;f2=0;
  sendDataPrevMillis3 = millis();
  digitalWrite(beep, 1);
}
```

```
  //  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("                ");
  lcd.setCursor(0, 0);
  lcd.print("Temp:");
  lcd.setCursor(6, 0);
  lcd.print(String(temperature) + "'C");
  delay(300);
  lcd.setCursor(0, 1);
  lcd.print("              ");

  lcd.setCursor(0, 1);
  if (gas)
  {
    lcd.setCursor(0, 1);
    lcd.print("                   ");
    lcd.setCursor(0, 1);
    lcd.print("Gas: Ok");
  }
  else
  {
//    digitalWrite(buzzerPin, 0);
    lcd.print("HarmFul Gas Found!");
    delay(200);
  }
  lcd.setCursor(0, 2);
  if (flame)
  {
    lcd.setCursor(0, 2);
    lcd.print("                   ");
    lcd.setCursor(0, 2);
```

```
    lcd.print("Fire: Ok");
  }
  else
  {
//    digitalWrite(buzzerPin, 0);
    lcd.print(" Fire Fire Fire!!!");
    delay(200);
  }

  lcd.setCursor(0, 3);
  if (gas && flame && temperature <= thValue)
    lcd.print("    All OK    ");
  else
    lcd.print("!!! Alarm !!!");

//    else if (!flame)
//    {
//      lcd.clear();
//      digitalWrite(buzzerPin, 1);
//      lcd.print(" Fire Fire Fire!!!");
//      delay(100);
//    }
//    else if (!gas)
//    {
//      lcd.clear();
//      digitalWrite(buzzerPin, 1);
//      lcd.print(" HarmFul Gas Found!");
//      delay(100);
//    }

  if (temperature > thValue)
```

```
  {
    lcd.setCursor(0, 0);
    lcd.print("                ");
    lcd.setCursor(0, 0);
    lcd.print(" High Temp!!!");
    flag = 1;
//    digitalWrite(buzzerPin, 0);
    delay(300);
//    digitalWrite(buzzerPin, 1);
    delay(300);
    digitalWrite(pumpPin, 0); //on

    //    delay(500);
  }
  else
    digitalWrite(pumpPin, 1); //off

  if (Firebase.ready() && signupOK && (millis() - sendDataPrevMillis > 2000 ||
sendDataPrevMillis == 0) && (gas != gasPv || temperature != tempPv || flame != flamePv || flag
!= flagPv || f1 !=f1Pv || f2 != f2Pv))
  {
    sendDataPrevMillis = millis();
    //    if (flag != flagPv) {
    //      sendData("/BoilerSafety/motor", flag);
    //      flagPv = flag;
    //      delay(100);
    //    }

    if (f1 != f1Pv) {
      sendData("/BoilerSafety/f1", f1);
      f1Pv = f1;
```

```
  delay(100);
}

if (f2 != f2Pv) {
  sendData("/BoilerSafety/f2", f2);
  f2Pv = f2;
  delay(100);
}

if (gas != gasPv) {
  sendData("/BoilerSafety/gas", gas);
  delay(100);
  gasPv = gas;
}

if (flamePv != flame)
{
  sendData("/BoilerSafety/flame", flame);
  delay(100);
  flamePv = flame;
}

if (temperature != tempPv) {
  sendData("/BoilerSafety/temp", temperature);
  tempPv = temperature;
}
Serial.println("send done");

//    delay(5000);

//    int a = getData("/test/float");
```

```
    //    Serial.println(a);
    count++;
  }
  else if (Firebase.ready() && signupOK && (millis() - sendDataPrevMillis2 > 13000 ||
sendDataPrevMillis2 == 0) )
  {
    sendDataPrevMillis2 = millis();

    sendData("/BoilerSafety/f1", f1);
    f1Pv = f1;
    delay(100);

    sendData("/BoilerSafety/f2", f2);
    f2Pv = f2;
    delay(100);



    sendData("/BoilerSafety/gas", gas);
    delay(100);
    gasPv = gas;



    sendData("/BoilerSafety/flame", flame);
    delay(100);
    flamePv = flame;



    sendData("/BoilerSafety/temp", temperature);
```

```
    tempPv = temperature;

    Serial.println("send done");

    //    delay(5000);

    //    int a = getData("/test/float");
    //    Serial.println(a);
    count++;
  }
  else if (! Firebase.ready() && !signupOK && (millis() - sendDataPrevMillis > 2000 ||
sendDataPrevMillis == 0) && (gas != gasPv || temperature != tempPv || flame != flamePv || flag
!= flagPv))
  {
    lcd.setCursor(14, 0);
    lcd.print("NE");
    delay(300);
  }



  //  delay(500);
}

void sendData(String path, int val)
{
  if (Firebase.RTDB.setInt(&fbdo, path, val)) {
    //      Serial.println("PASSED"+String(count));
  }
  else {
    Serial.println("FAILED");
    Serial.println("REASON: " + fbdo.errorReason());
```

```
  //    lcd.clear();
  lcd.setCursor(14, 0);
  lcd.print("NE");

  //    counter = 0;
  //    WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  //    Serial.print("Connecting to Wi-Fi");
  //    while (WiFi.status() != WL_CONNECTED && counter < 10) {
  //      Serial.print(".");
  //      counter++;
  //      delay(100);
  //    }
  //
  delay(200);
  return;
 }
}
```