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IIoT BASED AUTOMATED BURNER MANAGEMENT SYSTEM

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Abstract: The Internet of Things is a developing topic of social, technical and other branches. This concept is very progressive in the future of the Internet of Things which will transform the real world objects into the intelligent virtual objects. The main aim of the paper is to discuss an automatic extension to the industrial furnace. We discussed the new topic that is the development of the smart furnace by using Internet of things and optimization of that smart furnace with the help of some advance techniques and solutions. BMS is used for safe power generation in process plants. We can safely start and shut-down our burners with the help of a BMS. It includes timer, flame intensity, gas leakage detection. It brings safety to an industry process. We are planning to automate the industrial burner. By using Raspberry Pi we are planning to set a wireless communication. In this paper, we will be discussing about implementing IIoT to our industrial furnace as well developing a mobile application just to analyse our furnace measurements and readings.

Index Terms - **BMS, IIoT, PLC, gas leakage detection, mobile application, Raspberry Pi, Python, SCADA, burner, boiler, efficiency, furnace, safety.**

I. INTRODUCTION

We all know what a burner management system is. As name specifies, it is one of the most prominent method for controlling as well as monitoring an industrial furnace. An industrial furnace can be used for a variety of uses which include providing heat for any kind of industrial processes. It is primarily used when we need to attain temperatures more than 400ºC. In every furnace, basic mechanism includes mixing fuel along with oxygen or preheated air. Exhaust gases are sent out through the chimney as flue gas. There are many types of industrial furnaces based on its function, fuel type, air mixture and need of furnace.

When a burner is controlled and monitored, it is known as burner management system [1]. The major function of a BMS is to prevent explosions and implosions. It's mainly used to prevent any damage to machinery and injuries to mankind working with it. Boilers are clubbed with furnace to heat the component in it and this is known as a burner boiler. When a burner boiler is managed it is boiler BMS [19]. National fire protection association or NFPA is an organization dedicated to avoid death and injury due to industrial hazards. For a boiler BMS, we have just one NFPA standard and that is NFPA 85. The NFPA 85 boiler code allows multiple fuels firing system. While for an oven and furnace, its standard NFPA 86 [2]. The most preventive method to avoid an injury is by utilizing BMS. It is the final control element. The most common cause of boiler explosions is due to human error. BMS acts like an artificial human intelligence. In this paper, we will be discussing about implementing IIoT to our industrial furnace as well developing a mobile application just to analyze our furnace measurements and readings [3].

II. COMPONENTS

The schematic diagram of an industrial process furnace is as shown in Fig 1. Our furnace is divided to various parts such as radiant section, convection section, shield section, bridge zone, coil, burner, stack and damper.

Radiant Section

All the heat from the burner is absorbed by the fluids in the tube. For a vertical furnace, tubes are placed vertically. Basically tubes can be vertical or horizontal.

Convection Section

It is just above the radiant section. This is where the fluid will be able to recover additional heat. It is comparatively much cooler. Here, convection process happens. Tubes are also finned.

Shield Section

Tubes here aren't finned and hence called bare tubes. It is the region between the convection section and radiant section which consists of the first three rows of tube in the bottom of convection section and at the top of radiant section. It can absorb radiation from the firebox and shields the convection section tubes which are of less resistance.

Bridge Zone

The area between radiant section and convection section is known as bridge zone.

Coil

Coil absorbs heat through radiation. It is a set of tubes which are either horizontal or vertical.

Burner

For different types of furnaces we have different positions for burners. It can be side fired burners or vertical burners. A furnace is always lit by a small pilot flame. This pilot flame is responsible for developing the main flame. Pilot flame utilizes natural gas and the main gas can use both the natural gas and diesel. Once when the pilot flame lights the main flame, then the pilot flame is turned off. When using a pilot flame we can reduce the risks involved for ignition.

Stack

Stack basically works as a chimney and this is the cylindrical structure of the top of all heating chambers. Stack is necessary to send out all the flue gasses to the atmosphere so that it will not affect any individuals by accidently healing it up. A damper is always attached to a stack.

Damper

The working principle behind a damper is that of a butterfly valve. It is necessary to pull out the flue gas in a furnace. It regulates the pressure difference between the airs. A damper is also very important to control the amount of heat lost through the stack. When the damper closes the amount of heat send out through the stack reduces.

The fluid goes in through the convection section flows through tubes and then goes out in the radiant section. Air and fuel is given at the bottom and it mixes in the burner and gives flames. This heats the fluid in the tubes. Flue gases are ejected with the help of stack and damper system.

Flue gases are harmful to be inhaled by human beings. It has to be treated before being sent to the surroundings. It may cause air pollution and lead to various global issues like global warming. It is the gradual increase in the earth's global temperature. Flue gases have to be treated before discharge.

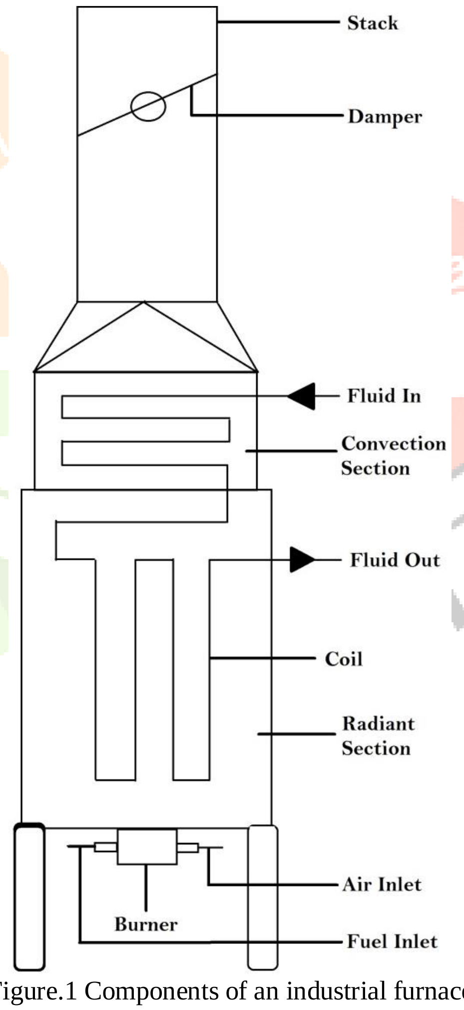

Figure.1 Components of an industrial furnace

III. OVERVIEW

Overview of plant is as shown in Fig. 2. Fuel comes from the fuel storage tank. Air comes from the blower. Fuel is burnt with air inside the burner. The pilot flame is lit. This starts the main flame. It heats up the tubes inside the radiant section and this is where the combustion takes place. Here, heat transfer is by the process of radiation. The fluid is always sent through the tubes [18]. With the help of burner, it can attain the desired temperature. The flue gases from the combustion processes moves to the convection section where heat can be recovered. After this the flue gases exit the furnace through this stack damper mechanism.

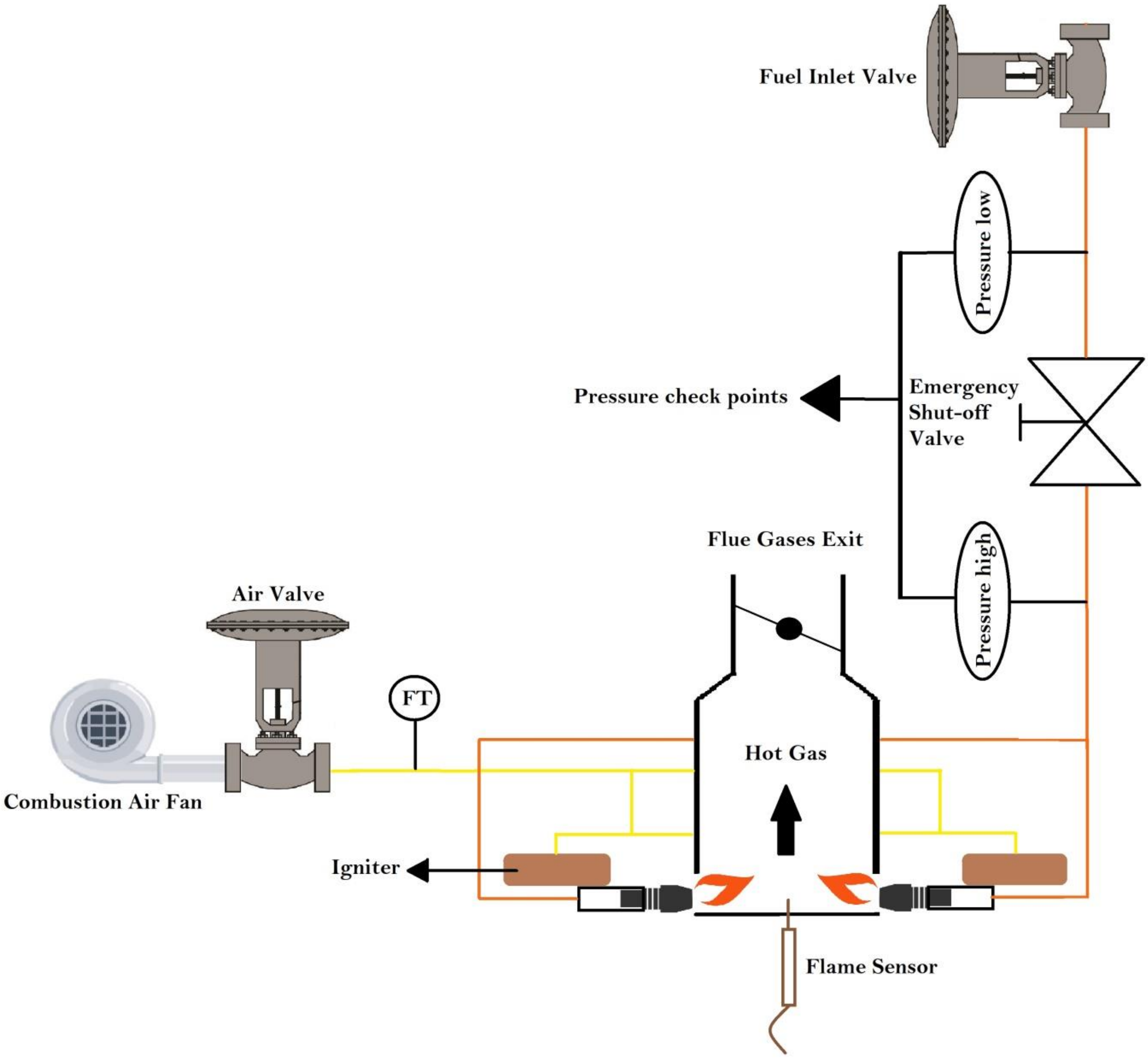

Figure 2. Burner Management System Working

IV. Model Description

As discussed earlier, we know BMS is the final control element with regard to safety. In addition to existing mechanism we are adding an extra support element. As explained earlier, these are the present day models. To this we are adding a few specifications to improve safety and analyze the plant more. Consider Fig. 2 in detail. Our furnace is now utilizing IIoT and SCADA [14]. Basically IIoT is used to analyze the furnace at any point of time from any place. For security reasons we will only give access to only authorized personals to analyze the data.

IIoT are implemented in this system using Raspberry pi. Raspberry pi is also connected to the PLC. The control adjustments are done using the PLC. The flow control to the furnace is adjusted using a servomotor which is in turn control by messages from the main control room. IOT are implemented in this system using Raspberry pi. Raspberry pi is also connected to the PLC. The control adjustments are done using the PLC. The flow control to the furnace is adjusted using a servomotor which is in turn control by messages from the main control room. SCADA is used for the supervisory control of the entire process and for storing data. SCADA [6] has an operator interface which allows monitoring and giving commands to any controllers. Sensors and actuators are all connected to these platforms.

Raspberry Pi is the IIoT [8] platform for implementing our project. We use raspberry pi to analyze the current status of our process in our mobile phone. Only analyzing is possible with this. We can't control the process using IIoT [5]. If that is made possible, it will lead to many security and safety issues.

The control of the flow valves are done by PLC or SCADA [7]. A solenoid valve is used for the same. The temperature and flow of gas are all monitored. This information or data is shared using Raspberry Pi to a mobile application of personnel who is in charge of main control room. In case of any deviation from standard values, application alerts him or her. This can help in reducing unexpected accidents or injuries.

Major components involved in our new model are supervision computers, remote units, PLC, communication networks, human machine interface, Raspberry Pi, mobile application, internet access. Supervision computers are the core of our project. It is responsible for collection of data and sending information to devices in the field [16]. Remote units are all connected to sensors and actuators remotely and to the supervisory computer system. Programmable logic controllers are familiar to us. All the remote units and PLCs are connected using communication interfacing networks. Our operating system is known as human machine interface. It helps us view plant process data to the personnel working on it [15]. Graphical representation and diagrams are used to represent the system. Alarms, interlocks, measurements, set points are all presented in this screen. Human machine interface is directly linked to the supervisory computer and process. It provides us with the live values from the plant. Detailed analysis of the plant will be made by comparing other valves and any sort of deviations from the set point or preset values or reference values. Diagrams in SCADA are basically mimic diagrams. Mimic diagrams comprises of line graphics, symbols or digital images of process equipment. HMI assists operators in issuing control commands. Any external peripherals like mouse, keyboards or touch screens can be used to send these messages.

Our next important possibility with SCADA is alarm management. System continuously checks if all conditions are satisfied. If faulty conditions arise, an alarm is sent out. Different types of alarms are present. If any conditions are alarmed, proper monitoring and evaluation are to be done to rectify the situation [17]. Raspberry Pi is connected to the entire process and gives an analysis option to the operators.

The process flow diagram is shown in Fig. 3.

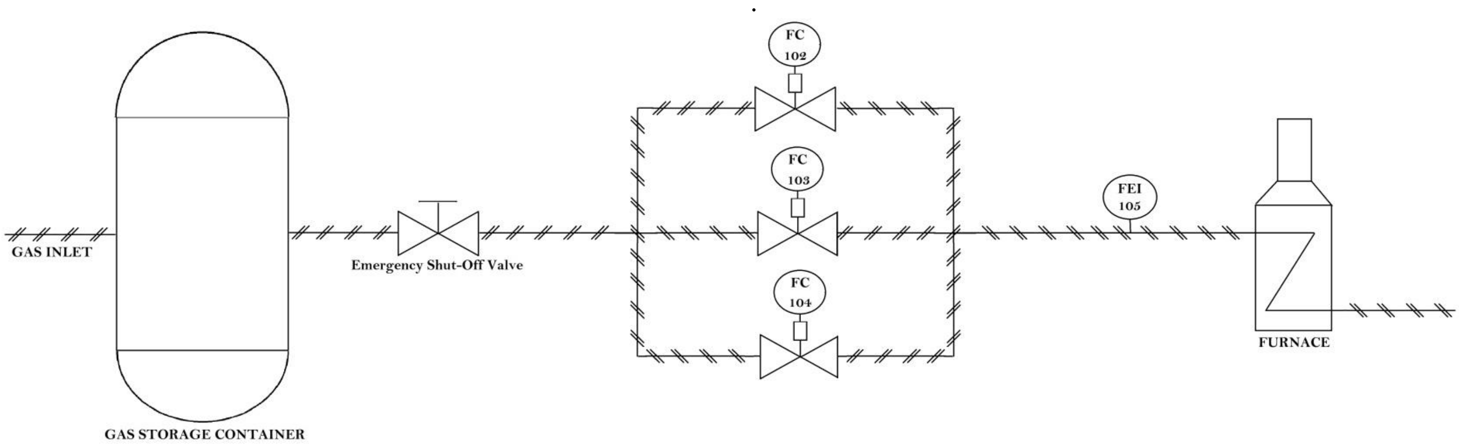

Figure 3. Process Flow Diagram

V. PROTOTYPE AND SIMULATION

To develop a basic prototype, we have developed a prototype as in Fig. 4. We have utilized a gas storage tank. It is connected to various other parts with the help of pipe with extremely large diameter and strong material to withstand the high pressure. From there, we have emergency shut-off valve like in Fig. 5, to stop the gas flow to the next section of the prototype in case of any variation in pressure due to leak. Our gas stove will work as a burner. We have three solenoid valves of 24 V DC with 2.5 mm orifice like in Fig. 6 which are controlled using PLC [11] like in Fig. 6. Flow of gas is regulated using these valves. The burner is lit when the ignition is given as in Fig 7 [4]. The temperature, pressure and flame are all monitored. The information and data was sent to a mobile application using IIoT.

We have done a basic PLC programming and we have included it as Fig. 8 [10]. The first PLC [9] program is to start and manual an emergency shutdown. Up next, we have developed a program to detect any gas leakages. Our solenoid valves are used to regulate the flow and its programs are also specified.

We have developed basic python programs to on or off our solenoid valve. A TIP120 can handle very large current [20]. When Raspberry Pi sends signal from the GPIO pin to transistor, it will allow current pass through solenoid. When solenoid is connected to GPIO pin 4, the python script is as follows:

```
import RPi.GPIO as GPIO
import time
GPIO.setmode (GPIO.BCM)
GPIO.setup (4, GPIO.OUT)
GPIO.output (4, GPIO.HIGH)

time.sleep (2)
GPIO.output (4, GPIO.LOW)
time.sleep (2)
GPIO.cleanup ()
```

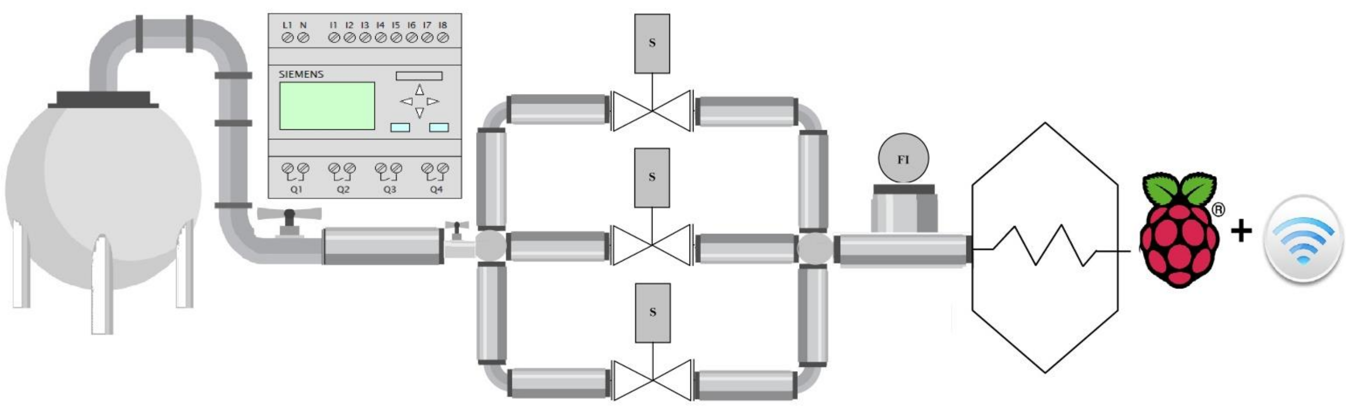

Figure 4. Prototype

Figure 5. Emergency shut-off gas valve

Figure 6. Solenoid Valve

Figure 7. Gas Burner

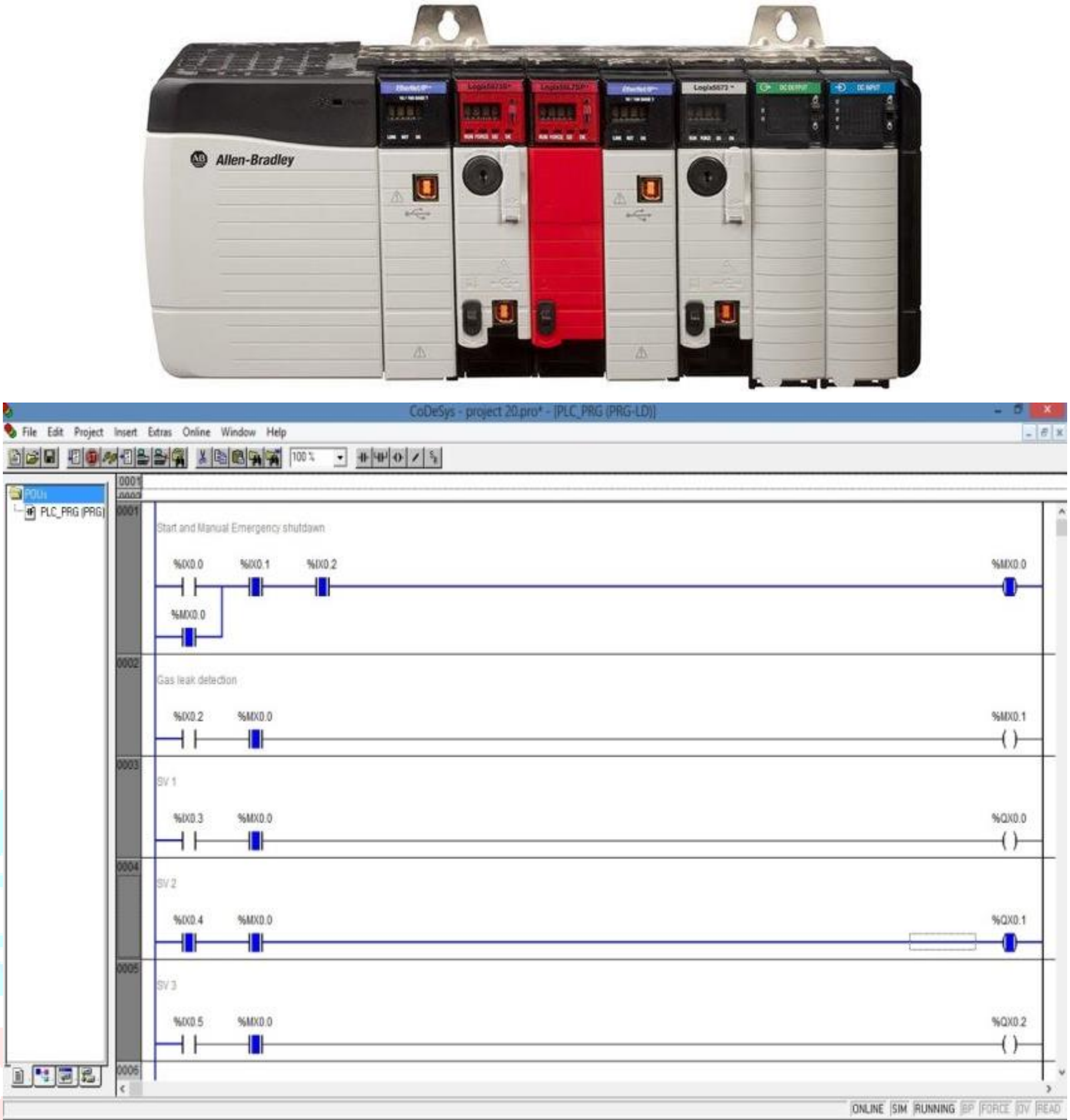

Figure 8. PLC

VI. Acknowledgment

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VII. Conclusion

The global market for industrial furnaces, highly fragmented and exceptionally diverse, is currently advancing at a rapid pace in the face of global economic development combined with regional manufacturing trends and the influence of transitional technologies and systems. With a high rate of innovation and customization, the global industrial furnace industry is characterized by a wide array of niche markets that provide custom and semi-custom-tailored furnace solutions, along with a segment of increasingly standardized production-level and packaged type furnace systems. Herein, key regional and national technology-level and application-oriented opportunities for development will drive strong growth in the industrial furnace market through 2023. Several key factors are influencing industrial furnace markets on usage of furnaces. It is mandatory for many sectors in the industry. Various scopes include utilizing a robotic technology that can assist and aid humans.

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