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IOT APPLICATION IN MONITORING AND CONTROL OF INDUSTRIAL BOILER

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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. Boiler parameters are monitored by using sensors. Temperature, humidity, water level and gas are the parameters to be monitored and monitored values are visualized through think speak by using Internet of Things.

Currently, boiler parameters like pressure, temperature, gas leakage, humidity, water level are monitored and controlled manually in many industry at high risk which is difficult in everyday life owing to adverse industrial disasters. As a result of which, several boiler explosions/blasts are reported even till today. Thus, continuous monitoring of these boiler parameters plays an important role.

The suggested prototype will fit this notion and give a start-up initiation to automate the monitoring systems in several boiler sectors. Water level, Ultrasonic, Temperature, Humidity sensors along with MCU ESP8266 are used to implement the prototype. The designed prototype finds applications in many boiler industries where human intervention can be replaced to save many lives.

Keywords: *Automation, boiler, Internet of Things, thermal power plant, temperature sensor, gas sensor, Node MCU*

I. INTRODUCTION
Over the last few decades, the field of industrial automation has expanded rapidly by replacing humans by machines. The thermal power plant is one such industry that needs regular inspection and monitoring. Any rapid unfavorable changes at the power plant's should be reported immediately to the central controlling unit, which shall act immediately and take situation into control. Data's are securely used to monitor the parameters of the boiler and analyze the critical issues like boiler blast in many industries.

Role of Internet of Things in Information Technology plays an important role in monitoring and control of parameters in any automation systems. Thermal power plants is one such industry where approximately 65% of the world's power is generated. The efficiency of the thermal plants, their control strategies, different hierarchical levels have taken a new face off due to present automation and IOT. Maintenance operation through sharing of data and safe remote monitoring system makes the system to be fully efficient.

II.LITERATURE SURVEY
The BMS (Boiler Monitoring and Control System) in boiler industry uses a variety of methods and technology to keep track of the operations. Navneet Kumar Verma (Verma et al. 2018) simulated and automated a boiler system using sensors and IOT that collected data from the thermal power plant using modeling, pattern finding, as well as data mining approaches. Marek Moleda implemented a model utilizing IoT, big data, and cloud computing to identify any deviation or malfunction in boiler feed pumps from normal operations (Moleda et al. 2020) Stefano Tedesch implemented an data acquisition unit capable of self-learning while a machine tool was running. The systematic approach focused on risks that cause the monitoring system to lose data or information. This monitoring system was used as a remote-control system for various actuators in future development. This laid the foundation for the creation of a safe remote monitoring system for machine tools through IoT devices and analyses the critical issues focusing on the manufacturing environment (Tedeschi et al. 2017). Tawanda Mushiri used CBM and fuzzy logic to control and maintain the parameters of the boiler. This increased the efficiency of boiler and reduced Clinker formation (Mushiri et al. 2018). Y. Nandini Reddy proposed a method which monitors and controls boiler temperature remotely using wireless communication. This method uses Internet of Things (IoT) as the platform of communication (Reddy et al. 2017)

On the basis of smart devices, F.M. Aiysha Farzana suggested an autonomous boiler monitoring system to maintain temperature, steam, flow level, and pressure. If any abnormal values of temperature, steam, flow level, or pressure were detected by related sensors, the monitoring system transmitted alarm messages to the people through GSM (Farzana et al. 2019). K. Gowri Shankar presented an automation system for

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continuous monitoring that used SCADA and a communication wire to connect to the PLC. (Shankar, 2008) L. Navaneeth delivered a paper on employing wireless communications to remotely monitor and regulate boiler settings. (Navaneeth and Rukkumani, 2016). Joshuva Arockia Dhanraj implemented a system using CAN for information sharing and with the help of LabView for controlling the process (Dhanraj and Ramanathan, 2020). S Mythili proposed a system to monitor the boiler parameters using Think Speak and Internet of Things (Mythili and Gokulkumar, 2018). Aixia Duan, A ZigBee based online gas leakage monitoring system was implemented to monitor the boiler industry (Duan et al. 2018).

III. SUPPORTING SOFTWARE TOOLS

The Arduino IDE v1.6.1 and Embedded 'C' software's were used in our proposed Boiler Control and Monitoring System. The Node MCU ESP8266 Wi-Fi module was used for communication and programming using embedded C. The Arduino IDE is a platform-independent program. It comes with an editor and a compiler, as well as the ability to easily upload sketches to the board and the cloud. Embedded C is a programming language that is widely used in the creation of embedded systems. Compared to Assembly, BASIC, C++, Embedded C remains popular because to its efficiency, shorter development time, and portability.

IV. System hardware architecture:

The proposed prototype of a boiler monitoring and control system consists of field unit and control unit as shown in fig 1, which includes a power supply, voltage regulators, current controllers, water level, temperature, humidity, and gas sensors, as well as an Arduino UNO and Node MCU ESP8266 Wi-Fi shield.

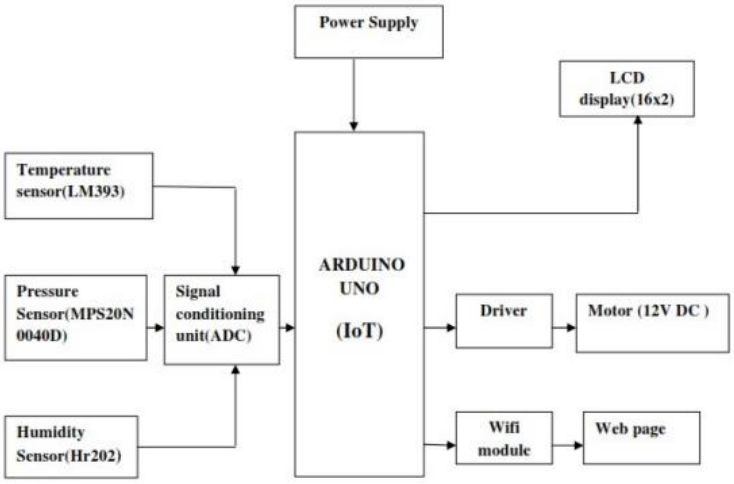

Fig. 1: Block diagram of boiler monitoring in power plant using IoT

Power Supply: The proposed model uses single phase 230v, 50Hz AC power supply.

Voltage Regulator circuit: 3 DC voltages (+5v, +5v and +12 volts) were used from Voltage regulator circuit to provide voltages for sensors, two pumps and for microcontroller as shown in fig 2.

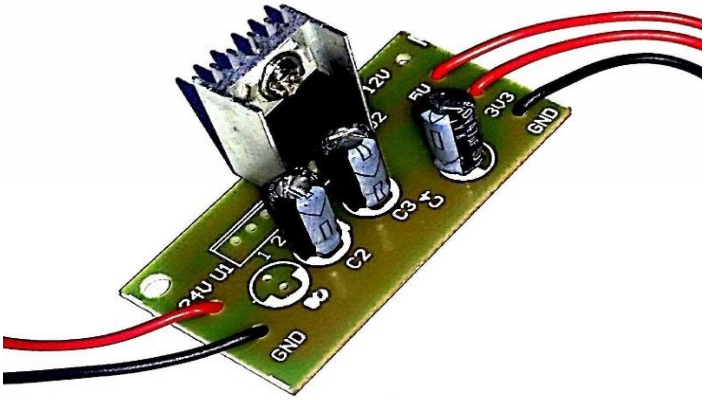

Fig. 2 : Voltage Regulator Circuit

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ARDUINO UNO

Arduino is an open-source physical computing system based on microcontroller ATmega328 that includes an IDE for creating software to run the board.

SENSORS

Ultrasonic sensor **(HC- SR 04)** determines the amount of water in the drum. A minimum and maximum threshold value is fixed so that water in the drum will be always full. LM35 Temperature Sensor was used to measure the temperature inside the boiler. DHT11 Temperature and Humidity Sensor is an digitally controlled sensor which measures the relative temperature and humidity created in the immediate vicinity of the Boiler power plant. MQ-04 gas sensors were also used to measure gas leaks around the boiler surroundings. Gases like methane, LPG, hydrogen, NH3, Benzene, and Propane can also be sensed, which may leak due to many reasons inside power plant. 5V Relay is utilized to connect the boiler, pump, and supply to regulate the current flow to various sensors to control water level. Two 5V DC micro pumps are used to continuously feed water to the boiler, while the other is used to provide cooling- when the boiler temperature goes above a particular degree. LCD Display is used to display the collected date from field unit.

Node MCU is an open-source platform based on the **ESP8266** that enables the connection of objects and the transmission of data over the Wi-Fi protocol. Microcontroller functionalities such as GPIO, PWM, ADC are used for communication.

The Blynk Application is a platform that allows us to control Arduino, Raspberry Pi, and other devices via the Internet using IOS and Android applications. It's a digital dashboard that was utilized in our project to develop a graphical interface.

V. RESULTS AND DISCUSSION.

The proposed boiler Monitoring system using Arduino UNO Microcontroller is implemented using above mentioned components and sensors which is shown in fig 3.

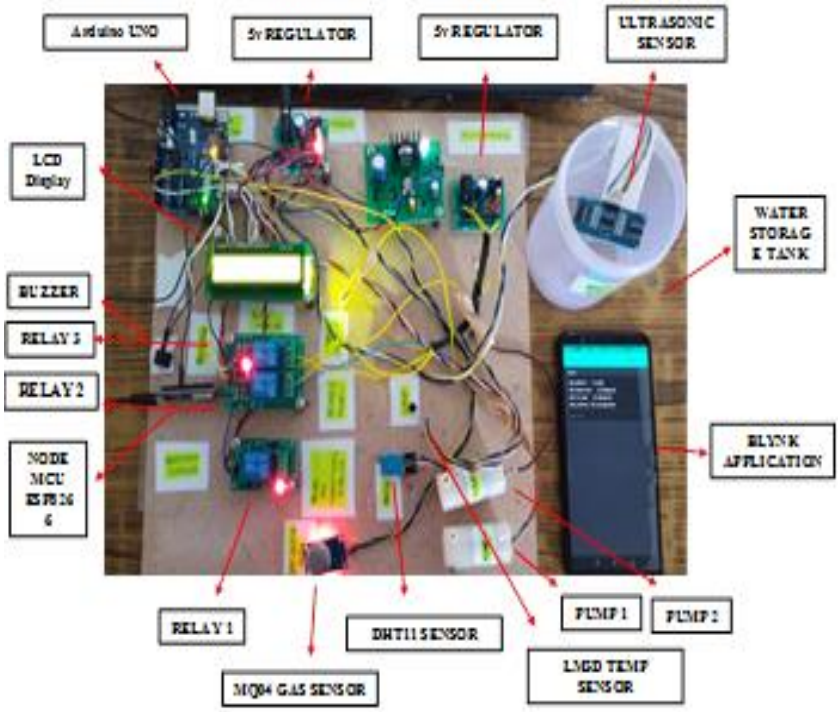

Fig. 3. Boiler Monitoring system using Arduino UNO Microcontroller

The regulator circuit reduces the voltage from 230V to +5V and +12V, respectively such that it offers an efficient input voltage supply to all of the sensors utilized in the proto type model.

Ultrasonic sensor checks for Quantity of water in the drum by comparing the water level with minimum threshold (5cm) and maximum threshold value (24 cm), so that water in the drum will be always full. The ultrasonic "**turns on**"" the pump with the help of relay 1, when the distance in the drum is less than 5cm and "**turns off**"" once the distance of the water reservoir is at most 24cm with the help of relay 2. An embedded C programme has been dumped inside the microcontroller for the same. Continuous level of the water in the

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drum is monitored and displayed in blink and LCD simultaneously as shown in fig 4 and 5 (when water is less and water is full respectively) .

Fig. 4: Output of Ultrasonic Sensor when water is less

Fig. 5: Output of Ultrasonic Sensor when water is full

LM35 Temperature sensor is placed inside the boiler to monitor the temperature of the boiler. A constant current is supplied via relay 1 to the boiler as shown in fig 6.

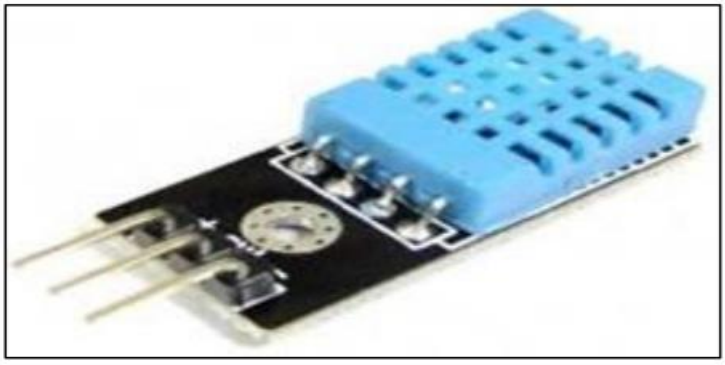

Fig. 6: Temperature Sensor

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Temperature of the boiler is constantly measured and displayed in LCD and Blynk continuously as shown in fig 7 and 8. Fig 7 represents condition when temperature of boiler (0 < boiler temperature < threshold value (40^{o}C)).

Fig. 7: Rise in temperature of the boiler is displayed both in LCD and blink app simultaneously and continuously

Fig 8 displays value of boiler temperatures greater than 40^{o}C (temperature > threshold temp).

Fig. 8: Display of Boiler temperature, when it increases beyond the Threshold value (LCD and blink app) simultaneously.

Once boiler temperature increases greater than 40^{o}C, the supply which is used to heat the boiler will be turned off using relay 1 and relay 2, which will continuously sends water to the tank. Immediately relay 3 is turned on, to supply water across the surroundings of boiler to cool the system and bring back the temperature to normal operating condition.

Relative temperature and relative humidity across the boiler environment is measured using DHT11 sensor and is as shown in fig 9. MQ-04 Gas Sensor is also used to measure the gas content in boiler surrounding gas shown in fig 10.

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Fig. 9: Relative Temperature and Humidity across the boiler power plant

Fig. 10: Output of gas sensor

A Boiler Monitoring System protype has been developed and implemented which can operate automatically without human interaction. This system constantly monitors and display data using IoT. The situation in and around boiler can be easily understood and controlled so that unfavorable conditions can be controlled easily.

CONCLUSION

An promising way to Monitor and Control BMS has been implemented using an simple prototype using sensors which shall display messages to persons in control unit if any abnormal conditions exists, which may lead to malfunctions.

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