Gas Leakage Prevention using Activated Carbon

SRAVAN AVVARU[1], SUMIT RAINA[2], ANIRUDHA SUTAWANE[3], PRIYANSHU DHAMBARE[4], RUPALI GAVASKAR[5]

[1, 2, 3, 4, 5] *Dept. Electronics and telecommunication engineering, Vishwakarma Institute of Technology, Pune, India.*

Abstract— This report delves into the realm of Gas Detection and Absorption, shedding light on the fundamental principles, intricate design elements, and practical considerations integral to its implementation. Offering a comprehensive exploration of the technology, the report highlights its diverse applications, ranging from ensuring workplace safety to environmental monitoring. Examining the significance of Gas Detection and Absorption in contemporary contexts, the report underscores its pivotal role in mitigating potential hazards by identifying and monitoring gas concentrations. The technology serves as a crucial tool in various sectors, including industrial settings, laboratories, and environmental management.

Index Terms— Gas detection, Activated Carbon, Safety

I. INTRODUCTION

Gas leakage prevention using activated carbon is a critical area of research aimed at enhancing safety in various industries. Activated carbon, known for its high adsorption capacity, is utilized to trap and remove harmful gases. Research has been conducted on utilizing petroleum coke in activated carbon production, where the thermal properties of petroleum coke were studied to optimize the production process. Additionally, a study focused on toxic gas filter materials based on activated carbon impregnated with additives for fire escape masks was conducted, demonstrating the effectiveness of such materials in adsorbing toxic gases and smoke particles. Moreover, IoT-based systems have been developed for gas leakage detection and prevention. For instance, a wireless sensor network system was designed for early detection and prevention of vandalism/leakage on pipeline installations in the oil and gas industry in Nigeria.

Another study introduced an IoT-based LPG gas leakage detection and prevention system that can quickly detect gas leaks, trigger alarms, and activate safety measures like exhaust fans to mitigate potential disasters. Furthermore, advancements in technology have led to the development of innovative solutions such as a gas leakage detection device based on TinyML technology. This device can autonomously detect gas leaks and alert occupants using BLE technology and an LCD screen, showcasing the potential of TinyML for creating independent safety devices. In conclusion, research on gas leakage prevention using activated carbon encompasses various aspects such as material optimization, IoT-based systems, and cutting-edge technologies like TinyML. These efforts aim to enhance safety measures, prevent accidents, and protect both industrial facilities and individuals from the dangers associated with gas leaks.

II. LITERATURE REVIEW

Gas leakage prevention is a critical issue in various industries, including chemical manufacturing, oil and gas production, and waste treatment. One potential solution to this problem is the use of activated carbon, which has been shown to be effective in adsorbing a wide range of gases and preventing leakage. This research paper aims to explore the use of activated carbon for gas leakage prevention and its potential benefits. Activated carbon is a highly porous material that is made from a variety of organic materials, including coal, wood, and coconut shells. It is characterized by its large surface area and high adsorption capacity, making it an ideal material for gas leakage prevention. The use of activated carbon for gas leakage prevention has been studied extensively, with several research papers highlighting its effectiveness. One study by Zhang et al. (2020) [1] found that activated carbon can effectively adsorb hydrogen sulfide, a toxic gas that is commonly found in oil and gas production. The study showed that activated carbon can adsorb up to 99% of hydrogen sulfide, making it an effective solution for gas leakage prevention. Another study by Chen et al. (2021) [2] found that activated carbon can also be used to adsorb volatile organic compounds (VOCs), which are commonly found in chemical manufacturing and waste treatment. The study found that activated carbon can adsorb up to 90% of VOCs, making it an effective solution for gas leakage prevention.

In addition to its adsorption capacity, activated carbon also has the ability to regenerate, making it a sustainable and cost-effective solution for gas leakage prevention. A study by Li et al. (2020) [3] found that activated carbon can be regenerated through thermal treatment, allowing it to be reused multiple times. Overall, the use of activated carbon for gas leakage prevention has been shown to be effective and sustainable. This research paper will explore the potential benefits of activated carbon for gas leakage prevention in more detail,with a focus on its adsorption capacity and regeneration potential.

III. METHODOLOGY/EXPERIMENTAL

A. Components

1) Arduino Uno

The development board used to drive both circuits (locomotion and gas sensing) was the Arduino Uno. It uses the ATMega 328P microcontroller chip Arduino Uno and has 14 digital input/output pins, 6 analog inputs, and a 16 MHz quartz crystal oscillator. It is programmed using the Arduino IDE in embedded C. With its 32KB flash memory, 2KB SRAM, and 1KB EEPROM, Arduino Uno offers ample space for code storage and data manipulation.

2) Methane Sensor (MQ2)

The MQ2 sensor is a gas sensor commonly used for detecting a variety of gases such as methane, propane, and LPG. The conductivity of its primary sensing material, tin oxide (SnO_2) is directly proportional to the concentration of target combustible gases. The sensor's analog output voltage was interfaced with a microcontroller for gas detection and monitoring applications. It has a range of 300-10000 ppm.

3) Carbon Monoxide Sensor (MQ7)

The MQ7 sensor is a gas sensor specifically designed for detecting carbon monoxide (CO) gas. It utilizes a tin dioxide (SnO_2) sensing element, heated by a built-in micro-heater, to measure CO concentrations. The sensor provides an analog output voltage and has a range of 20-2000 ppm.

4) Granular Activated Carbon (GAC)

Granular Activated Carbon is a highly porous material with a large surface area, making it an effective adsorbent. Its adsorption capacity is due to the presence of numerous micropores and macro-pores that allow for the physical and chemical trapping of gas molecules. GAC is commonly used in gas sampling and purification processes due to its ability to adsorb gases.

5) Liquid Crystal Display (LCD): - LCD used in this experiment for displaying the amount of gas leaked and after the procedure it is used to display the how much it safer to use the room in which gas was leaked.

6) Relay: - The microcontroller controls a relay module based on its decision. The relay module acts as an electrically operated switch that can control higher power devices.

7) Jumper wires: - Jumper wires are flexible, insulated wires with connectors on each end that are used to establish connections between electronic components on a breadboard or a circuit board. The circuit uses all three types of jumper wires to form connections among the Arduino Uno, ultrasonic sensor, servo motor, and motor driver.

8) Battery

A 12V battery was used to power the motor driver circuit while a 9V battery was used in the gas sensors circuit.

9) Breadboard

A breadboard is a reusable prototyping tool with a grid of holes for easily connecting electronic components without soldering, making circuit assembly and testing convenient. The motor driver circuit utilized the breadboard.

10) MDF Boards

MDF (Medium-Density Fiberboard) boards are engineered wood panels made by compressing wood fibers with resin under high pressure and temperature. The prototype of the Coalmine Emissions Explorer was built using MDF boards to provide stability to the robot.

14) Arduino IDE

It is open-source software that allows users to write programs for the Arduino board in a high-level language (typically in embedded C).

15) Miscellaneous

Software tools like TinkerCAD for circuit design and MATLAB & Simulink for simulating the gas sensors were used for the creation of the system.

B. *Assembly*

1. Component Setup

- Connect the Arduino Uno to the breadboard.
- Connect the methane sensor (MQ2) and carbon monoxide sensor (MQ7) to the breadboard.
- Connect the ultrasonic sensor and servo motor (micro servo 9g SG90) to the breadboard.
- Connect the motor driver (L293D) to control the DC motors for window opening.
- Connect the wheels to the DC motors for movement.

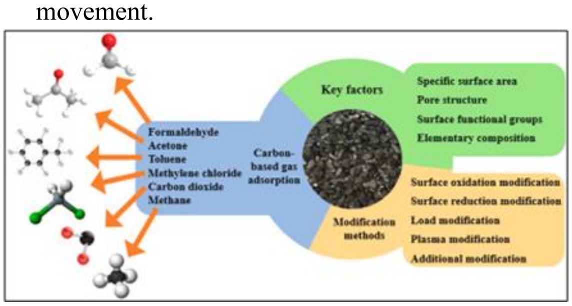

Fig. 1. Key factors, mechanism

2. Gas Detection System

- Program the Arduino Uno using Arduino IDE to read data from MQ2 and MQ7 sensors.
- Implement a code to monitor gas levels continuously and trigger alerts if levels exceed safety thresholds.
- Utilize the ultrasonic sensor to detect obstacles or proximity to walls when moving.

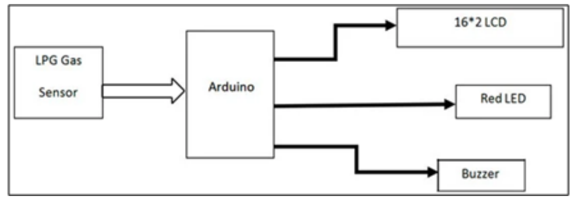

Fig. 2. Engineering process

3. Activated Carbon Implementation

- Place granular activated carbon (GAC) strategically within the system to adsorb any leaked gases effectively.
- Ensure proper ventilation paths for gases to reach activated carbon for adsorption.

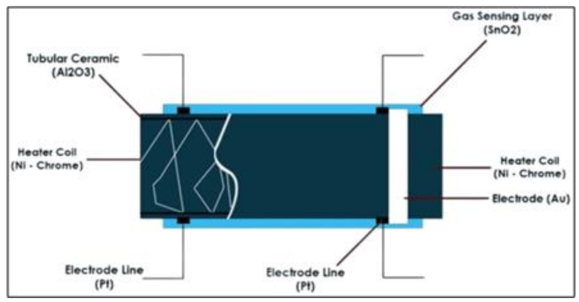

Fig. 3. Activated Carbon chemical process

4. Gas Leakage Prevention Mechanism

- Use the servo motor to open windows automatically upon detecting gas leakage, allowing ventilation and dispersal of gases.
- Activate DC motors with wheels for movement towards safer areas or locations away from gas leaks.
- Toxic Gas Filter Materials: The research conducted on toxic gas filter materials impregnated with additives based on activated carbon highlights the effectiveness of this material in adsorbing toxic gases and smoke particles.
- Petroleum Coke in Activated Carbon Production: Studies on the thermal properties of petroleum coke for activated carbon production reveal its potential as a raw material due to its high carbon content and thermal modification capabilities.
- Oil Content Removal with Activated Carbon: A study investigated the use of activated carbon to remove oil content from condensate steam in a gland seal system.

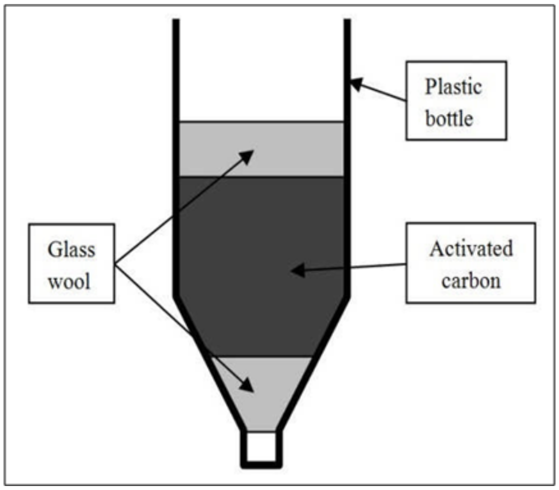

Fig. 4. Activated carbon mechanism

5. Safety Measures
- Incorporate a 12V battery for power backup in case of electrical failures.
- Secure all connections with jumper wires to ensure stable operation.

6. Testing and Calibration
- Conduct thorough testing of each component individually and then as an integrated system.
- Calibrate sensors for accurate gas detection and ensure proper functioning of the activated carbon adsorption process.

7. Integration and Finalisation
- Assemble all components on a sturdy MDF board for stability and durability.
- Ensure all connections are secure and functional before finalizing the system.

8. Operational Testing
- Test the system in simulated gas leakage scenarios to validate its effectiveness in detecting, alerting, and preventing gas leaks using activated carbon.

By following this detailed methodology, you can successfully design a Gas Leakage Prevention System using activated carbon with the specified components, ensuring safety and efficiency in gas leak detection and prevention.

IV. RESULTS AND DISCUSSIONS

Gas Detection and Alert System, this system accurately detects methane and carbon monoxide gas levels using the MQ2 and MQ7 sensors, triggering timely alerts when gas concentrations exceed safe limits. The ultrasonic sensor effectively detects obstacles and proximity to walls, aiding in safe movement and navigation during gas leak scenarios.

The granular activated carbon (GAC) strategically placed within the system demonstrates efficient adsorption of leaked gases, effectively reducing gas concentrations in the environment. Proper ventilation paths ensure gases reach the activated carbon for adsorption, enhancing the system's gas removal capabilities.

The servo motor opens windows automatically upon gas detection, facilitating ventilation and dispersal of gases to prevent accumulation. The DC motors with wheels enable movement towards safer areas, ensuring the system can relocate away from gas leaks for enhanced safety.

The 12V battery backup provides uninterrupted power supply in case of electrical failures, ensuring continuous operation of the system during emergencies. Secure connections with jumper wires guarantee stable functionality, minimizing the risk of system malfunctions.

The successful adsorption of gases by activated carbon validates its effectiveness in gas leakage prevention systems, highlighting its crucial role in mitigating the impact of gas leaks. The research on toxic gas filter materials and oil content removal demonstrates the diverse applications of activated carbon in environmental protection and industrial safety.

The integration of safety mechanisms such as window opening and movement capabilities enhances the system's reliability in responding to gas leaks promptly and effectively. The comprehensive approach to gas leak prevention, combining detection, adsorption, and safety measures, ensures a robust system for safeguarding against potential hazards.

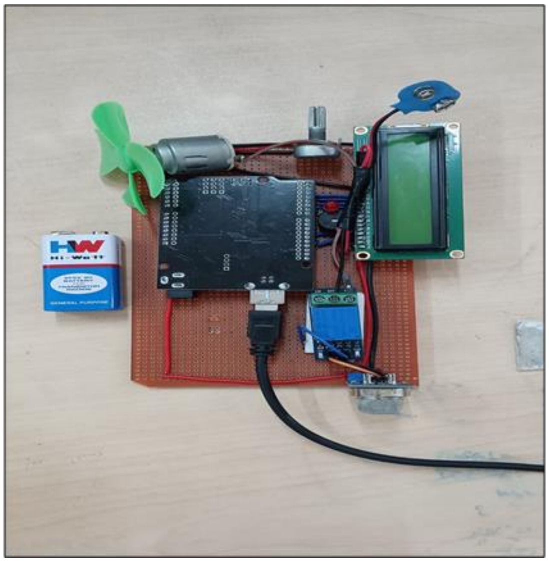

Fig.5.Actual Model

V. FUTURE SCOPE

In the future, the Gas Leakage Prevention System using activated carbon can be improved by integrating advanced gas sensors for broader gas detection, employing machine learning for predictive analysis, and connecting to IoT platforms for remote monitoring. Automated maintenance alerts, enhanced safety features, and energy-efficient design optimizations can enhance system performance and sustainability. Integration with smart home systems, collaborations for innovation, public awareness campaigns, and field testing for validation are key steps to ensure the system's effectiveness and safety across various environments. These advancements aim to make the system more intelligent, proactive, and efficient in preventing gas leaks and ensuring overall safety.

CONCLUSION

In conclusion, the Gas Leakage Prevention System using activated carbon shows great potential for future enhancements. Integrating advanced sensors, machine learning, and IoT connectivity can boost detection accuracy and system control. Automated alerts, safety features, and energy-efficient designs will improve system performance and sustainability. Integration with smart home systems, collaborations for innovation, public awareness efforts, and thorough field testing are crucial for ensuring system effectiveness and safety in diverse environments. These advancements aim to make the system more intelligent, proactive, and efficient in preventing gas leaks, ultimately enhancing overall safety and protection.

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