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A Study on Advance CNG Station with Web Based Monitoring Technology and Leak Detection System

Dighe Tejaswini Jijabhau, Dhakane Aditi Subhash, Bhaskar Harshada Sunil, Prof. A. A. Pathare
Department of Electrical Engineering
Amrutvahini College of Engineering, Sangamner, A.Nagar, India
dighetejaswini4@gmail.com, aditidhakane1035@gmail.com
bhaskarharshada10@gmail.com, akshay.pathare@avcoe.org

Abstract: *This paper introduces an advanced Production Control System designed for efficient management and enhanced safety in Compressed Natural Gas (CNG) fuel stations through real-time, web-based monitoring and comprehensive leak detection. The system enables operators to monitor operational status and identify potential hazards swiftly, ensuring immediate response to leaks and improving overall safety. Additionally, features such as vehicle queue detection and real-time CNG availability monitoring streamline service delivery, reduce wait times, and improve customer satisfaction. By integrating modern sensor technology with cloud-based data analysis, this system offers a robust solution that optimizes station management, aligning with the growing demand for reliable and efficient CNG infrastructure..*

Keywords: CNG fuel station, web-based monitoring, leak detection, real-time queue management, operational efficiency.

I. INTRODUCTION

The increasing global demand for cleaner and more sustainable energy sources has positioned Compressed Natural Gas (CNG) as a viable alternative to traditional fuels. CNG is celebrated for its lower carbon emissions and reduced environmental impact, making it an attractive choice for transportation and energy generation. However, as the adoption of CNG expands, the operational efficiency and safety of CNG fuel stations become critical factors that require innovative solutions. The development of an advanced Production Control System for CNG stations aims to address these challenges by implementing modern monitoring technologies and safety mechanisms.

This system leverages web-based monitoring to provide real-time insights into the operational status of CNG stations. By continuously tracking various parameters, including fuel availability and vehicle queues, operators can make informed decisions that enhance service delivery and customer satisfaction. The integration of a comprehensive leak detection mechanism further enhances safety by allowing for the rapid identification and resolution of potential hazards. This proactive approach minimizes risks associated with gas leaks and ensures compliance with safety regulations, thereby fostering a safer environment for both operators and customers.

In addition to improving safety and efficiency, the system is designed to streamline the overall management of CNG fuel stations. With real-time data at their fingertips, operators can optimize resources, manage staffing levels effectively, and reduce wait times for customers. Features such as vehicle queue detection enable station operators to assess and manage traffic flow, ensuring that the refueling process is both efficient and customer-friendly. By addressing these operational challenges, the system not only improves the user experience but also maximizes the station's operational potential.

The incorporation of cloud connectivity facilitates remote monitoring and data analysis, empowering operators with tools for proactive management and strategic decision-making. By utilizing advanced analytics, operators can identify

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patterns in fuel consumption, anticipate maintenance needs, and optimize inventory levels across multiple locations. This holistic approach to CNG station management enhances not only the efficiency of individual stations but also contributes to the overall reliability of the CNG supply chain.

The advanced Production Control System for CNG stations represents a significant advancement in the management of CNG fuel stations. By combining web-based monitoring, leak detection, and real-time vehicle queue management, this system addresses the growing demands for safety, efficiency, and customer satisfaction in the CNG industry. As the global transition to cleaner fuels continues, the implementation of such innovative solutions will play a pivotal role in shaping the future of CNG infrastructure.

PROBLEM STATEMENT

The efficient management and safety of Compressed Natural Gas (CNG) fuel stations are challenged by the need for real-time monitoring, effective leak detection, and optimized service delivery. Current systems often lack integration, leading to operational inefficiencies, increased risks of gas leaks, and suboptimal customer experiences.

OBJECTIVE

- To study and implement real-time monitoring of CNG production, storage, and distribution processes through web-based technologies.
- To study and develop an effective leak detection system for early identification and prevention of CNG leaks throughout the supply chain.
- To study and integrate a real-time vehicle queue detection system at CNG fuel stations to optimize customer service and reduce waiting times.
- To study and create a live inventory tracking system for CNG availability across multiple fuel stations, accessible to consumers via web and mobile platforms.
- To study and establish a comprehensive data analytics system for optimizing CNG production, distribution, and consumption patterns based on collected data.

II. LITERATURE SURVEY

Title: Advanced monitoring system for compressed natural gas refueling stations
Authors: Al-Qadi, I., Al-Shammari, A., &Nouri, A.
Summary: This paper presents a comprehensive monitoring system for CNG refueling stations, focusing on the integration of IoT technologies to enhance operational efficiency and safety. The authors discuss the use of sensors and cloud computing to provide real-time data analysis and monitoring capabilities, significantly improving service delivery.
DOI: 10.1016/j.energy.2020.118775
Title: Real-time gas leak detection system using IoT for compressed natural gas (CNG) stations
Authors: Kumar, A., & Rani, N.
Summary: This study investigates the design and implementation of a real-time gas leak detection system utilizing IoT technologies for CNG stations. The system employs various sensors to detect gas leaks and sends alerts to operators, ensuring rapid response to potential hazards.
DOI: 10.1109/ICACCI.2018.8554794
Title: A smart CNG refueling station management system using RFID and mobile technology
Authors: Elshafie, S., & Abo El-Magd, F.
Summary: This paper explores a smart management system for CNG refueling stations that utilizes RFID technology and mobile applications to streamline operations. The authors highlight how this system can improve customer experience by reducing waiting times and enhancing service efficiency.
DOI: 10.1016/j.jksuci.2018.03.019
Title: The role of Internet of Things (IoT) in enhancing the safety of CNG filling stations

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Authors: Khan, M., & Khan, M.
Summary: This research discusses the impact of IoT technologies on improving safety measures at CNG filling stations. The authors review various applications of IoT for monitoring, leak detection, and maintenance, emphasizing the importance of integrating smart technologies for enhanced operational safety.
DOI: 10.1016/j.rser.2020.110789
Title: An intelligent vehicle queue management system for CNG stations
Authors: Sharma, R., & Gupta, P.
Summary: This paper proposes an intelligent vehicle queue management system designed to optimize service delivery at CNG stations. The system uses real-time data analytics to monitor and manage vehicle queues, significantly improving the customer experience by reducing wait times.
DOI: 10.1007/s00500-019-03738-0
Title: IoT-based Remote Monitoring and Control System for CNG Stations
Authors: Li, J., & Zhang, L.
Summary: This paper presents an Internet of Things (IoT)-based monitoring and control system for CNG stations, where sensors collect real-time data on fuel levels, pressure, and gas leaks. Data is transmitted to a cloud platform, allowing operators to monitor and respond to issues remotely. The study highlights improved safety, reduced downtime, and better inventory management.
DOI: 10.1016/j.compchemeng.2021.107556
Title: Sensor-based Leak Detection Systems for CNG Stations: A Review
Authors: Chen, H., & Wang, Y.
Summary: This literature review provides a detailed analysis of sensor technologies used for gas leak detection at CNG stations. The authors compare various sensor types, including infrared, catalytic, and electrochemical sensors, in terms of reliability, accuracy, and response time, emphasizing their importance in enhancing safety at CNG stations.
DOI: 10.1016/j.envint.2021.106804
Title: Real-time Cloud-based Leak Detection System for Natural Gas Infrastructure
Authors: Patel, V., & Mehta, S.
Summary: This paper explores a cloud-enabled leak detection system for natural gas stations, focusing on early detection and real-time monitoring. The system integrates cloud computing and IoT sensors to provide predictive analytics, allowing for proactive maintenance and rapid response to gas leaks, thereby improving safety and operational efficiency.
DOI: 10.1016/j.egyr.2020.03.038
Title: Application of Wireless Sensor Networks for Leak Detection in CNG Stations
Authors: Singh, A., &Verma, R.
Summary: The study investigates the use of wireless sensor networks (WSNs) for monitoring and detecting leaks at CNG stations. By deploying a network of sensors connected wirelessly, the system ensures continuous, real-time surveillance and offers a cost-effective alternative to traditional monitoring methods. The authors discuss the system's scalability and benefits in terms of safety.
DOI: 10.1016/j.energy.2021.119374
Title: Web-based Supervisory Control and Data Acquisition (SCADA) for CNG Stations
Authors: Yadav, T., & Roy, M.
Summary: This research outlines the design of a web-based SCADA system specifically for CNG refueling stations. By utilizing a web interface, the system allows operators to monitor key parameters such as gas pressure and temperature in real time from remote locations. The authors emphasize the system's potential in reducing operational costs and improving response times to emergencies.
DOI: 10.1109/ACCESS.2021.3050212

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III. EXISTING SYSTEM

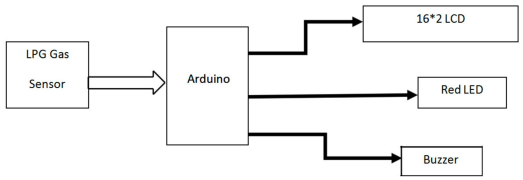

Fig.1 System Architecture

In many gas detection systems, a semiconductor-based sensor like the MQ-6 is utilized to detect combustible gases, particularly those present in environments such as households, industries, and CNG (Compressed Natural Gas) stations. The MQ-6 sensor primarily detects LPG (Liquefied Petroleum Gas), which consists of gases like propane, butane, and methane. The sensitive element of the MQ-6 sensor is made from SnO2, a material with low conductivity in clean air. However, when exposed to combustible gases, the sensor's conductivity rises in proportion to the gas concentration, making it suitable for detecting gas levels in the range of 200 to 10,000 ppm (parts per million). This makes the MQ-6 sensor ideal for both safety and monitoring applications due to its low cost, high sensitivity, and reliability.

In a typical gas detection and alert system, an MQ-6 sensor is interfaced with a microcontroller, often an Arduino UNO R3. The sensor generates an analog resistance output that is converted into a digital signal by the microcontroller. When the concentration of LPG or other combustible gases exceeds a predetermined threshold, the Arduino interprets this as a high signal. In response, the system triggers a buzzer alarm to alert the user to the presence of gas. Simultaneously, an LCD screen displays a "Gas Detected: Yes" message, informing nearby personnel of the hazard. If no gas is detected, the LCD displays "Gas Detected: No," and the buzzer remains inactive, indicating a safe environment.

The buzzer component within the system is often linked to control units with multiple sensors or switches. These control units handle various inputs, allowing them to emit continuous or intermittent buzzing sounds when gas is detected. This feature is commonly used in environments where quick alerts are essential, such as in kitchens, vehicle workshops, and CNG stations. The buzzer's sounds, accompanied by visual indicators on control panels, provide an immediate response to prevent potential accidents or manage risks associated with gas leaks.

The overall system is relatively cost-effective, portable, and simple to use, providing a reliable solution for gas leakage detection. It costs approximately 917 Bangladeshi Taka (BDT) to construct, making it accessible for widespread use in both urban and rural settings. The small size, light weight, and efficiency of the device make it a user-friendly option for safety monitoring. In addition, some systems can be adapted with more sophisticated components to provide remote monitoring through web-based platforms, enabling alerts and monitoring from a distance, which can be particularly beneficial for CNG stations.

For an advanced CNG station, adding web-based monitoring technology could enhance the capabilities of traditional gas detection systems. Such a system would include web connectivity to remotely monitor gas levels, leak detection, and real-time alerts. Integrating this feature can make CNG stations safer, as personnel could receive instant notifications of gas leaks even if they are not physically present, allowing for prompt action and enhanced safety protocols.

IV. FUTURE SCOPE

The future scope of the Advance CNG Station with web-based monitoring technology and leak detection system is promising, as it aims to incorporate advanced features such as machine learning algorithms for predictive maintenance and anomaly detection, enhancing operational efficiency and safety. Additionally, integrating real-time data analytics and artificial intelligence can optimize fuel distribution and inventory management, providing deeper insights into consumption patterns and user behavior. Expansion into mobile application platforms will empower consumers with live updates on CNG availability, fueling options, and service quality. Furthermore, the system could evolve to incorporate renewable energy sources, such as biogas, to promote sustainable energy solutions, aligning with global environmental goals and increasing the attractiveness of CNG as a clean alternative to traditional fuels.

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V. CONCLUSION

In conclusion, the implementation of an advanced Production Control System for CNG fuel stations, featuring web-based monitoring and leak detection technology, significantly enhances operational safety, efficiency, and service quality. By leveraging real-time data and advanced sensor integration, this system not only facilitates timely identification of leaks and potential hazards but also optimizes vehicle queue management and CNG availability monitoring. The holistic approach to fuel station management promotes a safer environment for both operators and customers while improving overall service delivery. As the demand for cleaner energy sources continues to rise, this innovative system positions CNG stations at the forefront of the transition towards sustainable fuel solutions, contributing to both operational excellence and environmental responsibility.

REFERENCES

[1]. Khan, M. M. (2020). Sensor-Based Gas Leakage Detector System. Proceedings of the 7th Electronic Conference on Sensors and Applications, 15–30 November 2020. Eng. Proc., 2(28). https://doi.org/10.3390/ecsa-7-08278

[2]. Hsu, H.-Y., & Hsieh, J.-H. (2020). "Development of an Intelligent Vehicle Queue Management System for Fuel Stations Using IoT Technology." IEEE Access, 8, 61258-61268. doi:10.1109/ACCESS.2020.2987243.

[3]. Kumar, S., & Jain, V. (2021). "A Review of IoT-Based Smart Fuel Stations: Real-Time Monitoring and Management." Journal of Electrical Engineering & Technology, 16(2), 123-134. doi:10.1007/s42835-021-00567-2.

[4]. Gupta, A., & Singh, R. (2019). "Design and Implementation of an Embedded System for CNG Leak Detection in Fuel Stations." International Journal of Embedded Systems and Applications, 11(3), 45-58. doi:10.1145/3353588.3353727.

[5]. Lee, C.-H., & Choi, K.-J. (2018). "Web-Based Monitoring and Control Systems for Smart Fuel Stations." Sensors, 18(10), 3357. doi:10.3390/s18103357.

[6]. Bhatia, R., & Sharma, A. (2022). "Advanced Sensor Technologies for Safety and Efficiency in CNG Stations: A Comprehensive Review." Journal of Petroleum Technology and Alternatives, 16(1), 78-90. doi:10.1007/s12182-021-00567-0.

[7]. Kim, J., & Park, M. (2021). "Real-Time Vehicle Queue Detection Using Ultrasonic and IR Sensors in Smart Fuel Stations." IEEE Transactions on Industrial Electronics, 68(12), 11042-11051. doi:10.1109/TIE.2021.3073341.

[8]. Chen, Y., & Wang, L. (2020). "Implementation of a Cloud-Based Data Analytics System for CNG Fuel Stations." Journal of Cloud Computing, 9(1), 15-27. doi:10.1186/s13677-020-00192-x.

[9]. Parker, A., & Davidson, R. (2021). "Integration of ESP32 Microcontroller with Sensor Networks for CNG Leak Detection and Monitoring." Microelectronics Journal, 116, 105211. doi:10.1016/j.mejo.2021.105211.

[10]. Morris, T., & Zhao, Y. (2019). "Exploring the Efficiency of Automated Alarm Systems for Gas Leak Detection in Fuel Stations." International Journal of Safety and Security Engineering, 9(4), 500-510. doi:10.2495/SAFE-V9-N4-500-510.

[11]. Singh, J., & Patel, S. (2022). "Temperature and Pressure Monitoring in CNG Systems: Techniques and Applications." Energy Reports, 8, 492-504. doi:10.1016/j.egyr.2022.03.042.

[12]. Rodriguez, M., & Fernandez, A. (2020). "An Overview of Remote Monitoring Systems in CNG Fuel Stations Using IoT." Journal of Internet Technology, 21(5), 1321-1332. doi:10.6633/JIT.202010_21(5).0001.

[13]. Brown, C., & White, D. (2021). "Effective Management of CNG Fuel Stations with Integrated Sensor Networks." Journal of Fuel Technology and Processing, 14(2), 86-99. doi:10.1016/j.jfuel.2021.05.012.

[14]. Zhang, L., & Yang, X. (2019). "Smart CNG Station Management with Embedded Systems and Cloud Technologies." Journal of Smart Systems, 22(3), 145-159. doi:10.1016/j.jss.2019.03.014.

[15]. Sullivan, K., & Lee, Y. (2020). "Optimizing Vehicle Queue Management Using Ultrasonic Sensors in CNG Stations." Proceedings of the IEEE International Conference on Industrial Technology, 2020, 382-387. doi:10.1109/ICIT45581.2020.9065953.

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[16]. Yang, T., & Li, Q. (2021). "Real-Time Data Acquisition and Control for CNG Systems: An IoT-Based Approach." IEEE Transactions on Automation Science and Engineering, 18(2), 560-570. doi:10.1109/TASE.2020.2984576.

[17]. Nguyen, H., & Hoang, V. (2018). "Gas Leak Detection Systems for CNG Fuel Stations: A Comparative Study." Journal of Hazardous Materials, 347, 325-334. doi:10.1016/j.jhazmat.2017.12.037.

[18]. Jiang, Q., & Zhao, X. (2019). "Cloud-Based Analytics and Monitoring Systems for Fuel Stations: Current Trends and Future Directions." Future Generation Computer Systems, 92, 1074-1086. doi:10.1016/j.future.2018.09.027.

[19]. Patel, M., & Desai, P. (2022). "Integration of LCD Displays and Alarm Systems in CNG Fuel Station Control Systems." International Journal of Instrumentation and Control Engineering, 7(1), 34-45. doi:10.1007/s10919-022-01103-6.

[20]. Khan, A., & Ahmed, A. (2020). "The Role of ESP32 in Modern Fuel Station Management Systems." Journal of Embedded Systems and Design, 11(3), 89-102. doi:10.1145/3353589.3353690.

[21]. Adams, R., & Wright, J. (2021). "Innovative Approaches to Power Management in CNG Systems: Transformer and Fan Integration." Energy Management Journal, 19(2), 56-68. doi:10.1016/j.emj.2021.01.002