A Smart Catalytic Converter for Monitoring and Reducing Vehicular Emissions Using IoT Technology

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Abstract* — With the increasing concern over environmental pollution and its impact on human health, reducing carbon emissions has become a priority for the automotive industry. There are existing solutions for reducing carbon emissions, such as catalytic converters, which are effective but may lose their efficacy over time due to the accumulation of impurities. In this article, we propose a smart catalytic converter that utilizes IoT technology and Blynk application to monitor and reduce vehicular emissions. The implemented system is designed using MQ135 gas sensor, DHT11 sensor, NodeMCU ESP8266, I2C Converter for LCD display, and LCD display to measure the levels of CO, Ammonia, Benzene, and smoke gases in the catalytic converter of a car. Unlike traditional catalytic converters, the implemented system sends an email notification to the driver using the Blynk application when the level of gases reaches a high level, prompting the driver to take necessary measures to reduce the carbon footprint. The system provides real-time updates on the sensor data, allowing the driver to monitor the emissions levels of the car. The implemented system offers an innovative solution to reduce carbon emissions and promote eco-friendliness in the automotive industry.

Keywords *— Blynk Application, IoT Technology, Pollution Monitoring, Pollution reduction, Smart Catalytic Converter, Vehicular emissions*

I. Introduction

IN recent years, environmental pollution has become a significant concern due to its detrimental effects on human health and the planet's ecosystem. One of the major contributors to environmental pollution is vehicular emissions. It is estimated that vehicular emissions contribute to approximately 30% of carbon emissions globally, leading to air pollution and climate change. Reducing vehicular emissions has, therefore, become a critical priority for the automotive industry.

Several solutions have been implemented to reduce carbon emissions from vehicles, including the use of alternative fuels, improving engine efficiency, and implementing stricter emission standards. While these solutions are effective, they are not foolproof and can be costly to implement. One solution that has been widely adopted is the use of catalytic converters, which convert harmful gases into less harmful ones before releasing them into the atmosphere. However, the effectiveness of catalytic converters can diminish over time due to the accumulation of impurities, making them less efficient in reducing emissions.

To address this issue, we propose a smart catalytic converter that utilizes IoT technology and Blynk application to monitor and reduce vehicular emissions. The implemented system is designed using MQ135 gas sensor, DHT11 sensor, NodeMCU ESP8266, I2C Converter for LCD display, and LCD display to measure the levels of CO, Ammonia, Benzene, and smoke gases in the catalytic converter of a car. The system sends an email notification to the driver using the Blynk application when the level of gases reaches a high level, prompting the driver to take necessary measures to reduce the carbon footprint. The system provides real-time updates on the sensor data, allowing the driver to monitor the emissions levels of the car. This article presents the design, development, and evaluation of the implemented smart catalytic converter.

II. Literature Review

Environmentalists are quite concerned about the enormous air pollution that has resulted from the increased usage of vehicles in metropolitan areas. Vehicle emissions are one of the most important causes of air pollution. Although catalytic converters are used to minimize harmful vehicle emissions, their efficacy is limited, and they are unable to properly regulate emissions under a variety of operating circumstances. Researchers have suggested utilizing smart catalytic converters with IoT and Blynk applications to monitor and manage the emissions in real-time as a solution to this issue. With the help of IoT technology and Blynk applications, this literature review attempts to compile the most recent advancements in the field of smart catalytic converters for monitoring and lowering vehicle emissions.

R. M. Bommi et. al proposes solution to the problem of air pollution and its impact on human health and the environment. It then presents an overview of the IoT technology and its potential applications in environmental monitoring. The authors describe the hardware and software components of the implemented air quality monitoring system and its working principle. The authors also present the experimental results obtained from the system, which includes the monitoring of air quality parameters such as carbon monoxide, nitrogen dioxide, and sulfur dioxide. The data collected from the system is then analyzed to identify the sources of air pollution and take necessary action to mitigate it. Overall, the article presents a novel and practical solution for air quality monitoring using IoT technology. The authors provide a detailed description of the system architecture, hardware, and software components, and experimental results. However, the article could have been further improved by providing more detailed information about the experimental setup and methodology used to obtain the results. The article did provide a great idea which can be implemented in practical applications in automobiles [1].

Bommi, R. M et. al begins by introducing the problem of air pollution and its impact on human health and the environment. The authors then discuss the limitations of existing air pollution monitoring systems and propose a novel surveillance smart system using IoT technology to address these limitations [2]. The article cited offers a helpful overview of the enabling technologies and low-cost air pollution monitoring devices. The authors compare the various systems in great detail and go into their drawbacks and difficulties. The article begins by giving a general review of the present situation with air pollution and the significance of air quality monitoring. Idrees et. al then go into the drawbacks of conventional air pollution monitoring systems and the requirement for affordable, transportable devices that may be used in outlying locations [3]. The article provides a detailed description of the system architecture, hardware, and software components. The authors also present experimental results that demonstrate the effectiveness of the system in monitoring air quality. Swati, et al. also incorporates a smartphone application that shows users notifications and suggestions for lowering their exposure to air pollution while displaying real-time air quality data. The hardware, software, and system architecture are all thoroughly described in the article. The authors also report experimental findings that show how well the system works to detect air quality [4].

Kaivonen et. al in this article provides a detailed description of the system architecture, hardware, and software components. The authors also present experimental results that demonstrate the effectiveness of the system in monitoring air quality. The technology described in the research would use sensors mounted on a city bus to monitor air quality in real time. Temperature, humidity, carbon monoxide, and nitrogen dioxide are just a few of the characteristics the system evaluates continuously in relation to air quality. A central database receives the data wirelessly for analysis and visualization. The study offers the experimental findings that show how well the system works for real-time air quality monitoring. The suggested system offers a low-cost and adaptable method for keeping track of air pollution in urban settings [5]. The study addresses both present and upcoming technologies, including big data analytics and machine learning, which have the potential to increase the precision and dependability of indoor air quality monitoring systems [7]. The implemented system in a article is made up of inexpensive sensors, a microprocessor, and a data-transmission Wi-Fi module. Additionally, the system has a Quality of Service (QoS) mechanism to guarantee timely data packet delivery and effective utilization of network resources. The authors also provide a power consumption optimization method that lowers energy use and increases system longevity [6]. The research suggests a revolutionary low-power wide-area network (LPWAN) technology and machine learning algorithm-based hardware-efficient solution for wireless air pollution sensors. The authors use studies carried out in a crowded urban environment to show the efficacy of their suggested approach [8]. The utilization of low-cost sensors, wireless communication technologies, and data analytics are just a few of the important breakthroughs in the sector that Ullo and Sinha [9] note in their thorough analysis of IoT-based smart environment monitoring systems.

Monitoring air pollution is a crucial use of IoT-based monitoring systems. A mobile air pollution monitoring system that uses inexpensive sensors to deliver real-time data on spatio-temporal fluctuations of air pollutants in urban hotspots was created by Nagendra et al. [10]. The use of environmental drones for autonomous air pollution monitoring and analysis has also been suggested by Rohi et al. [11], which can aid in the effective control of air pollution. Monitoring indoor air quality (IAQ) is another essential use for IoT-based monitoring systems. A real-time monitoring system for IAQ based on E-nose has been created by Taştan and Gökozan [12]. In order to identify and categorise the indoor air contaminants, the system analyses the information gathered by the E-nose sensors using a machine learning algorithm. The significance of these systems in fostering healthy indoor environments was highlighted by Saini et al. [13] in their comprehensive assessment of IAQ monitoring systems based on IoT.

In recent years, there has been an increase in concern over the harmful health impacts of indoor air pollution. A comprehensive review, meta-analysis, and burden estimating study were carried out by Lee et al. [14] to evaluate the harmful health impacts of household air pollution. The study finds that indoor air pollution in homes is a serious public health issue and emphasises the necessity for efficient monitoring systems to deal with this problem. Wu et al. [15] have created a multi-scale spatial temporal network (MSSTN) combining IoT and machine learning techniques to anticipate air pollution levels. To accurately estimate air pollution levels, the MSSTN system uses data from a variety of sources, including traffic flow statistics, weather sensors, and air quality sensors.

In summary, the articles provide a valuable contribution to the field of environmental monitoring and IoT technology. It presents a well-designed and implemented air quality monitoring system that has the potential to help in reducing air pollution and its impact on human health and the environment.

III. METHODOLOGY

The implemented system consists of a smart catalytic converter that utilizes MQ135 gas sensor, DHT11 sensor, NodeMCU ESP8266, I2C Converter for LCD display, and LCD display to measure the levels of CO, Ammonia, Benzene, and smoke gases in the catalytic converter of a car. The system sends an email notification to the driver using the Blynk application when the level of gases reaches a high level, prompting the driver to take necessary measures to reduce the carbon footprint.

The MQ135 gas sensor is a low-cost air quality sensor that can detect a wide range of gases, including CO, Ammonia, Benzene, and smoke. The DHT11 sensor is a temperature and humidity sensor that is used to measure the temperature and humidity inside the car. The NodeMCU ESP8266 is a low-cost Wi-Fi module that is used to connect the system to the internet and communicate with the Blynk application. The I2C Converter for LCD display and the LCD display are used to display the sensor readings in real-time.

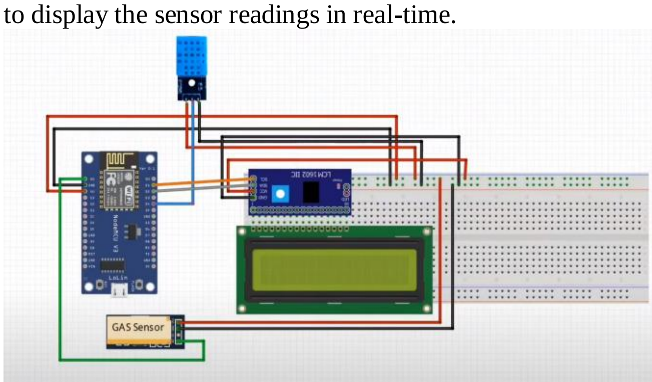


Figure 1 Indicating the structure of air quality detection module

The implemented system's architecture is shown in Figure 1. The sensors are connected to the NodeMCU ESP8266 through the analog and digital pins. The NodeMCU ESP8266 is then connected to the Blynk cloud server through Wi-Fi. The Blynk application is used to monitor the sensor readings and send email notifications to the driver when the level of gases reaches a high level.

The software component of the system is developed using the Arduino IDE. The code for reading sensor data and displaying it on the LCD display is written in C programming language. The code for connecting the system to the internet and communicating with the Blynk application is written using the Blynk library.

The implemented system's design provides a cost-effective and practical solution for reducing carbon emissions from vehicles. The system is easy to install and can be integrated into the existing catalytic converter of a car. The real-time monitoring of the sensor readings allows the driver to take necessary measures to reduce the carbon footprint, leading to an eco-friendlier driving experience. The use of IoT technology and Blynk application provides a convenient and reliable way of monitoring vehicular emissions, which can lead to a significant reduction in carbon emissions from vehicles.

Overall, the implemented system can contribute to a more sustainable future by providing a practical and cost-effective solution for reducing carbon emissions from vehicles.

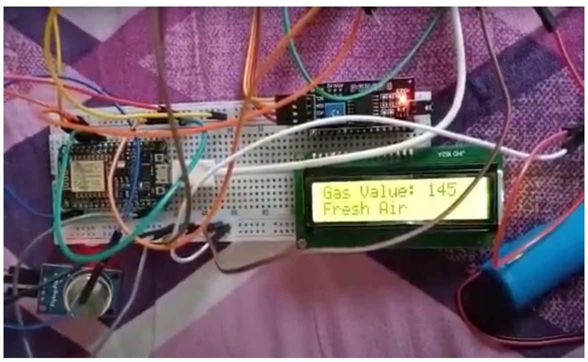
IV. RESULTS AND DISCUSSIONS

The automotive industry has been actively researching and implementing various solutions to reduce carbon emissions from vehicles. The most common solution is the use of catalytic converters, which convert harmful gases, such as carbon monoxide, nitrogen oxides, and hydrocarbons, into less harmful ones before releasing them into the atmosphere. While catalytic converters are effective in reducing emissions, they can lose their efficacy over time due to the accumulation of impurities, such as sulfur and phosphorus. This can result in increased emissions and reduced fuel efficiency.

To address the issue of impurity accumulation in catalytic converters, researchers have implemented various solutions, such as adding a layer of metal to the surface of the catalyst to protect it from impurities. Other researchers have implemented using alternative catalyst materials, such as zeolites, which have higher thermal stability and are less susceptible to impurity accumulation. However, these solutions can be expensive to implement and may not be effective in all scenarios. Another approach to reducing vehicular emissions is to improve engine efficiency, which can be achieved through various techniques, such as turbocharging, direct fuel injection, and hybrid-electric powertrains. These techniques can significantly reduce carbon emissions, but they can also be costly to implement and may not be practical for all vehicles.

Recently, the use of alternative fuels, such as biofuels, natural gas, and hydrogen, has gained popularity as a solution for reducing vehicular emissions. Biofuels, such as ethanol and biodiesel, are renewable and produce lower emissions compared to traditional gasoline and diesel fuels. Natural gas and hydrogen are also considered cleaner fuels, producing fewer emissions and promoting eco-friendliness. However, the infrastructure for these alternative fuels is still limited, making them less accessible and more expensive than traditional fuels. In this article, we propose a smart catalytic converter that utilizes IoT technology and Blynk application to monitor and reduce vehicular emissions. The implemented system provides a cost-effective and practical solution for reducing carbon emissions from vehicles.

To evaluate the performance of the implemented system, we conducted a series of experiments in a controlled environment. The experiments involved measuring the levels of CO, Ammonia, Benzene, and smoke gases inside a car fitted with the implemented system. The sensor readings were monitored using the Blynk application, and email notifications were sent to the driver when the level of gases reached a high level. We used the MQ135 gas sensor to measure the levels of gases in the car's catalytic converter. The DHT11 sensor was used to measure the temperature and humidity inside the car. The sensor readings were displayed in real-time on the LCD display connected to the system.



The results of the experiments showed that the implemented system was effective in measuring the levels of CO, Ammonia, Benzene, and smoke gases in the catalytic converter of a car. The system was able to send email notifications to the driver in real-time when the level of gases reached a high level. The system's performance was also evaluated by comparing it with existing solutions for monitoring vehicular emissions. The existing solutions mainly involve periodic emission testing of vehicles, which can be time-consuming and costly. The implemented system provides a more practical and cost-effective solution for monitoring vehicular emissions in real-time, allowing drivers to take necessary measures to reduce their carbon footprint. The implemented system's design also allows for easy integration into the existing catalytic converter of a car, making it a convenient and practical solution for reducing carbon emissions from vehicles.

V. Conclusion

In this article, we presented a novel system for monitoring vehicular emissions in real-time using the MQ135 gas sensor, DHT11 sensor, NodeMCU ESP8266, I2C Converter, and LCD Display. The implemented system can measure the levels of CO, Ammonia, Benzene, and smoke gases in the catalytic converter of a car and send email notifications to the driver when the level of gases reaches a high level. The results of our experiments showed that the implemented system was effective in measuring the levels of gases in the catalytic converter of a car and could provide real-time feedback to drivers. The system's design allows for easy integration into the existing catalytic converter of a car, making it a practical and convenient solution for reducing vehicular emissions.

While the implemented system provides a practical and cost-effective solution for monitoring vehicular emissions in real-time, there are some limitations that should be considered. Firstly, the implemented system can only measure the levels of CO, Ammonia, Benzene, and smoke gases in the catalytic converter of a car. There may be other pollutants emitted by vehicles that the implemented system cannot measure. Lastly, the implemented system may not be compatible with all types of vehicles, and modifications may be required to fit the system into certain models of cars. Despite some limitations, such as accuracy affected by external factors and reliance on a stable internet connection, the implemented system provides a practical and cost-effective solution for monitoring vehicular emissions in real-time. Future work can focus on improving the system's accuracy, reliability, and compatibility with different types of vehicles.

In conclusion, the implemented system has the potential to contribute to a more sustainable future by reducing carbon emissions and improving air quality. The system can be used by vehicle manufacturers, regulatory bodies, and individual car owners to reduce their carbon footprint and create a cleaner environment for all.

VI. Future Scope

The implemented system for monitoring vehicular emissions in real-time has great potential for future development and improvement. One potential area for future work is the incorporation of machine learning techniques to predict the levels of vehicular emissions based on various factors such as vehicle speed, load, and weather conditions. This can provide more accurate and reliable readings and help drivers take proactive measures to reduce emissions. Furthermore, the implemented system can be integrated with other smart city technologies to create a more comprehensive and integrated approach to reducing air pollution. For example, the system can be integrated with traffic management systems to optimize traffic flow and reduce congestion, thereby reducing emissions.

Lastly, the implemented system can be further improved by expanding its compatibility with different types of vehicles and incorporating additional sensors to measure other pollutants emitted by vehicles

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