DESIGN AND DEVELOPMENT OF DIESEL POWER PLANT EXHAUST GAS EMISSIONMONITORING BASED ON IOT

Dewa Made Brandiva Sidan[1*] , Hartono[2] , Suyatmo[3]

[1,2,3)]*Politeknik Penerbangan Surabaya, Jemur Andayani I/73 Wonocolo Surabaya, Jawa Timur, Indonesia, 60236*
**Corresponding author. Email: brandivasidan30@gmail.com*

ABSTRACT
The increasing air pollution from diesel power plants poses significant environmental and health risks. This study developed an IoT-based system to monitor real-time levels of nitrogen oxide (NOx), sulfur dioxide (SO2), and carbon monoxide (CO) emissions from a diesel generator. The methodology involved installing gas sensors and an ESP32 microcontroller connected to an IoT platform, enabling continuous data collection and online monitoring. Over a three-month period, daily monitoring was conducted. The results show that emissions from an 80KVA generator set are significantly higher than those from diesel vehicles, underscoring the need for more effective emission control strategies to mitigate environmental impact.

Keywords: IoT, 80KVA Generator, Sensors

1. INTRODUCTION

Technological advances in this modern era have had a major impact on various sectors, including the energy and environmental sectors. One important innovation in this sector is the use of generator sets as a backup power source, especially in areas that experience frequent blackouts or in locations that require a stable electricity supply, such as airports. Generators operate by converting kinetic (mechanical) energy into electrical energy through the process of electromagnetic induction. Although very useful, the use of gensets also has a negative impact on the environment, particularly through the exhaust emissions produced during the combustion of fossil fuels such as diesel. These emissions contain harmful substances such as nitrogen oxides (NOx), carbon monoxide (CO), and sulfur dioxide (SO2) that are not only damaging to the environment, but also potentially harmful to human health. Therefore, it is important to monitor and control generator set emissions to keep pollutants within safe limits and to reduce their adverse effects on the environment and health. To solve this problem, various technologies have been developed to monitor exhaust emissions from generators in real- time. One method that is commonly applied today is by integrating gas sensors such as MQ-7, MQ-135, and MQ-136 with microcontrollers such as ESP32, as well as Internet of Things (IoT) technology. This technology enables more efficient and effective monitoring of exhaust emissions, with data that can be accessed and analyzed directly through the web or mobile applications. In addition, the application of IoT technology in emissions monitoring allows for more accurate data collection and centralized storage, making it easier to analyze and make decisions for immediate action needed. Thus, the development and implementation of an IoTbased emission monitoring system not only helps reduce the environmental impact of generator set use, but also contributes to the creation of a cleaner and healthier environment in the future..

1. METHODOLOGY

The methodology used by the author is an experimental approach aimed at designing and testing an IoT-based exhaust gas emission monitoring tool for gensets. This research is conducted directly to understand the tool's operation and effectiveness under real-world conditions.

Data collection methods include several stages. The initial stage involves designing the monitoring tool circuit, including programming and integrating the sensors with the ESP32 microcontroller. The next stage involves testing the gas sensors, such as MQ-136 for SO2, MQ-135 for NOx, and MQ-7 for CO. This is followed by testing data communication via IoT networks and analyzing the received data. Finally, the tool is tested under various genset operating conditions to collect emission data and evaluate the tool's performance.

The research was conducted at the Surabaya Aviation Polytechnic from January to August 2024.

Application Design

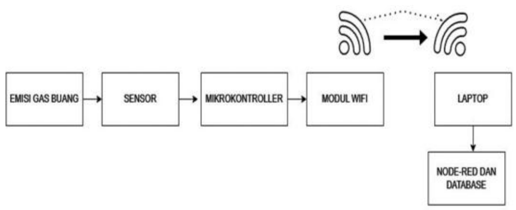


Figure 1 Application Design

The design of this tool begins with the installation of MQ-7, MQ-135, and MQ-136 sensors to detect genset exhaust emissions. These sensors will send data to the microcontroller, where it will be processed into digital data. After processing, the ESP32 microcontroller will connect the device to a Wi-Fi network and send the data to a web server via the internet. The readings of the genset exhaust emissions will be displayed as sensor values, which can be accessed and viewed through the Node-Red platform.

2. RESULTS AND DISCUSSIONS

This section presents the components used in the tool that has been assembled and tested. These components include:

1. *MQ-136*
2. MQ-135
3. *MQ-7*
4. ESP32 Microcontroller
5. ADAPTOR
6. BUCK CONVERTER LM2596
7. NODE-RED

Hardware Testing

Testing *ADAPTOR*

Table 1 Testing Adaptor

No	ROOM	INPUT (Vac)	OUTPUT (Vdc)
1	Asrama	222 VAC	12,5 VDC
2	Asrama	222 VAC	12,5 VDC
3	Asrama	221 VAC	12,45 VDC
4	Mesin	221,5 VAC	12,5 VDC
5	Mesin	220 VAC	12,4 VDC
6	Mesin	222 VAC	12,5 VDC

Figure 2 Testing Adaptor

Based on the measurement data obtained through six trials, it can be seen that the adaptor successfully reduces the voltage from 200 VAC to 12 VAC, indicating that the adaptor functions correctly.

Testing of Buck Converter LM2596

Table 2 Testing of LM2596

Pengujian	ROOM	Tegangan Input (Vdc)	Tegangan Output (Vdc)
1	ASRAMA	12,4 VDC	5,03 VDC
2	ASRAMA	12,38 VDC	5,0 VDC
3	ASRAMA	12,4 VDC	5,0 VDC
4	MESIN	12,4 VDC	5,0 VDC
5	MESIN	12,35 VDC	5,0 VDC
6	MESIN	12,4 VDC	5,01 VDC

Figure 3 Testing of Buck Converter LM2596

Based on the measurement data obtained

through six trials, the input voltage from the 12 VDC power supply successfully drops to 5 VDC. The output from the buck converter will be used as the ESP32 supply. These results indicate that the LM2596 buck converter functions correctly.

Testing *LCD 16X2*

Figure 4 Testing *LCD 16X2*

After conducting a series of tests on the Liquid Crystal Display (LCD) component, including displaying the readings from the MQ-7, MQ-135, and MQ-136 gas sensors, the author can conclude that the Liquid Crystal component is functioning properly.

Software Testimg

Testing of *Arduiono Integrated Development Environment* (IDE)

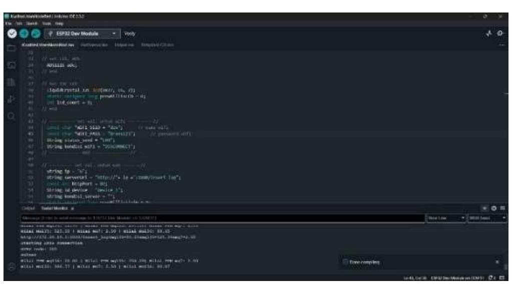


Figure 5 Implementation of ESP32 Control System Coding

In the illustration above, it can be concluded that the coding program for the Arduino Integrated Development Environment (IDE) on the ESP32 is functioning well and as expected. This is evidenced by the absence of error messages during the verification process or sketch compilation. Once this stage is completed, a notification saying “done compiling” appears, which means the data upload process was successful. Additionally, during the Final Project tool trials, there were no components found to be incompatible with the created program. **Testing *Xampp***

XAMPP application testing is necessary to determine whether the MySQL database is running or not. The purpose of this testing is to verify whether the database is operating correctly. Before conducting the test, ensure that the application is already running.

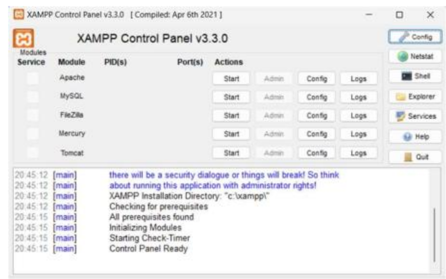
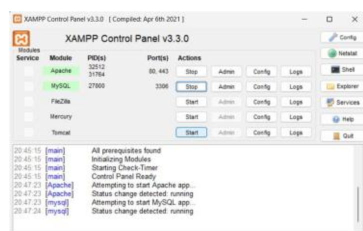


Figure 6 *intial Xampp display*

In the XAMPP application, there are many modules available, including Apache, MySQL, FileZilla, Mercury, and Tomcat. Then, we turn on or start Apache and MySQL.



g

Figure 7 Starting Apache dan MySql

Next, we open a browser and check whether MySQL is running. We verify if the database can be accessed and whether new databases can be created.

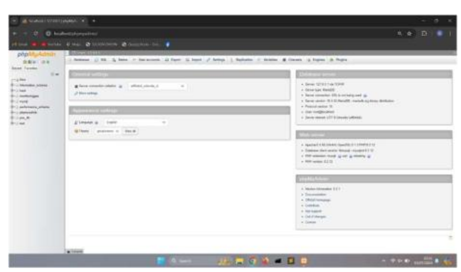


Figure 8 *XAMPP successfully running*

This is the display if everything is successful and ready for database entry. This screen indicates that there were no errors when starting the MySQL database.

Testing *Node-red*

The Node-RED testing is conducted to ensure that Node-RED is functioning properly. The first step in this testing phase is to input the Node-RED IP address, which will then display the Flow interface.

Figure 9 starting *node-red*

The next step involves designing the outputs from the tool that we want to monitor on Node-RED. After that, we connect the flow to MySQL and ESP32.

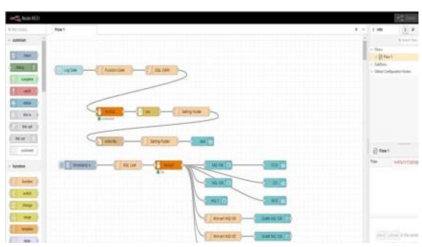


Figure 10 Node-red Flow display

The next step is to deploy or start Node-RED. Thisis done to check if there are any errors in the flow creation process. Afterward, we view the flow results on the UI page. Below is the flow result for monitoringthe sensors on our tool.

Figure 11 Node-re display

Analysis Results:

After testing Node-RED as a monitoring and IoT tool, Node-RED was found to be functioning properly. Measurements can be viewed from Node-RED, and there is a delay of about 2 seconds between the LCD and Node-RED.

Measurements Results

Gas measurements must be conducted to determine whether the results can be reliably expected or not. The method used to collect data from the sensor involves providing input from diesel vehicle exhaust and a Generator Set by taking several samples. The gas sensor measurement results are displayed via a 16x2 LCD, on the Node-RED website, and in the database.

GENSET 80KVA MEASUREMENT

Table 3 Genset 80KVA Measurement Results

Date	*Time*	*NOx*	*So2*	*CO*	*distance*
24 JULI 2024	15:56:05	183.03	156.15	100.30	*10CM*
	15:56:09	203.05	191.64	101.3	
	15:56:11	217.35	222.28	101.25	
24 JULI 2024	15:43:24	105.81	112.89	81.25	*30CM*
	15:43:27	120.11	72.96	82.50	
	15:43:30	111.53	77.20	82.40	
24 JULI 2024	15:45:02	82.93	1.96	1.25	*100 CM*
	15:45:05	68.64	1.96	1.25	
	15:45:07	62.92	1.96	1.25	

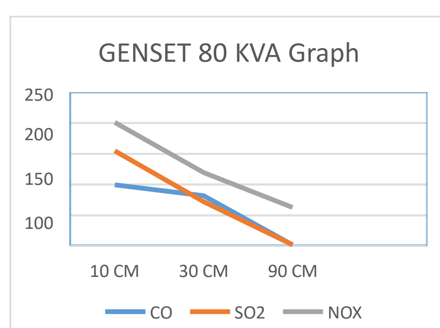


Figure 12 Genset 80KVA Graph

Figure 13 Genset 80KVA Measurement

DIESEL VECHICLE MEASUREMENT

Table 4 Diesel Vechicle Measurement

date	*Time*	*NOx*	*So2*	*CO*	*Distance*
23 JULI 2024	15:40:56	182.88	151.96	81.25	*10CM*
	15:40:59	178.78	165.76	76.34	
	15:41:02	155.65	164.53	81.10	
23 JULI 2024	15:43:02	92.88	81.55	61.25	*30CM*
	15:43:07	95.65	77.96	55.46	
	15:43:10	99.75	80.43	60.32	
23 JULI 2024	15:43:57	22.88	1.96	1.25	*100 CM*
	15:44:00	25.54	1.96	1.25	
	15:44:02	23.84	1.96	1.25	

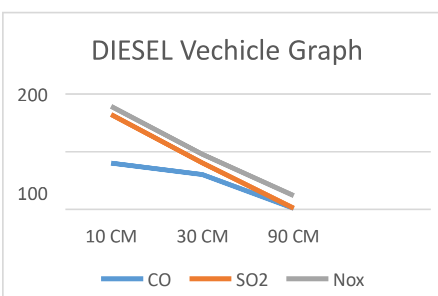


Figure 14 Diesel Vechicle Graph

From the analysis results, it was found that the further the monitoring tool is installed, the lower the concentration of emissions detected. Additionally, the comparison between the 80 KVA genset and the diesel vehicle shows a significant difference. It can be concluded that the emissions from the 80KVA genset are very dense and dangerous, with maximum levels for the Generator Set 80KVA being NOx: 3400, SO2: 160, and CO: 3400.

Advantages and Disadvantages of the toolAdvantages

- Helps technicians easily monitor generator set gas emissions through the web.
- Includes a database to store and monitor data inMySQL and Excel.
- Allow users to select dates in the database as needed.

Disadvantages

- The web interface can only be used on a local host.
- There is no comparison between the author's tooland a calibrated tool.

4. CONCLUSION

Conclusion:

Based on observations after constructing the final project titled “Design and Development of an IoT- Based Diesel Power Plant Emission Monitoring System,” as explained in the previous chapters, the following conclusions can be drawn:

1. This tool is designed using the ESP32 microcontroller, connected to various gas sensors such as the MQ-7 sensor for detecting carbon monoxide (CO), the MQ-135 sensor for detecting various hazardous gases including nitrogen oxides (NOx) and sulfur dioxide (SO2), and the MQ-136 sensor. Data obtained from these sensors is transmitted to IoT NODE-RED via the internet, enabling real-time monitoring of exhaust gas emissions.

2. The sensors are installed on the exhaust channel of the generator set. Data from the sensors is processed by the ESP32 microcontroller and sent to NODE-RED for analysis and monitoring. Users can access emission data online through a dashboard that displays real-time concentrations of hazardous gases. This tool allows technicians to monitor emissions in real-time with a database. The average monitoring of an 80KVA generator set emission at a 10cm sensor distance is CO: 100mg/nm3 | SO2: 195.36 mg/nm3 | NOx: 204.48 mg/nm3, and the average diesel vehicle emission at a 10cm sensor distance is CO: 79.43 mg/nm3 | SO2: 153.68 mg/nm3 | NOx: 175.85 mg/nm3

The conclusion of the test is that the farther the sensor is installed, the lower the concentration and emissions detected. The standard emission limits for an 80KVA generator set are CO: 170 mg/nm3 | NOx: 300 Mg/nm3. According to the Ministry of Environment and Forestry's regulations, emission tests on generator sets should be conducted 20 cm from the chimney of the generator set. Therefore, the 80 KVA generator set meets the emission standards set by the Ministry of Environment. The monitoring tool designed provides an efficient solution for monitoring exhaust gas emissions from generator sets, supporting efforts to create a sustainable environment.

Reccomendations

In the process of creating this final project, the author recognizes that the tool still has limitations and is not yet perfect. Therefore, the author suggests several points for future development to improve and perfect the tool. The suggestions are as follows:

1. For large-scale research, a standardized calibration tool is needed to ensure that this tool can truly monitor diesel power plantemissions.
2. For IoT-based monitoring, a website that does not rely on a local host should be used.
3. For additional research, it is necessary to compare small-scale and large-scale generator sets to assess the effectiveness of this monitoring tool.

ACKNOWLEDGMENTS

With the completion of the preparation of this paper, Penlis expressed his gratitude to his beloved father and mother, all lecturers and instructors of the Diploma 3 Study Program in Airport Electrical.

Engineering, as well as colleagues who always provide support and advice and help in the completion of this paper

REFERENCES

[1] Ariyanto, S. R. (2020). Pengaruh Diesel Particulate Filter Tipe Honeycomb Berbahan Tembaga Terhadap Performa Mesin Diesel Empat Langkah.*Infotekmesin*.

[2] Daffa Zulianza, N. (2018). Prototype Alat Pengukur Kadar Karbon Monoksida (CO) pada Asap Rokok di Dalam Smoking Room Menggunakan Logika Fuzzy. *Ijccs*.

[3] Mulyana, R. (2018). Alat Monitoring Emisi Gas Buang Kendaraan Bermotor Berbasis Android. *Jurnal eLEKTUM*.

[4] Nasution, H. (2020). Implementasi Logika Fuzzy pada Sistem Kecerdasan Buatan. *ELKHA: Jurnal Teknik Elektro*.

[5] Nataya Kinanti, V. (2018). Prototype Penyaring Asap Rokok Pada Smoking Area Menggunakan Pulse Wi

[6] TAQWA, M. Z. (2021). Rancang Bangun Alat Monitoring Kadar Gas So_2 Dan Co_2 Sebagai Early Warning System Pada Kawah Candi Gedong Songo Menggunakan Nodemcu Dan Logika Fuzzy.

[7] Utomo, B. T. (2016). Simulasi Sistem Pendeteksi Polusi Ruangan Menggunakan Sensor Asap Dengan Pemberitahuan Melalui SMS (Short Message Service) Dan Alarm Berbasis Arduino. *Jurnal Ilmiah Teknologi Informasi Asia*.

[8] Wicaksono, H. A. (2017). Rancang Bangun Sistem Monitoring Konsentrasi Gas Nitrogen Oksida (NOx) Sebagai Emisi Gas Buang Menggunakan Sensor Gas MQ – 135 Berbasis Mikrokontroller STM32F4 Discovery.