Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 6, No.3, July 2024, pp. 02403010-01 ~ 02403010-08
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v6i3.615

Characteristics of the MQ-135 Sensor for Testing Medium Speed Ship Engine Exhaust Gases

Arif Rakhman Suharso[1], Ario Hendartono[2], Slamet Supriyadi[3*]

[1]Engineering Department, Indonesian State Maritime Polytechnic, Pawiyatan Luhur I, Bendan Duwur, Gajahmungkur, Semarang, Indonesia

[2]Nautical Department, Indonesian State Maritime Polytechnic, Pawiyatan Luhur I, Bendan Duwur, Gajahmungkur, Semarang, Indonesia

[3]Mechanical Enguneering Department, Faculty of Engineering and Informatics, Universitas PGRI Semarang, Jl. Sidodadi-Timur No.24 Semarang, Central Java, Indonesia

*corresponding author: slametsupriyadi@upgris.ac.id

Abstract. International Convention that regulates air pollution caused by shipping activities as is indicated in Annex VI. So far, many ships' exhaust gases still contain a lot of NOx and SOx gases which can damage the air and are one of the contributors to air pollution. The aim of this research is to analyse the use of the MQ-135 sensor as a ship exhaust gas detection sensor connected to an Arduino Uno and a computer. Testing ship exhaust gas was using the medium speed ship's main engine in the engine laboratory of the Indonesian State Maritime Polytechnic. The measuring point was at the end of the exhaust chimney. The measurement variations consisted of low, medium and high engine speed (RPM) of the main engine. The result suggested that the higher the engine RPM, the higher the reading on the serial monitor. The average of measurement results from three measurements concluded that the high RPM is 96, for medium RPM is 81 and low RPM is 66 as displayed on the Arduino IDE serial monitor. From the results of the equipment testing that has been carried out, it can be concluded that the MQ-135 sensor can be used to detect ship exhaust gas from medium ship engine.

Keywords: MQ-135 sensor, ship exhaust gas, ship engine, diesel engine

(Received 2024-05-22, Accepted 2024-05-12, Available Online by 2024-06-24)

1. Introduction

Exhaust gases produced by diesel engine as the main propulsion of ships include CO, HC, CO2, NOx, SOx and PM, where these gases are very dangerous for human health and have an impact on global warming [1] [2] [3]. The regulation that controls pollution at sea is Marine Pollution (MARPOL) 1973/1978 which consists of annexes I-VI, including annex VI discusses preventing pollution in the sea by air [4] [5]. The convention that controls ship exhaust gas is Marine Pollution (MARPOL) 73/78 annex VI with the aim of controlling pollution resulting from exhaust gas produced by diesel engine as the main propulsion of ships, one of them is Nitrogen Oxide gas (NOx). Nitrogen Oxide is formed due to the combustion of fuel in ship diesel engines.[6] Air pollution by NOx gas or NO and NO_2 gas is caused

by high temperature of combustion in engine [7]. The main air pollution from ship mostly dominated by carbon dioxide (CO2) [8] [9].

The MQ-135 sensor is a tool to identify the presence of carbon dioxide (CO_2) gas, Nitrogen Oxide, Sulfur Oxide and then convert it into an electrical signal or voltage between 0 volts and 5 volts [10]. The MQ135 sensor is a chemical sensor or gas sensor which has a resistance value of Rs which will change when exposed to gas and also has a heater which is used to clean the sensor chamber from outside air contamination [11]. The MQ-135 air quality sensor is a sensor that monitors air quality to detect ammonia gas (NH3), sodium-(di) oxide (NO2), alcohol/ethanol (C2H5OH), benzene (C6H6), carbon dioxide (CO2), sulfur gas /sulfurhydroxide (H2S) and smoke/other gases in the air [12] [13]. This sensor reports the results of air quality detection in the form of changes in the analog resistance value at its output pin. This output pin can be connected to the ADC (analog to-digital converter) pin on the Arduino microcontroller/ analog-input pin by adding just one resistor (functions as a voltage divider). Analog To Digital Converter (ADC) is an electronic device [14]

To detect NOx gas from diesel engine, the MQ-135 sensor can be used by counting concentration of NOx gas which uses the voltage increase resulting from the MQ-135 sensor output in the form of an analog output voltage [15] [16]. Hadi et.al modified MQ 135 sensor to sense common and harmful gases including Hydrogen, Carbon Monoxide, and Chlorine gases [17]. A CO2 gas detection system was designed to detect mixed gases with other gases using the MQ-135 sensor has also been studied [18]. Developing and upgrading the MQ135 sensor to adopt and sense gases such as highly explosive hydrogen, chlorine and carbon monoxide has also been examined [19]. Up to recently, there has been no study on monitor of air quality specifically exhaust gas released from medium speed ship diesel engine using the MQ135 sensor. Therefore, the aim of this research is to design a tool to monitor air quality specifically exhaust gas released from medium speed ship diesel engine using the MQ135 sensor. The MQ-135 sensor was chosen as the gas sensor in this research because the MQ-135 has relatively high sensitivity to various gases including ammonia, benzene, alcohol, CO2, smoke and other gases. Furthermore, the MQ-135 sensor is a type of inexpensive sensor compared to other sensor. It has for many purposes that can detect different gases, The MQ-135 sensor has many advantages including a long lifespan, low cost, a straightforward drive circuit [20] [21].

2. Methods

2.1. Research Procedures

This research was carried out at the Indonesian State Maritime Polytechnic (Polimarin) using medium speed ship main engine which is usually used for practical class for cadets majoring in engineering. The engine used is a medium speed engine with the range of 250 rev/min to about 1200 rev/min supplied by Stem Isi Impianti, Genova Italy, Ref. J744 year 2005. The experiment carried out was a direct experiment by measuring ship exhaust gas at the exhaust gas end pipe in the ship's main engine. The Medium Diesel engine and its exhaust pipe can be seen in figure 1. In this research, exhaust gas from the diesel engine was measured using a variation of 3 types of engine speed, namely: 300 RPM (low speed), 600 RPM (medium speed) and 1000 RPM (high speed). The test was carried out 3 times to get a value close to the actual value. Smoke sensor testing is carried out by applying smoke to the sensor and then observing whether the sensor can detect the presence of smoke in the air. To see the effectiveness of the sensor in detecting smoke, this is done by looking at the sensor resistance value on the serial monitor on the Arduino IDE. Measurements are made by measuring the exhaust gas from the ship's main engine at the end of the gas exhaust chimney.

Figure 1. Medium Diesel engine and its exhaust pipe

2.2. Experimental set up

The equipment that was used for research purposes to detect ship exhaust gas included the MQ-135 sensor, Arduino Uno, and Personal computer (PC). The MQ-135 sensor was used to detect ship exhaust gas in accordance with Marpol annex 6 regulations. The output of the MQ-135 sensor is analog data 0 V to 5 V which is connected to the Arduino analog pin. Futhermore, analog data is processed with a program that has been created using Arduino IDE software to be converted into digital data which will be read by the Arduino serial monitor, the process as can be seen in figure 2.

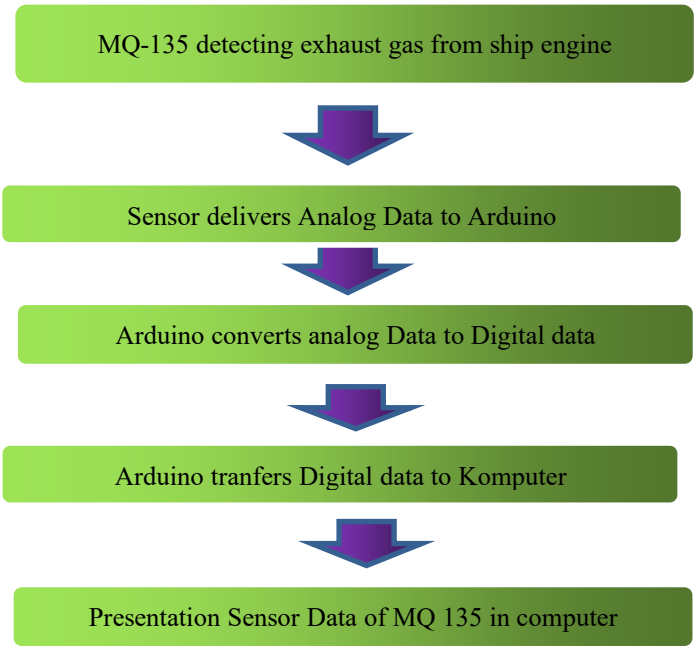

Figure 2. Schematic Diagram of Experimental set up

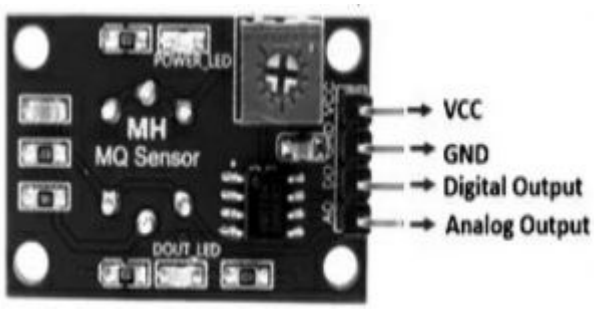

Figure 3. MQ135 Air Quality Sensor Pin Configuration

2.3. Data Collection

The MQ-135 sensor was chosen because is a gas sensor that can detect compounds/levels of some gases that can disrupt air quality including of NOx, alcohol, benzol, smoke, CO and CO_2. The MQ-135 sensor provides air quality detection results in the form of changes in the analog resistance value on its output pin. The MQ-135 sensor has 4 pins, as shown in figure 3, consisting of:

Pin 1: VCC: The pin refers to the 5V positive power supply that powers the MQ135 sensor module.

Pin 2: GND (Ground): This is the reference potential pin, which connects the MQ135 sensor module to ground.

Pin 3: Digital Out (DO): This pin refers to the digital output pin which provides digital output by setting the threshold value with the help of potentiometer. This pin is used to detect and measure certain gases and makes the MQ135 sensor work without a microcontroller.

Pin 4: Analog Out (AO): The pin produces an analog output signal of 0V to 5V and depends on the intensity of the gas. This analog output signal is proportional to the gas vapor concentration measured by the MQ135 sensor module. This pin is used to measure gas in PPM. It is driven by TTL logic, operates with 5V, and is mostly interfaced with a microcontroller. This sensor has good durability as a air pollution marker because it is practical and consume less of power. Adjustment of sensor sensitivity is determined by the resistance value of the MQ-135 which is different for various gas concentrations [8].

Figure 4. MQ135 Air Quality Sensor

The design of the MQ-135 sensor series for ship exhaust gas detection apart from requiring software containing command sequences or programming also requires hardware devices to build a ship exhaust gas detection system. The design of hardware and software requirements in the form of a series of ship exhaust gas detectors is described as several tools or components that function as follows

a. MQ-135 sensor as a means of detecting smoke in the air.

b. Arduino is a microcontroller tool that processes the output from the MQ-135 sensor.

c. Arduino software is an idea for programming the Arduino Uno and displaying the serial monitor

d. Computer to display MQ-135 sensor readings.

The hardware circuit of the ship's exhaust gas detection system using the MQ-135 sensor and Arduino is shown in the hardware diagram as follows:

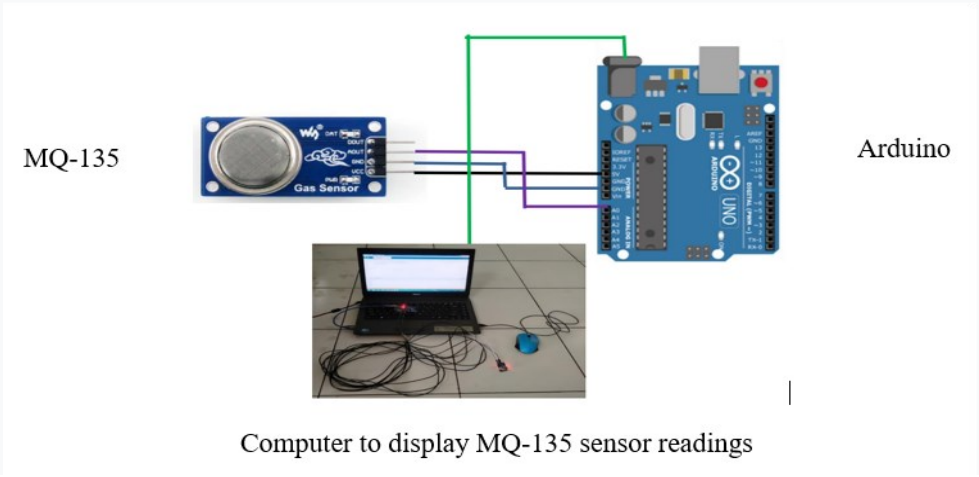

Figure 5. Experimental set up

3. Results and Discussion

Smoke sensor testing was carried out by applying smoke to the sensor and then observing whether the sensor can detect the presence of smoke in the air. The effectiveness of the sensor in detecting smoke was done by looking at the sensor resistance value on the serial monitor on the Arduino IDE. Measurements were made by measuring the exhaust gas from the ship's main engine at the end of the gas exhaust chimney.

The results of the ship's main engine exhaust gas measurements for the MQ-135 sensor used the serial monitor found in the Arduino IDE software. Serial Monitor Arduino IDE is a feature of the Arduino IDE software to display data issued by the MQ-135 sensor via serial communication using USB connected between the Arduino Uno and the computer.

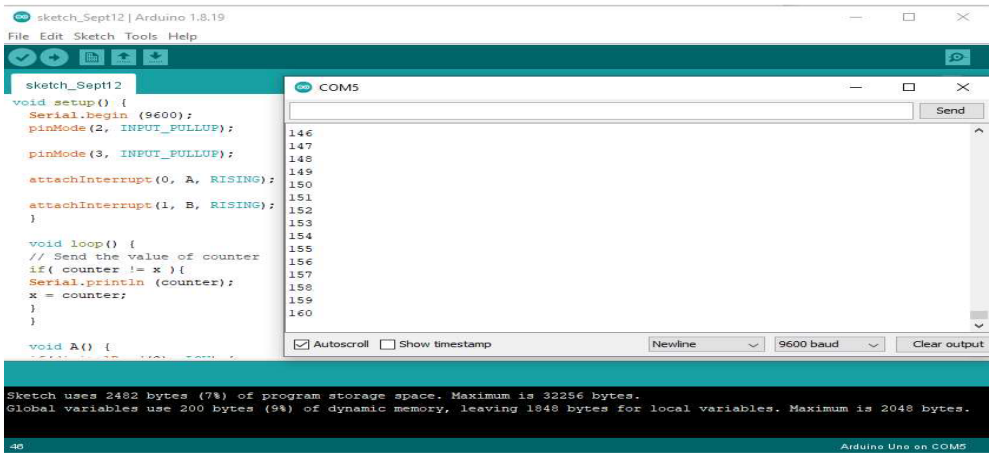

Figure 6. Display MQ-135 sensor readings

The test was carried out 3 times to get a value that was close to the actual test value .The 3 measurements were carried out, namely at low RPM speed (300 RPM), medium RPM speed (600 RPM) and high RPM speed (1000 RPM). Data collection was carried out by measuring the exhaust gas at the end of the exhaust gas chimney of the ship's main engine with the result being the value of the ship's exhaust gas

detected by the MQ-135 sensor using the Arduino IDE serial monitor. The following diagram describes the data measurement obtained.

Table 1. Measurement of Exhaust Gas from Main Engine

	RPM Main Engine	Initial Speed (exhaust gas value)	Running speed (exhaust gas value)
	1st Measurement		
1	Low RPM speed	12	66
2	Medium RPM speed	12	81
3	High RPM speed	12	96
	2nd Measurement		
1	Low RPM speed	12	68
2	Medium RPM speed	12	79
3	High RPM speed	12	95
	3rd Measurement		
1	Low RPM speed	12	65
2	Medium RPM speed	12	82
3	High RPM speed	12	96

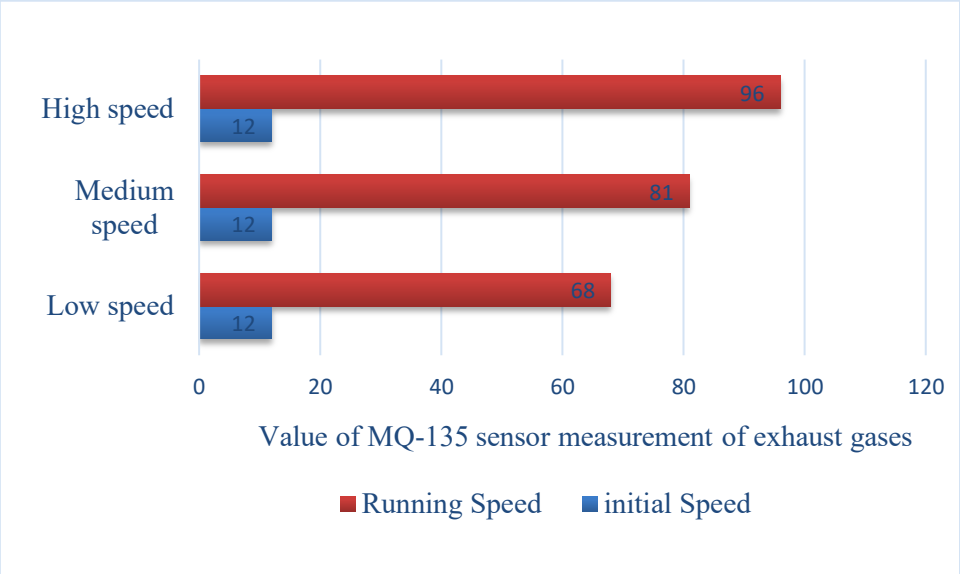

Figure 7. Diagram of MQ-135 sensor measurements of exhaust gas

The Table 1 and figure 7 above show the results of the research that has been conducted. It can be seen that the measurement results of the MQ-135 sensor when detecting ship exhaust gas in each experiment, namely for high engine RPM speed, medium engine RPM speed and low engine RPM speed. The average of the high RPM speed measurement results from three measurements is 96, for medium RPM speed is 81 and low RPM speed is 66 as displayed on the Arduino IDE serial monitor. The result indicated that the higher engine RPM speed also rises the exhaust gases produced. It can be concluded that the higher engine RPM speed resulted in a higher exhaust gas release from the exhaust pipe, and it can be detected by the MQ-135 sensor.

4. Conclusions

From the results of the equipment testing that has been carried out, it can be concluded that the MQ-135 sensor can be used to detect ship exhaust gas from medium speed ship engine. The design of a tool to detect ship exhaust gas using the MQ-135 sensor is controlled using an Arduino to be displayed on the Arduino IDE serial monitor. The tests that were carried out using the ship's main engine in the engine laboratory of the Indonesian State Maritime Polytechnic were conducted three times to get results that were close to the actual values. The test results showed that the exhaust gas of a high RPM speed from three measurements was 96, for medium RPM speed was 81 and low RPM speed was 66. The higher the RPM of the medium speed ship's main engine, the higher the value of exhaust gas displayed on the serial monitor.

Acknowledgments

We would like to thank the Indonesian State Maritime Polytechnic for funding this research through the University's internal research scheme and the lecturers who have helped with all of this research activity so that it can be carried out well.

References

[1] H. Palebangan, "Analisis Kapal Berbahan Bakar LNG Sebagai Marine Fuel Dalam Mengurangi Emisi Gas Buang Terhadap Lalu Lintas Kapal di Pelabuhan Bitung". *Warta Penelitian Perhubungan*, *31*(1), 25–34. 2019. https://doi.org/10.25104/warlit.v31i1.912,

[2] B. Wahyudi dan I. Fachruddin, "Analisa Daya Dan Biaya Penggunaan Low Sulfur Fuel Oil (LSFO) Dengan High Sulfur Fuel Oil (HSFO) Dilengkapi Scrubber Pada Kapal Niaga," Dinamika Bahari, vol. 1, no. 1, pp. 31–37, 2020.

[3] F. Telaoembanoea, "Penelitian Kandungan Gas Buang Beracun Pada Mesin Diesel 2500 cc Yang Menggunakan Bahan Bakar Solar Dan Bahan Bakar biosolar," Jurnal Warta Edisi : 50 , 2016, DOI: https://doi.org/10.46576/wdw.v0i50.202.

[4] Kuncowati,"Pentingnya Pemahaman Awak Kapal Mengenai Annex I Marpol 1973/1978 dan Latihan Pencegahan Pencemaran Minyak Terhadap Penanggulangan Pencemaran Minyak Dari Kapal," *Jurnal Sains dan Teknologi Maritim,* no. 1, 2018.

[5] Anggara dan Q. Nurlaila, "Perancangan Pembersih Gas Buang Kapal Dengan Kapasitas 70.000 kg/jam," Sigma Teknika, vol. 4, no. 2, pp. 243–254, 2021.

[6] Suganjar, Kundori, "Pengaruh Pemanfaatan Air Scrubber Dalam Mengurangi Pencemaran Udara Dari Kapal Sesuai Marpol 73/78 Annex VI," *Jurnal Manajemen Riset dan Teknologi*, vol. 4, no. 1, Agustus 2022.

[7] C.I.Y. Gessal, AS.M. Lumenta, B A. Sugiarso, " Kolaborasi Aplikasi Android Dengan Sensor MQ-135 Melahirkan Detektor Polutan Udara" Jurnal Teknik Informatika vol 14 no. 1 Januari-Maret 2019,

[8] T. K. Utami, F. S. Puriningsih, "Penghitungan Kadar Emisi Gas Buang Di Pelabuhan Belawan Emission Calculation At Belawan Port," *Warta Penelitian Perhubungan*," vol. 26, no. 5, pp. 285-292, 2014.

[9] D. P. Risky V.A, I. W. Arthana, and I. W. Suyasa, "Inventarisasi Emisi Sumber Bergerak Dari Transportasi Laut (Non-Road) di Wilayah Pesisir Kota Denpasar," ECOTROPHIC : Jurnal Ilmu Lingkungan (Journal of Environmental Science), vol. 9, no. 1, p. 10, 2015.

[10] A. Asniati, E. M. Hasiri, and W. O. Rosmiani, "Prototipe Sistem Pendeteksi Polusi Udara Menggunakan Sensor Asap MQ-2, Sensor Gas MQ-6 Dan Sensor Api Pada Ruangan dengan Output Alarm Berbasis Mikrokontroller Arduino," Jurnal Informatika, vol. 11, no. 2, p. 137, 2022.

[11] A. S. Mannaf, F. A. Setyaningsih, I. Ruslianto, "Purwarupa Sistem Deteksi Dan Pengurangan Kadar CO, CO2 Dan NO2 Berbasis Mikrokontroller," Jurnal Coding, Vol. 4, No.3, pp. 1-8, 2016.

[12] E. I. A. Kasenda, V. A. Suoth, and H. I. R. Mosey, “Rancang Bangun Alat Ukur Konsentrasi Gas Sulfur Dioksida (SO2) Berbasis Mikrokontroller Dan Sensor MQ136,” Jurnal MIPA, vol. 8, no. 1, p. 28, 2019.
[13] Junaedy, Sajiah, Zhahira Azzahrah, Idaryani “Rancang Bangun Alat Kontroling Kadar Udara Bersih Dan Gas Berbahaya CO, CO2 Dalam Ruangan Berbasis Mikrokontroler” JTech Vo.2 No.2. 2022
[14] M. Asmazori, N. Firmawati, “Rancang Bangun Alat Pendeteksi NOx dan CO Berbasis Notifikasi Via Telegram dan Suara,” JITCE (Journal of Information Technology and Computer Engineering), vol. 5, no. 2, pp. 57-62, 2021.
[15] U.Salamah, Q. Hidayah, D Y Kusuma,”CO2 detection system in mixed gas using MQ-135 sensor“ Newton-Maxwell Journal of Physics (Oktober, 2021) Vol. 2 No. 2
[16] M. Zidni, M. H. H. Ichsan , S. R. Akbar, “Sistem Monitoring Kesehatan Udara Menggunakan Sensor MQ7 dan MQ135 Terhadap Berbagai Gas Berbahaya Pada Mobil,” Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, vol. 6, no. 9, pp. 4322-4328, 2022.
[17] A. S. Hadi, M. Alsaker, A Eshoom, M. Elmnifi, MA. Alhmode, LJ. Habeeb, “Development of Low cost and Multi-Material Sensing Approach for MQ135 Sensor” Volume 17 issue 05 *Journal of Xi’an Shiyou University*, Natural Science Edition, May 2021.
[18] FN Abbas, MIM Saadoon, ZK Abdalrdha, EN Abood,”Capable of Gas Sensor MQ-135 to Monitor the Air Quality with Arduino uno“, *International Journal of Engineering Research and Technology*, Volume 13, Number 10 (2020), pp. 2955-2959, 2020
[19] F. Rivaldi, R. Maulana, M. H. H. Ichsan, “Sistem Deteksi Pencemaran Gas Beracun CO, HC, NOx Dalam Ruangan Tertutup dengan Metode Support Vector Machine,” Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, vol. 6, no. 8, Agustus 2022, pp. 4033-4038, 2022.
[20] R. Purbakawaca and S. A. Fauzan, “Rancang Bangun Sistem Pemantauan Kualitas Udara Dalam Ruangan Berbiaya Rendah berbasis IOT,” Jurnal Talenta Sipil, vol. 5, no. 1, p. 118, 2022
[21] D. Montreano and S. Pradana, “Pengendalian Tangan Robot Perakit Pada Disain Computer Integrated Manufacturing Berbiaya Rendah (CIM) Menggunakan Visual Basic dan Arduino,” Bina Teknika, vol. 14, no. 2, p. 199, 2018